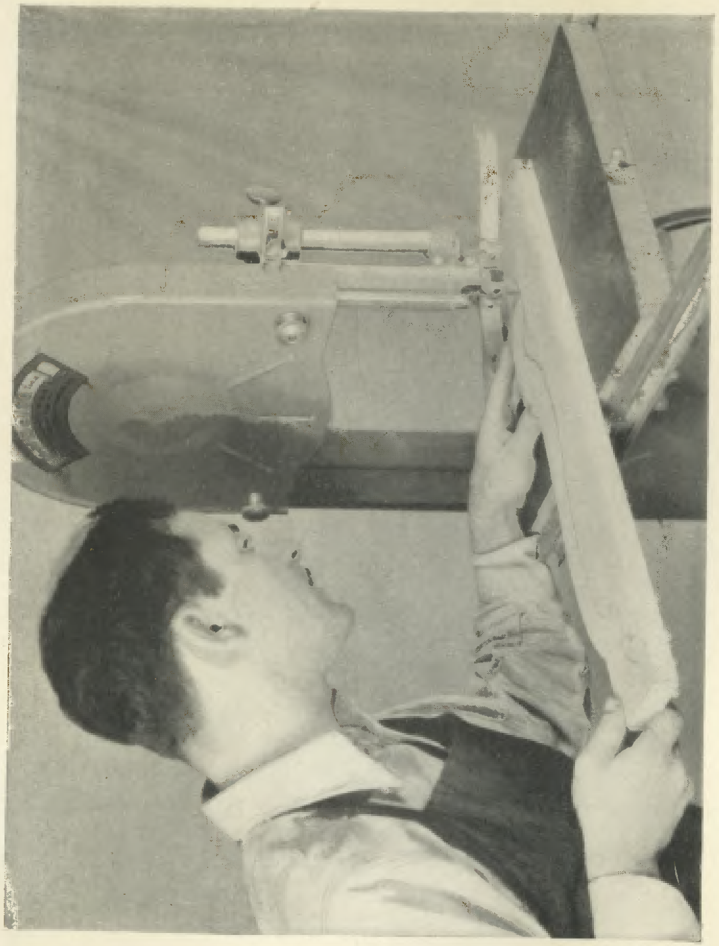

THE AMATEUR WOODWORKER AT THE BAND SAW

THE WOODWORKER SERIES

AMATEUR POWER WORKING TOOLS

BY

A. FREDERICK COLLINS

AUTHOR OF

"MOTOR CAR TRAILERS"

"THE MARCH OF CHEMISTRY"

"HOW TO UNDERSTAND ELECTRICITY"

"THE NEW WORLD OF SCIENCE"

ETC.

WITH 86 ILLUSTRATIONS

PHILADELPHIA

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LONDON

A WORD TO YOU

In the long, long ago when Man made his debut on this good earth of ours the first things that he crudely fashioned with his hands were formed of wood, and, it follows then, that *woodworking* is the oldest of all the crafts. Since this is true the natural desire and innate ability to use tools are inborn in the human race, and whether or not they are developed by the individual and put into a concrete form depends on numerous factors and various circumstances.

Woodworking has not only been one of the chief trades of skilled artisans from time immemorial but it has also been the happy hobby of many people whose efforts are directed along distinctly different fields of endeavor. To have a little shop all your own in the attic, in the basement, or in the backyard, and to make ornamental and build useful things of wood with your own hands is a hobby that will give you unalloyed pleasure, clear the cobwebs from your brain, add to your physical well-being, and, finally, provide you with a side-line that will materially help your bank account along, that is if you want it to.

Now until a few years ago the only tools the amateur had to work with were hand ones, if we except the little foot-power jig saw and turning lathe, and even these latter machines required a considerable expenditure of muscular energy to operate them. Since the fractional horse-power electric motor came into popular use the *work* in woodworking has been entirely eliminated, and so thousands of new followers have taken up the hobby, with the result that you will find innumerable miniature power workshops wherever you go—in the cities, the towns, the villages—in fact, everywhere that electricity is available.

The chief kinds of amateur woodworking power tools are (*1*) the jig saw, (*2*) the band saw, (*3*) the circular saw, (*4*) the lathe, (*5*) the drill press, (*6*) the jointer or planer, (*7*) the spindle shaper, (*8*) the sander, (*9*) the flexible shaft, and (*10*) the grinder. All of these power tools are run by electric motors that develop from 1/4 to 3/4 horsepower, and you can do nearly all kinds of work with them, and with practically no effort, in far less time, and a great deal more accurately than you can with hand tools.

With a power *scroll saw* you can saw out the most intricate designs and do the finest kind of marquetry, and by using what is called a *saber saw blade*, you can saw through wood that is upwards of 2 inches thick. A power *band saw* does the same kind of work as a jig saw but on a larger scale, while with a power *circular saw* you can saw off and rip boards at a rapid rate and with great accuracy.

The power *drill press* is, ordinarily, a machine for drilling holes in metals, but you can use it for a number of woodworking operations, the chief ones of which are (*a*) boring holes, (*b*) mortising square end holes, (*c*) routing out intricate work, that would take hours if you did it by hand, (*d*) shaping the edges of work, and, finally, (*e*) smoothing up work. The power *jointer* or *planer* is a machine with which you can plane off boards or other stock evenly and with dispatch, while a power *spindle shaper* enables you to make mouldings of dozens of different patterns, and to shape the edges of straight and curved work.

The power *sander* is a machine that sandpapers with a minimum of labor on your part and which would take hours to do by hand. By using a power *flexible shaft* you can get into places and do jobs that you cannot do otherwise, and, lastly, with a power *grinder*, you

can not only grind your cutting tools, but you can buff and polish work with it as well.

There are numerous makers of power woodworking tools and while they are fundamentally all alike they differ considerably in design and construction and, it follows, in price. I have described various makes and given a detailed description together with the current prices of them to the end that you can select those which will conform to your pocket-book and at the same time meet the requirements of the work you want to do.

Considering the capacity of these small power woodworking tools they are all very inexpensive and it is truly surprising how such good machines can be made to sell for so little. Of course the answer is found in the enormous output by the factories that manufacture them, *i.e.*, mass-production.

In any event if you are a woodworker, or are contemplating becoming one, you should by all means equip your workshop with these up-to-the-minute power tools. You don't need to buy them all at once, but you can get a jig saw, and then a lathe; follow on with a band saw, a circular saw, a planer, a shaper, a sander, a flexible shaft and a grinder, then you will have power tools that will do any kind of a job you want to do, however small or large, or whether you do it for pleasure or profit, or both.

A. FREDERICK COLLINS.

Hollywood, California

CONTENTS

ILLUSTRATIONS

Chapter I

ABOUT POWER WOODWORKING TOOLS

Working in wood is one of the oldest of the crafts and one of the most fascinating and useful. From the time that Man made his initial appearance on this good old earth of ours he has fashioned things of wood according to his ability and the tools he had at hand.

The First Hand Tools. In the beginning of things the tools he had to work wood with were made of *stone*, and considering the crudity of these and the low level of his mentality he used them nobly and well. Millenniums after came the *Bronze Age* and with it tools of a better kind, and, it follows, his skill as a woodworker showed marked improvement.

By the time that *iron* was discovered the human race had advanced mightily in brain power, and with it, came the coördination of eye and hand. *Homo sapiens* had, as his name indicates, become a quite nimble-witted fellow, and he not only made fairly good tools but he had learned how to use them with amazing dexterity.

The Earliest Mechanical Tool. The first of the simple hand tools were the hammer, the axe, the knife and the saw, while the earliest *mechanical tool* was the drill. The first primitive drill consisted of a fish bone, or an awl made of bone set in one end of the cylindrical wooden stick and this was given an alternate rotary motion by holding it between the palms of the open hands and then rolling it forth and back between them.

As a drill of this kind could only be used for making holes in soft materials prehistoric man improved upon it by fixing a bit of flint, or other hard stone, in the end of the stick. Now while this kind of a drill-point was good enough as a cutter, the speed of it was comparatively slow and it required a lot of energy to keep it going.

Since this was the way of it improvements were in order and then an Edison of his race appeared on the scene of action; looping the cord of his bow around the stick a couple of times and resting the free end of the drill in the palm of his hand, as shown in *Fig. 1,* he

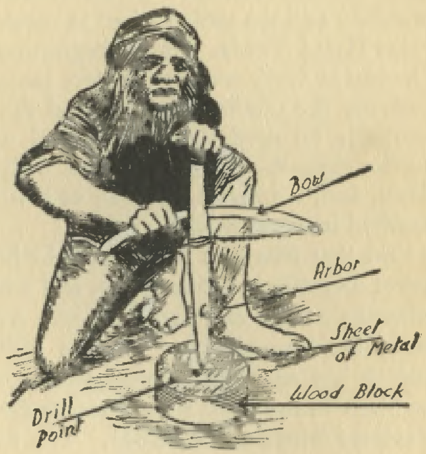


FIG. 1. THE PRIMITIVE BOW DRILL

could, by sawing the bow forth and back, drill a hole in far less time and with much less effort than he could by rolling with his hands. From this primitive drill has been evolved the turning lathe.

The Development of Foot Power Tools. Having developed the various kinds of hand tools that are necessary for working wood, he discovered how to make and temper steel for producing the tools, and how to use them with great skill; the next and obvious thing was to improve upon them so that, (*1*) less

energy would be required to do a given amount of work, (*2*) to do the same amount of work faster, and (*3*) to do it more accurately.

Now since man has more muscular strength in his legs than he has in his arms and, hence, can develop more power with the former than he can with the latter, he conceived the noble idea of making use of them to operate such tools as he could, when he would not only relieve the strain of his arms but would have his hands free to guide the work that was being done.

Since even the brainiest man is seldom able to think more than one jump ahead of what is already in his mind, so when he set out to produce a *machine tool, i.e.,* a machine that will do the work of a hand tool, he nearly always begins by trying to couple the latter with whatever source of power he wants to use by means of one or more of the mechanical movements. This premise being true it is not at all strange that the first machine for turning wood, or *turning lathe* as it is called, was worked on the principle of the bow drill and the earliest of these of which there is an authentic record was invented in the *16th* century.

It was called a *pole lathe,* and it consisted of a lathe bed on which was fixed a headstock and a tailstock, and between the centers of these was placed the work that was to be turned up. A cord was wrapped around the one end of the work and the lower end of it (the cord) was fastened to the free end of a treadle, while the upper end was fixed to the free end of a hickory or other springy pole, and, finally, the other end of this was secured to a beam or other suitable support as pictured in *Fig. 2.* Now when the turner pressed down on the treadle with his foot the cord caused the work to rotate in one direction, and when the pressure on the treadle was released the bent pole pulled the cord up and this

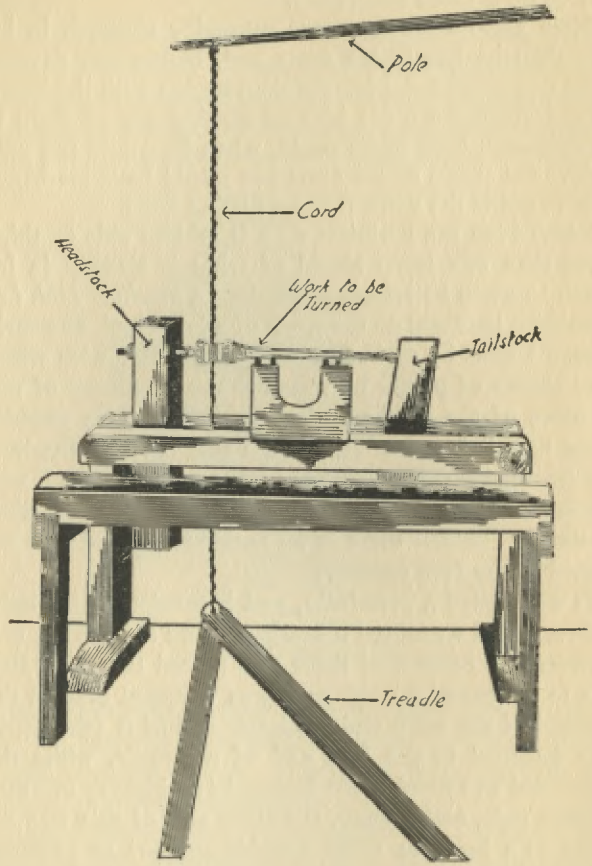


FIG. 2. A POLE LATHE OF THE 16TH CENTURY

rotated the work in the opposite direction. Pretty crude you will say but it was the best lathe of its time.

In the later part of the *17th* century the *foot power lathe*, in which the treadle was connected with a grooved wheel by means of a rod called a *pitman*, came into use. At first these foot-power lathes were used by professional artisans but when water and steam power became available, they (the foot power lathes) were made in lighter and more compact forms and were used by the amateurs.

The *jig saw, fret saw* or *scroll saw*, as it is variously called, had its beginning when a very fine saw blade was fitted into a rectangular frame, and thousands of woodworking hobbyists throughout the world are still using it. Later on the jig saw was operated on the principle of the pole turning lathe, that is to say a cord or wire was fastened to the lower end of the saw blade, while to the upper end of the latter another cord or wire was fixed, and this was secured to a spring pole.

The saw blade was held in a vertical position by guide blocks above and below the table on which the work was placed. Now when the sawyer pressed down on the treadle with his foot the cord or wire would pull the blade down and make the cutting stroke, and when he released the pressure on the treadle the bent pole pulled the cord or wire up and, of course, the saw with it.

Following on came the jig saw that was operated with a wheel and pitman; this was belted to a pulley on a shaft that was rotated by either water or steam power, and a small portable one that was worked by foot power, for the amateur.

The Beginning of Power Driven Tools. *The water wheel* was the first machine that was devised which could deliver anything like useful power for woodworking tools. It was greatly improved by Jean Victor Poncelot, a French mathematician and engineer, about *1750*, and for the next fifty years it was the only prime mover that could provide satisfactory power for operating machines.

In *1826*, Bennoit Fourneron, also of France, invented the *water turbine* and this had an efficiency of nearly *40* per cent more than the best designed water wheel. It consisted of a wheel that had guides or blades fixed to it and this was enclosed in a case which has a like number of fixed guides or blades secured to its inner circumference.

Now different from the water wheel, the turbine is wholly submerged in the water, and this must have a considerable *head* in order to develop the necessary power. The way it works is like this: when the water flows into the turbine the fixed blades deflect it so that it strikes against the blades of the rotating element with the greatest possible force. The used, or *dead water* as it is called, then flows out of the turbine through a central opening.

The *steam engine* had its beginning when Denis Papin, a French physicist, in *1690*, put a piston in a cylinder and drove it forward with steam. Then Thomas Newcomen, and John Cawley, of England, built a piston engine in *1705*, that worked on the *vacuum principle*, and this was used for pumping water from mines.

Next James Watt, of Scotland, built, in *1769*, an engine in which a *separate condenser* was used, and a few years later he invented the *double acting* engine, in which the steam is alternately admitted into both ends of the cylinder. Finally, in *1776* he coupled the piston to the crank of a flywheel with a connecting rod so that the reciprocating motion of the former would be changed into rotary motion of the latter.

With the invention of the water turbine and the steam

engine cheap power in large amounts could be had almost anywhere and inventors bended their energies toward developing woodworking machines that could be operated with them. The lathe and the jig saw were easily adapted to be run by either water or steam power, and then followed the inventions of the circular saw, the band saw, the boring machine and the planer.

The *circular saw* was invented in Holland as early as *1700*, but who the genius was that first conceived the idea of cutting teeth in the periphery of a steel disk and rotating it at a goodly speed so that a continuous sawing action resulted is not, unfortunately, known.

In *1777* Samuel Wilder, of England, greatly improved upon the circular saw machine, and he it was who introduced nearly all of the improvements that are to be found in it at the present time. The *band saw* was invented by Thomas Newberry, of London, in *1807*, and in a patent granted to him in the following year he described in detail the pivoted table, the radial guide and other essential features which are embodied in the machine that is in use at the present time.

The band saw, however, did not come into general use until the middle of the *19th* century, probably because of the danger of the saw blade breaking. Later on when the methods of making and tempering steel were improved upon this potential danger was removed and it became a popular machine tool in shops and factories. The first *planing machine*, or just *planer* as it is called for short, was invented by Samuel Bentham, of London, in *1779*, and it consisted of a large plane made like a jack plane, and this was moved forth and back by a power driven arm.

The *rotary planing machine*, which is the kind now in use, was the result of the efforts of three inventors. The first one, whose name is not recorded in history, put parallel cutting blades on a rotating cylinder in *1776*.

Then Charles Hammond, of London, invented, in *1811*, the feed rolls for moving the board or other piece of lumber continuously along and at a given rate of speed. Finally, in *1850*, Henry Woodsworth, also of London, combined the roller feed motion with the rotary cutting cylinder and so produced the planer as we know it today.

The *boring, mortising and dovetailing* machines had their beginnings in *1793* when Samuel Bentley, of England, built all three of them. The boring machine is clearly based on the principle of the lathe but to apply the necessary pressure to the bit while the boring operation is going on and then to raise the bit after the hole is bored out, required in those early days of machine design, a considerable amount of inventive ability.

Electric Power Driven Tools. Since a water turbine requires a stream of water, or a *race* as it is called, that has a good head, and a steam engine must have a boiler of appropriate size, to operate them, these prime movers are available only for shops on a fairly large scale. Even when the gas engine came into use in the early *70's* of the last century it was far from a suitable motive power for driving the machines of the amateur woodworker's shop as it was heavy, noisy and costly.

Came then that new and marvelous power producer —you know—that bright and strong young stripling who, paradoxically enough, is known as *old man electricity*. Now the first practical dynamo for generating a current of electricity was built by Zenobe Theophile Gramme, a Belgian electrician, in *1870*, and a little later Charles F. Brush, of Cleveland, Ohio, built a much more efficient dynamo, and this he used to supply current to his arc lighting system.

A few years prior to this Edison began his experiments which resulted in the incandescent lighting system, and this he installed in New York City in *1872*.

The engine which drove the dynamo was a *175*-horsepower one, and this was the real beginning of what is known as the *electrical age*.

In the next year (*1873*) another industrial exposition was held in Vienna and Gramme had a pair of improved dynamos on exhibition. These machines were either, by accident or by design, connected together by someone—the culprit was never discovered, more's the pity —when the current was being generated by one of them was found to be energizing and running the other one. In a word when mechanical power is applied to a dynamo it generates an electric current, and, the other way about, when an electric current is made to energize a dynamo it develops mechanical power, and, it follows, it becomes a *motor*.

This, then, was the beginning of electric motorization, and it opened up a thousand new uses for the electric current. As time moved on apace large factories equipped their machines with individual electric motors thus doing away with shafts and belting and this made, not only for greater efficiency in operation, but a higher factor of safety.

Since it is easy to build fractional horsepower motors and these are cheap, compact and economical to operate amateur mechanics everywhere began to use them to run their jig saws, lathes and other power tools. So great was the demand for these home power driven tools that individuals and concerns have gone into the business of making them in units, that is, in which the electric motor and the tool it runs are integral parts of each other.

The use of electric driven tools takes the last vistage of *work* out of woodworking and leaves to the amateur only the wood and the pleasure of working it, and so easy and fascinating has the motorized craft become that thousands of amateurs all over the world have taken it up as a hobby and are getting the greatest mental and financial profits out of it.

You will find all these amateur power tools fully described in the following chapters together with instructions for using them, and much other detailed information concerning them.

Chapter II

THE POWER JIG SAW

A *scroll saw*, or *jig saw* as it is commonly called, consists of a fine saw blade supported in such a way that it can move rapidly up and down in a straight line, and the saw blade is thin and narrow enough so that it can turn sharp curves.

The jig saw is by all odds the most popular and, it follows, the most widely used of all the amateur power driven tools. This is because a greater variety of work can be done with it than with any of the other tools in this class. Not only can it be used for sawing out the finest precision marquetry but also the heaviest sabre-blade work, and, further, it can be used for sawing soft sheet metal in making jewelry and Catalin work.

Besides these jig sawing operations it can also be used, by employing specially made tools and attachments, for filing and sanding, cutting grooves, spindle carving, dovetailing, shaping and grinding. I shall tell you about the different makes of jig saws that are manufactured at the present time, then how to use it and, finally, about the various attachments that make it the power tool par excellence of the amateur woodworker.

The Parts of a Jig Saw. A power jig saw is built up of six chief parts and these are (*1*) the base, (*2*) an open end frame, (*3*) a table, (*4*) a mechanical movement for changing rotary motion into reciprocating motion, (*5*) a tension spring and (*6*) a saw blade guide.

The lower arm of the frame is usually mounted on the base, though in some jig saws it forms the base in which case, the upper arm is bolted to it. In the better machines the table can be tilted at an angle. Various mechanical movements are used to change the rotary motion of the pulley shaft into a reciprocating motion of the rod to which the lower end of the saw is clamped; also various kinds of springs are employed in the end of the upper arm to provide the necessary tension for the upper reciprocating rod, to which the top end of the saw is clamped.

The Ward 12-inch Power Jig Saw.[1] This is the

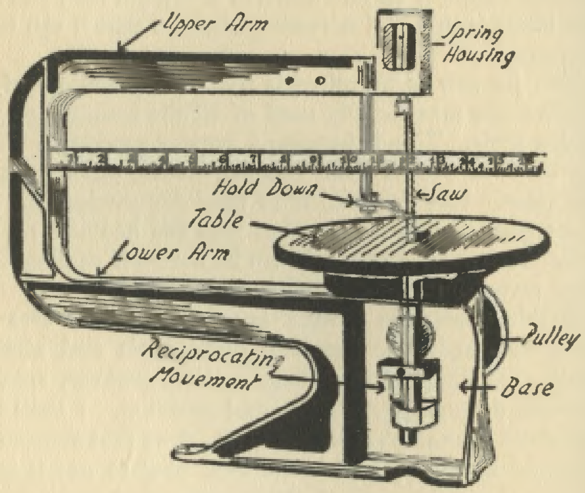


FIG. 3. THE WARD 12-INCH JIG SAW

smallest of the power jig saws, and the frame of it is made of gray, close-grained cast iron, while the mechanical parts are made of hardened steel. This jig saw has a *12*-inch clearance, or *throat* as it is called. It will, it follows, cut to the center of a *24*-inch circle, and stock that is ¾ of an inch thick.

It has a heavy, rigid adjustable rod that holds the

[1] This is made by Montgomery Ward and Co., Inc., Chicago, Ill.

steel guide for the saw. A tempered nickel-steel cam works against a hardened steel block that runs on a planed surface. The *table,* that is the surface on which the work is placed to be sawed, is *8½* inches in diameter and it is fitted with a graduated scale and indicator; it can be tilted to any angle up to *45* degrees, so that you can bevel the edges of the work you are sawing.

The drive shaft runs in long sleeve bearings and double bearings in the upper and lower heads make the saw blade work in a straight vertical line. The return spring provides an even tension at all points of the stroke of the saw blade all of the time, and this also reduces the breakage of the blades.

The jig saw has a *4*-inch V-shaped pulley and uses a *1¼*- or *1½*-inch pulley on the motor or line shaft and it can be run with a ¼-horsepower (H.P.) motor. Lastly it has an overall height of *16* inches and a shipping weight of *21* pounds. The price of this jig saw, which is shown in *Fig. 3*, is *$6.00.*

The Driver 14-inch Power Jig Saw.[2] This is a very practical jig saw and its chief features are a ground table *9* by *9* inches on the sides made of gray, close-grained cast iron. It has a throat capacity of *14* inches so that a *28*-inch wide board can be sawed through with it.

The blade clamps, or *vises* as they are sometimes called, are so made that they can be turned one-quarter way around and this allows you to saw from the sides of the table as well as in front of it, which is a necessity when you are sawing long pieces.

The distance from the upper blade clamp to the table is *1½* inches and it handles *1*-inch thick-stock. The table tilts to *45* degrees and it is fitted with an accurate scale and indicator. It has a positive plunger blower in

[2] This jig saw is made by the Walker-Turner Co., Plainfield, N. J.

the head that effectively directs a stream of air at the point where the saw is in cutting action, and this blows the sawdust away from the line you are sawing on.

One of the good features of this jig saw is that the crank mechanism is enclosed in a case, or housing, that

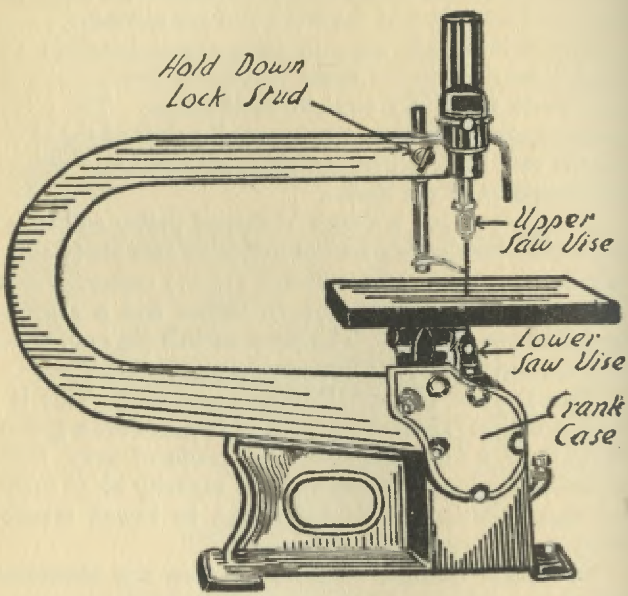


FIG. 4. THE DRIVER 14-INCH JIG SAW

is filled with medium weight motor car oil. This oil-tight crankcase prevents dust and dirt from getting into the mechanism, and this not only makes for quiet and smooth operation but prevents injury to the bearings, and hence, the jig saw is given a longer life.

It can be driven from a countershaft or by being belted directly to an electric motor, which amounts to the same thing. Whichever way you do it you can use a

$2\frac{1}{2}$-inch pulley on it and to drive it you can use a $\frac{1}{4}$-, or, better, a $\frac{1}{3}$-*H.P.* motor that has a speed of *1750* revolutions per minute (*R.P.M.*). It has an overall height of *$19\frac{1}{2}$* inches, an overall length of *21* inches and a shipping weight of *34* lbs. It costs *$11.50* without the motor. A $\frac{1}{4}$-*H.P.* motor costs *$6.00*, and a $\frac{1}{3}$-*H.P.* motor *$10.00*. It is pictured in *Fig. 4*.

The Ward 16-inch Power Jig Saw.[3] This is a nicely designed, compactly built, heavy duty jig saw and it takes up a minimum amount of space. It normally cuts to the center of a *32*-inch circle, but when the arm is unbolted and removed from the base and a sabre saw[4] is used stock of any size can be cut.

The base and arm are made of gray, close-grained cast iron; the countershaft, which is a balanced one, and the mechanical movement that changes the rotary motion of the crank into reciprocation motion of the rod that moves the saw blade, are of hardened steel. These parts are enclosed in a dust-proof case, or housing, and run in an oil bath. The motor is bolted to the base and the jig saw is, therefore, a self-contained unit.

It has a lower *chuck* that can be adjusted and it will take the finest saw blades, sabre blades, files, sanders, and other accessory devices. There is an adjustable support under the table that greatly facilitates heavy cutting with jig saw blades and sabre saw work. You will also observe there is a wing-nut at the elbow of the arm and the purpose of it is to adjust the spring so that the exact amount of tension on the blade can be had for the stock you are sawing. It follows that the thicker and wider the blade the greater the tension that is needed.

Two of the outstanding features of this jig saw are

[3] This jig saw is made by Montgomery Ward and Co., Inc., Chicago, Ill.

[4] Saws of this type will be described presently.

(*1*) *the roller guide* and (*2*) the *trunnion mounting.* The *roller guide,* in which the saw blade moves, is made of hardened steel and the rear edge of the saw blade makes contact with it, thus eliminating the friction that is set up by the blade when the sides of it slide up and down the surfaces of the fixed guide.

The table is *10* by *10* inches on the sides and this is solidly mounted on a trunnion. The table tilts to *45* degrees in either direction and when it is tilted the blade always remains in the center of the opening. It is firmly locked in place with an automatic cam lever. A scale and pointer indicates the angle at which the table tilts.

The overall height of the jig saw is $18\frac{3}{4}$ inches and the overall length of it is *22* inches. Its actual weight is *53* pounds and its shipping weight is *68* pounds. The price of the jig saw alone is *$15.00,* while a motor to run it will cost from *$6.00* to *$10.00* more.

The Ward 24-inch Heavy Duty Jig Saw.[5] This jig saw is built along the same general lines as the *Ward 16-inch* one which I have described above, only it is larger and has more refinements than the latter. It will saw stock up to $1\frac{7}{8}$ inches, and has a throat capacity of *24* inches. It is, therefore, large enough for all amateur purposes such as pattern making, cabinet making and other kinds of woodworking.

It is made of seasoned gray cast iron and has a heavy base on which is mounted a rigid full box style detachable arm so that sabre blades can be used when necessary. The weight of the jig saw is *61* pounds, and being of heavy and rigid construction it is practically free from vibration. It is fitted with a balanced crank-shaft and a hardened steel mechanical movement that runs in lubricating oil.

[5] This jig saw is made by Montgomery Ward and Co., Inc., Chicago, Ill.

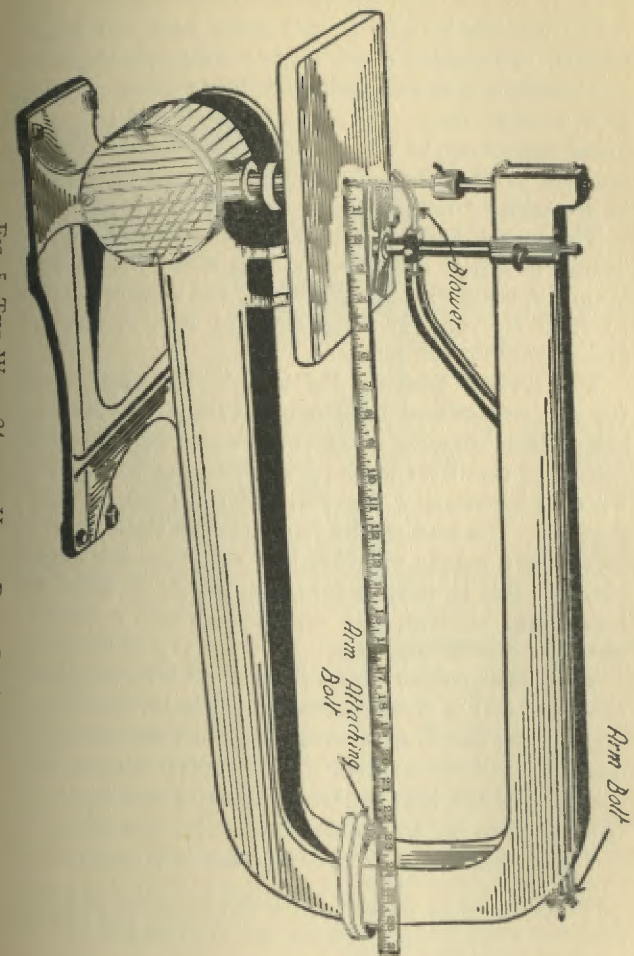


Fig. 5. The Ward 24-inch Heavy Duty Jig Saw

The jig saw also has a *universal chuck*[6] that takes all sizes of blades from the finest jeweler's blades to the heaviest sabre blades; it also takes files and sanding pencils. The upper chuck spindle runs in self-lubricating bearings, and this keeps the blade in an absolutely true vertical line. The jaws of both the upper and lower chucks can be turned at right angles to the normal position of the blade so that long pieces of stock can be cut without removing the arm.

The overall height of the jig saw is *19* inches and its overall length is *31½* inches. It is fitted with a *4*-inch V-pulley, requires a ¼-H.P. motor, and runs at from *800 to 1200 R.P.M.* It is pictured in *Fig. 5*, and costs *$22.00* without the motor.

The Driver 24-inch Jig Saw.[7] The specifications for this streamlined jig saw are, briefly, as follows: It has a throat capacity of *24* inches and a *12½*- by *16*-inch machined cast iron table. The table can be tilted forward or backward *5* degrees, and from side to side *45* degrees. The arm can be swung to the right or left by loosening a couple of studs and removing the aligning pin, and this is often a great advantage in sabre sawing, filing, sanding, and especially where a router is used for dovetailing, etc.

There is a positive blower in the head for removing the sawdust, and a *3*-way electric outlet is fitted to the upper arm; this is connected with the electric lamp and the router, while another *3*-way outlet is mounted at the rear of the base on the bench and this carries the feed wires to the arm outlet and the jig saw motor.

The overall height of the jig saw is *25½* inches and

[6] This is a simple form of chuck that is formed of a hollow stem that takes the shank of the saw or other tool and has a set screw for holding it tight.

[7] This jig saw is made by the Walker-Turner Co., Plainfield, N. J.

the overall length is *33* inches. It is fitted with a *4*-step pulley and this will give speeds of *644, 926, 1295* and *1750 R.P.M.*, a ¼- *or*, better, a ⅓-*H.P.* motor can be used to run it. The jig saw without the motor is priced at *$25.00*. It is shown with the motor in *Fig. 6*.

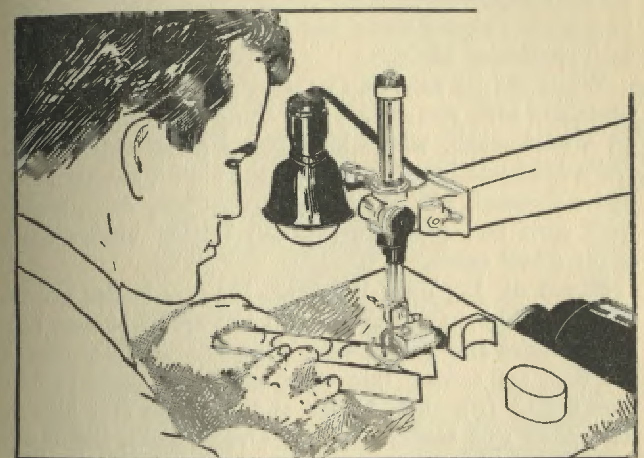


FIG. 6. THE DRIVER 24-INCH JIG SAW

The Delta 24-inch De Luxe Jig Saw.[8] This very fine jig saw is *14* inches wide, *23* inches high, *35* inches long, and it has a shipping weight of *117* pounds. Its chief features are (*1*) where very fine blades are used the *self-centering jaws* are quite superior to the ordinary jaws that are commonly used in the upper and lower chucks. (*2*) The *hand lock* which locks the table to the trunnion seats is a very convenient contrivance. The table tilts smoothly on heavy trunnions and the exact angle you want it to have is obtained by means of a graduated arc and an adjustable pointer.

[8] This jig saw is made by the Delta Manufacturing Co., 600 E. Vienna St., Milwaukee, Wis.

(*3*) A novel feature is a *spring hold down* which holds the work to the table, and this can be tilted so that it functions even when the table is at an angle, and (*4*) an outer sleeve that covers the upper chuck plunger is graduated and movable, and this enables you to accurately adjust the tension of the spring to suit the kind of a blade you are using and get the same tension with each particular blade.

While the jig saw, as *Fig. 7* clearly shows, is a self-contained unit you can, if you want to do so, mount it on a steel stand, which latter costs *$6.00* extra. The Delta De Luxe jig saw, without the motor, costs *$27.50*, and a *4*-speed, $\frac{1}{4}$-*H.P.*, *110*-volt, *60*-cycle, A.C., motor with cord and plug, switch and raising blocks costs about *$9.00* extra.

Kinds of Jig Saw Blades. Jig saw blades are of three chief kinds and these are (*1*) regular blades, (*2*) sabre blades and (*3*) jeweler's blades. *Regular blades* are used for sawing thin wood and these come in two styles, *i.e.*, (*a*) plain blades and (*b*) pin end blades. The *plain end blades* come in several sizes, but those used for fine work are usually *.010* of an inch thick and *.040* of an inch wide; these have *18* teeth to the inch, and cost *15* cents for a package of six blades. Those used for coarser work are *.020* of an inch thick, are $\frac{1}{8}$ of an inch wide and have *10* or *15* teeth to the inch; they cost *25* cents for a package of *12* blades, or you can get a package of assorted blades for a quarter.

The pin end blades are also *.010* of an inch thick, and *.040* of an inch wide; they have *20* teeth to the inch and a package of twelve costs *30* cents, or a package of assorted sizes for *30* cents. *Sabre saws* are thick, stout blades, and are $\frac{5}{32}$ of an inch wide and about $4\frac{1}{2}$ inches long. They are made for sawing thick stock and the

Note: You can get jig saw blades from Hammacher, Schlemmer and Co., Fourth Ave., and 13th St., New York City.

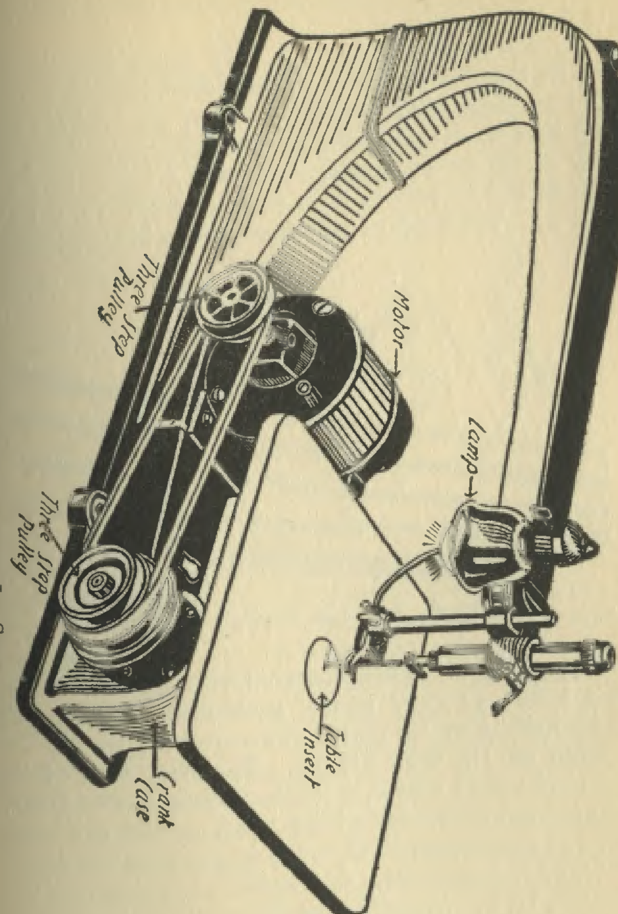


Fig. 7. The Delta 24-inch Jig Saw

upper end is free. A package of twelve saws will cost you *50* cents. These different kinds of blades are shown at A in *Fig. 8*.

Jewelers saw blades look very much like jig saw blades but they are made of finer steel, have finer teeth and are tempered more highly. They are used for sawing thin sheet metal such as brass, copper, silver, and any of the softer metals. They are *5* inches long and can be had in various sizes running from *No. 0* up to *No. 12*. The teeth of all these various kinds of blades

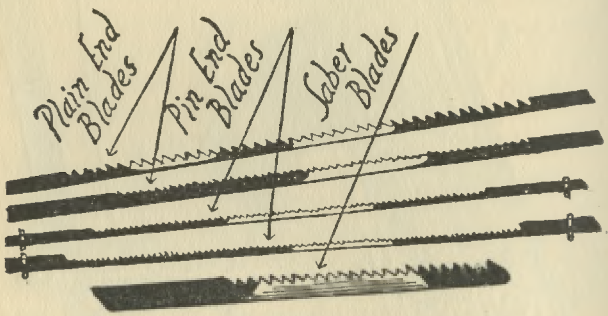


FIG. 8. KINDS OF JIG SAW BLADES

are spaced widely apart compared with the size of them (the teeth) as at B clearly shows, and they are so formed that they cut on the down stroke only.

Kind of Jig Saw Stocks. The chief kind of jig saw stocks is, of course, wood, both common and fancy. You can get the common kinds, such as, pine and basswood at any lumber yard, while you can get the fancy kinds, of various dealers who specialize in them, as, for instance, H. L. Wild, *510* East *11th* St., New York City. For inlay work you can often use mother-of-pearl to advantage and this you can get of the Pioneer Pearl Works, *443* Broome St., New York City.

LIST OF FANCY JIG SAW WOODS

Name	*Price per square foot planed to a thickness of* $\frac{1}{16}$ *to* $\frac{1}{8}$ *in.*	$\frac{3}{16}$ *in.*	$\frac{1}{4}$ *in.*
Bass, popular and white wood........	$0.07	$0.08	$0.09
Spanish cedar....................	.10	.12	.14
White maple....................	.10	.12	.15
Sycamore....................	.11	.13	.15
Hazel wood....................	.11	.13	.15
Oak and white ash....................	.11	.13	.15
White holly....................	.12	.14	.16
Black walnut....................	.14	.16	.18
Bird's-eye maple....................	.14	.16	.18
Mahogany....................	.14	.16	.18
Cocabola....................	.20	.25	.30
Amaranth....................	.20	.25	.30
Rosewood....................	.25	.30	.40
Satin wood....................	.30	.35	.40
Tulip....................	.50	.60	.75
Real ebony....................	.50	.50	.50

Note.—The above prices are subject to change.

Trimmings for Jig Saw Work. In making handkerchief, glove and other boxes, photo frames and brackets, and a thousand and one other knicknacks, you will need various kinds of trimmings such as brass and chromium plated hinges, knobs, drawer pulls, box hooks, latches and locks, French screws and wire nails, catches, escutcheons and metal legs, turned moldings, etc., and these you can also get of dealers in jig sawing materials, or of Hammacher, Schlemmer and Co., *13th* Street and Fourth Ave., New York City.

Jig Saw Designs and Patterns. If you are good at drawing you can make your own designs and patterns, or, allowing that you are not, you can buy them printed and all ready to use. Having the design on paper you can glue it directly to the surface of the wood and let it dry overnight when you are ready to go ahead and saw it out. If, however, you want to keep the design you can transfer it to the surface of the wood this way:

Lay a sheet of carbon paper, as the typists call it, or impression paper as jig sawyers term it, with the coated side next to the wood. Now lay the design sheet on top of it and fasten the corners of it to the wood with either glue or thumb tacks.[9] This done take a sharp, hard lead pencil and trace the outline of the design with it, when you will find that it is plainly marked in black lines on the wood.

You can get jig saw designs in great variety of dealers in jig saw materials and all of the makers of jig saws sell them. Thus the *Walker-Turner Co.*, have designs for a platoon of soldiers, a *zoo* of animals, a *16*-piece set of doll furniture and a double alphabet set. These designs are printed on wood panels so that all you have to do is saw them out. You can buy them for *30* cents apiece.

A new and money making hobby is to saw out lawn and garden ornaments. The patterns for these novelties are sold by Montgomery Ward and Co., and are printed on paper, and you have only to transfer or glue them onto the surface of the wood you are going to make them of.

When you have sawed them out paint them in the colors that are shown in the sketch which is printed on every pattern. When the ornament is painted and dry you must varnish the sides and edges of it; this protects it from the weather and gives it a lasting finish. There are some *20* different patterns and they range in height from *8* to *22* inches, and cost from *17* to *65* cents each.

How to Saw with the Jig Saw. Having, now, the jig saw and the wood with the design on it that you are going to saw out, you are all set to do the job. The

[9] These are short flat-headed tacks used by draughtsmen, and you can get them at the stationery store.

kind of a blade you want to use will depend largely on the kind of wood you are going to cut. Thus if the wood is a hard one you must use a fine toothed blade, and, conversely, if the wood is a soft one you must use a coarse toothed blade. Generally speaking, you should use the largest blade having the coarsest teeth that will make a clean cut and yet be able to take the sharpest curve in the pattern.

After you have clamped the blade in the chucks the next thing to do is to adjust the spring in the tension head. If you are using a very fine blade the tension of the spring must be slight, and, if a coarse blade is used the tension of the spring must be proportionately greater. The variation of the tension is had by pulling the saw chuck or upper tension plunger down a shade when you put in the blade.

There is no fixed speed at which the jig saw should run but, roughly speaking, it may vary from *600* to *1750* strokes[10] per minute for fine blades, and from *150* to *1200* strokes per minute for coarse blades. When sawing metal with a jewelers' blade it must be run at a very slow speed.

When you have made the tension adjustments, switch on the motor, lay the stock you are going to saw on the table and rest the tips of your fingers of both hands on top of it; while you are sawing it keep one hand on one side of the blade and the other hand on the other side of it, whenever it is possible to do so.

You must press down hard enough on the work to keep it in contact with the table against the up strokes of the blade; as the top of the table is planed, or ground smooth, it is easy to move the work around on it and to keep the saw on a straight line. Be careful not to feed the work against the blade faster than it can easily cut,

[10] One up and down movement of the blade is called a *stroke*.

and do not use wood that is thicker than the jig saw is rated to take, or the excess pressure will break it.

If you are using an electric lamp to work by adjust the position of it so that you can see the line you are sawing on right up to the teeth of the blade, and, lastly, adjust the blower so that it blows the sawdust away at the point of contact of the saw and the work you are sawing so that you can clearly see the line you are sawing on.

Some Useful Jig Saw Attachments. There are quite a few other things that you can do with a jig saw

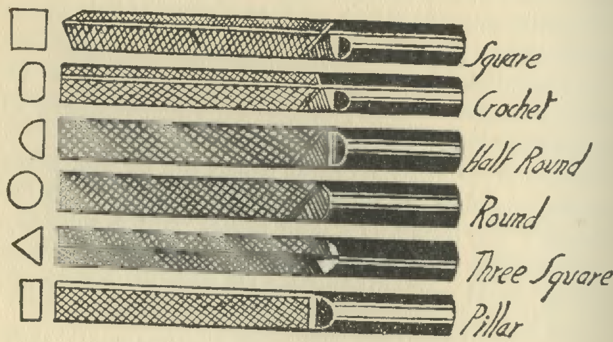


FIG. 9. KINDS OF JIG SAW FILES

besides sawing with it. Thus you can use it for (*1*) filing, (*2*) sanding, (*3*) hammering, (*4*) routing, (*5*) shaping, (*6*) carving, (*7*) dovetailing, (*8*) grooving or dados, and, lastly (*9*) grinding.

The Filing Attachment. Some jig saws are fitted with a *special chuck* and this not only holds regular, sabre and jewelers' saws, but also files and sanders, as the sandpapering device is called. The *files* are made with round shanks, see *Fig. 9*, and they are $\frac{1}{8}$ and $\frac{1}{4}$ inch in diameter, *12* inches long, and have various cross-sections, as is also shown in the picture. The

file works like a sabre saw, that is, it sets in a vertical position and moves up and down.

The Sanding Attachment. This attachment, which is shown in *Fig. 10*, consists of a semi-circular block that sets in a frame and this grips the sheet of sandpaper that fits around it. It is $\frac{1}{2}$ inch thick, about *1* inch

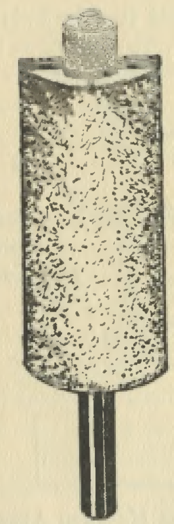


FIG. 10. THE SANDING ATTACHMENT

wide and $2\frac{1}{2}$ inches high, while the shank that fits in the chuck is $\frac{1}{4}$ inch in diameter. The Delta Manufacturing Co. makes it and it sells for *$1.35*. With it you can sandpaper flat, convex and concave surfaces and this saves a lot of tedious hand labor.

The Hammer Attachment. This automatic hammer is especially useful if you are doing hammered metal work, because you can not only do it without the tedious strain of repeated hand blows, but you can do it much faster and with greater uniformity than by the latter method.

To make it get a piece of spring steel $\frac{1}{32}$-inch thick, *1* inch wide and *12* inches long. Anneal it and drill a $\frac{1}{4}$-inch hole in one end, a $\frac{1}{2}$-inch hole in the other end, and a $\frac{1}{4}$-inch hole about half way between them. Heat the end of the spring that has the $\frac{1}{4}$-inch hole in it and bend it around so that it (the hole) is at right angles

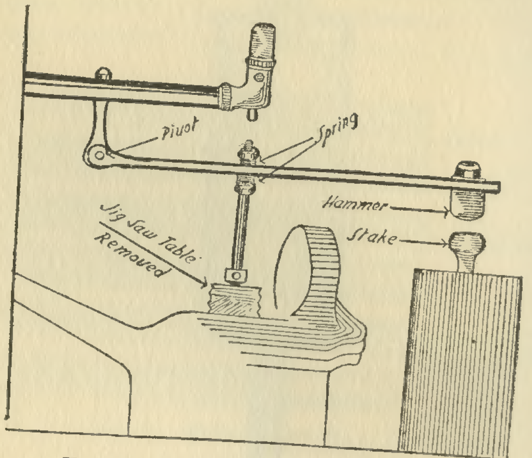


FIG. 11. THE HAMMER ATTACHMENT

to the other holes; now heat and temper the spring again. Next get a $\frac{1}{4}$-inch thick steel rod, *4* inches long, thread one end of it, flatten out the other end and drill a $\frac{1}{4}$-inch hole in it. Slip the threaded end of the rod through a hole in the arm of the jig saw and fasten it there with a couple of nuts.

This done, get a piece of steel, one end of which is rounded, that is about *1* inch in diameter and $1\frac{1}{2}$ inches long, and turn one end of it down so that it will have a diameter of $\frac{1}{2}$ inch and thread it. Push this end through

the hole in the end of the spring and screw on a nut. Now get a $\frac{3}{16}$-inch thick steel rod that is *3* inches long and thread it half way down. Put the unthreaded end in the lower clamp of your jig saw, screw a nut on the free end, and then slip on a short stiff spiral spring; this done slip the end of the rod through the middle hole of the flat spring, slip on another spiral spring and screw on another nut.

Pivot the rear end of the flat spring to the rod that is fixed to the arm of the jig saw with a machine screw and a nut. Finally make a stake of a piece of steel that is $1\frac{1}{4}$ inches in diameter and $2\frac{1}{2}$ inches long and set the small end of this in a hole in a block of wood, and all of which is shown in *Fig. 11*.

The Router Attachments. In mechanics the word *router* means an assembly that has a rapidly revolving spindle and cutter which scoops out the surface of the wood or metal. The router which I shall describe was developed by the *Walker-Turner Co.*, of Jersey City, N. J.

It consists of three chief parts, which are (*1*) a motor, (*2*) a spindle and (*3*) a chuck, and all of which is shown in *Fig. 12*. The subsidiary parts are (*a*) an adjustment screw, (*b*) a feed wheel, (*c*) three pulleys and (*d*) a foot treadle. With this router attachment you can do not only routing but also shaping, carving, dovetailing, grooving and grinding.

The *motor* is a high speed, ball bearing one, it develops *18,000 R.P.M.*, has a rating of $\frac{1}{3}$ of an *H.P.*, and will run on either direct or alternating current. The *spindle*, which is connected with the motor shaft, is ball bearing and runs inside of a quill, while a *Jacob's threaded key chuck* completes the major assembly.

One of the pulleys is attached to the rear end of the jig saw arm, while the other two pulleys are secured to the edge of the table. A cable is strung over these

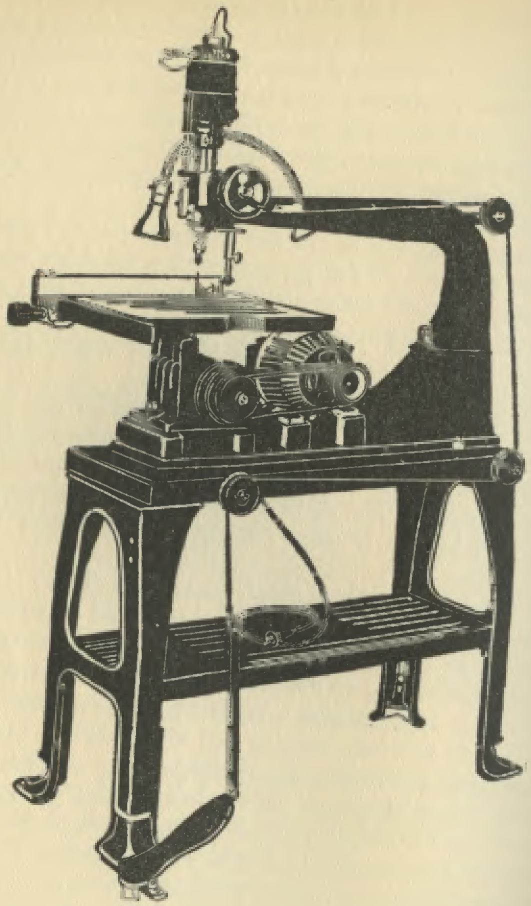


FIG. 12. THE ROUTER ATTACHMENT FOR THE JIG SAW

pulleys, and one end of it is connected with the router feed wheel while the other end is fixed to the foot treadle. This control arrangement enables you to raise and lower the quill and chuck, and so leaves your hands free to feed the work.

To attach the router assembly to the jig saw you have only to take out the long bolt that passes from the rear to the front of the arm, then lift off the jig saw head, put the router assembly in its place, and put the bolt back, when you have converted your jig saw into a new and versatile power tool.

About Router Operations. For routing out a piece of work, cutting grooves, shaping, carving, dovetailing and grinding, the router assembly is set in a vertical position. Various shaped cutters, or *burrs* as they are called, are used for the different operations, and in all of them the high speed of the router produces a perfectly smooth cut.

In *cutting grooves* the work is moved along the table just as though you were sawing a board, but to insure a straight-line groove the table of the jig saw must have a guide assembly fitted to it. For *dovetailing* joints a *dovetail jig* is used, and the work is fed into the router and moved from tooth to tooth of the jig comb.

When you are doing *spindle carving* you hold the work against the revolving burr and move it around according to the design you are carving. Finally to *carve with a flexible shaft* router a long flexible shaft it attached to the chuck of the router assembly and a carving burr is fitted into the chuck at the end of it (the shaft).[11] The work, be it wood, bone, celluloid or other plastic, is held on the table with one hand, and the burr is guided with your other hand.

[11] *See chapter VIII.*

Chapter III

THE POWER BAND SAW

THE term *band saw* is used to mean (*1*) a saw made in the form of an endless band or belt, that runs over a pair of aligned wheels, and (*2*) a power sawing machine in which this kind of a saw blade is used. The band saw is the big brother of the jig saw for it does practically the same kind of work as the latter but on a larger and heavier scale.

The Parts of a Band Saw. A band saw is formed of five chief parts and these are (*1*) a base, (*2*) a frame, (*3*) a table, (*4*) a pair of aligned wheels, (*5*) a band saw blade, (*6*) a spring tensioner, (*7*) a ripping fence or guide, and (*8*) a blade guide or support.

In some band saws the frame and base are cast in one piece, while in others the former is bolted to the latter. The table is pivoted to a pair of trunnions which are cast integral with the frame, so that it (the table) can be tilted. The wheels, which are of large diameter, are rubber covered, and run in either bronze or ball bearings.

The band saw blade is made of vanadium alloy steel which will twist but not break and is flexible enough to bend easily around the wheels. Finally the band saw blade is held in a straight vertical line where it passes through the table by a guide or support formed of roller or ball bearings.

The Ward 9-inch Band Saw. The smallest and cheapest band saw that I know of is the Ward *9*-inch one, which means that it will saw to the center of an *18*-inch circle. This little band saw has a heavy channel, gray iron frame that is cast in one piece and is

reinforced so that all springiness is eliminated and this keeps the wheels always in alignment. The frame has a one-piece safety guard hinged to it and this can be

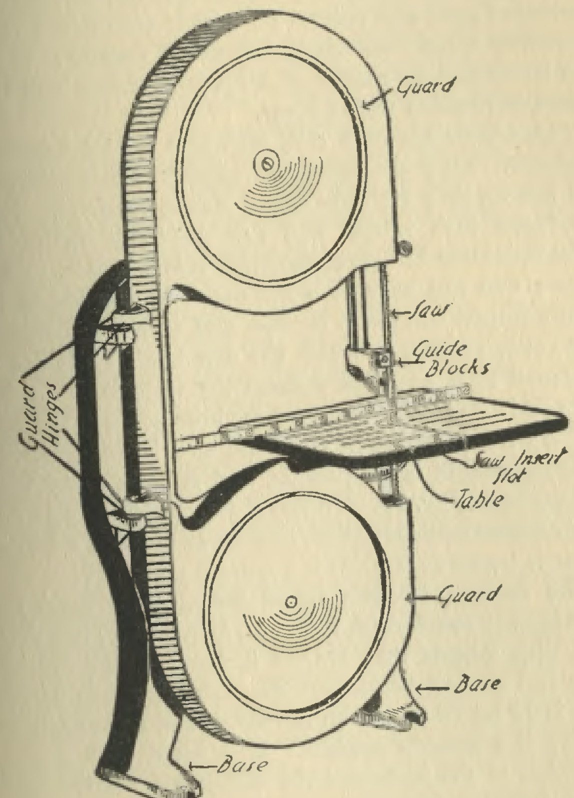


FIG. 13. THE WARD 9-INCH BAND SAW

swung back to allow the saw blade to be slipped on and off of the wheels.

The table, which is *9* by *9* inches on the sides, is a heavy reinforced casting and this is mounted on a rigid, double-way trunnion. In the center of the table is a small aluminum inset the purpose of which is to protect the blade should it by any chance get out of line. A graduated scale and pointer permits it (the table) to be accurately tilted through an arc of *45* degrees. It can also be leveled by means of a squaring screw and it is locked in position with a lever.

The wheels are of a disk type and are *9⅝* inches in diameter. They are accurately machined and balanced, and run on long self-lubricating sleeve bearings. They are faced with rubber and this not only makes for silent operation but gives the blade a longer life. Hand screws that are easy to work make it possible to instantly adjust the blade tension and wheel adjustment. The roller guides, in which the saw blade runs, are of hardened steel, and this reduces the friction to a minimum and also tends to prevent the breakage of the blade.

The overall height of the band saw is *26* inches, its shipping weight is *46* pounds, and it costs *$14.00*. It is pictured in *Fig. 13*. To run it you will need a ¼-*H.P.* motor where ordinary stock is to be sawed, but a ⅓-*H.P.* motor is better as it gives it a margin of power.

The Driver 10-inch Band Saw. This band saw has a heavily reinforced, rigid cast iron frame; it is fitted with disk wheels that are *10* inches in diameter and these run on ball bearings. The table is made of cast iron, is *10* by *10* inches on the sides, and it is machined to give it a smooth surface. It is fitted with a wood extension at the back and the distance from the blade to the frame is *10* inches.

The table tilts to an angle of *45* degrees and it moves easily and smoothly through this arc; the angle you want it to tilt to is had by means of a graduated quadrant and it is locked in position with a hand wheel. The upper guide assembly consists of a ball bearing, hardened steel disk in which the saw runs.

An aluminum disk is fitted in the center of the table to prevent saw breakage. The tension of the blade and the alignment of the top wheel to make the blade run straight in the center or *to track* as it is called, are controlled by a *tensioner* of the cushion type and this is fitted with precision. All of the adjustments that are necessary can be made without the use of tools.

The overall height of the saw is *26½* inches, and it has a shipping weight of *61* pounds, and costs *$19.00* without the motor, belt and motor pulley, but it includes a *72*-page book of instructions. It takes a ¼-*H.P.* motor to run it, or, better a ⅓-*H.P.* motor.

The Delta 10-inch Band Saw. The outstanding features of this band saw are that the frame is cast in two sections, the lower part of it being solid and the upper part of it hollow, and this prevents the frame from springing or the blade from twisting. The table, which is *10* by *10* inches on the sides, has an aluminum disk in the middle of it through which the saw passes, and this prevents any damage to the blade should it get out of line.

The table tilts through an arc *45* degrees and the exact angle you want to set it at is gauged by an accurately graduated segment, while an adjustable stop-screw returns it to a level position. The blade has a guard both in the front and rear and this increases the safety factor. It has electrically welded steel disk wheels and cementless rubber rims and this makes it an easy matter to renew the rubber facings when they wear out. The upper and the lower wheels run on ball bearings and these only need to be lubricated twice a year.

Both the upper and lower blade guides are fully adjustable and have square steel guide pins like those on the more expensive saws. The blade supports are ball bearing and double-ended so that either end can be used. The devices for adjusting the tension of the blade, for raising and lowering the upper blade support and guide for tilting and locking the table, and, finally, for setting the table square with the blade, are all of simple construction and yet function with exactness.

The distance between the blade guide and the table is a shade more than *6* inches so that a *6*-inch thick piece of wood can be readily cut with the saw. The softer metals can be easily sawed and the harder ones can be cut by reducing the speed of the blade. When you are cutting metals you must use a blade that is made especially for doing so. If you want to use a *router attachment* on the band saw you must have a Delta steel stand to mount them on and this will cost *$7.00* additional.

The overall dimensions of the band saw are as follows: height *29* inches, front to back $11\frac{1}{2}$ inches and width $17\frac{1}{2}$ inches. The shipping weight of it is *55* pounds, and it costs *$19.50* without the motor. The latter can be either of $\frac{1}{4}$ *H.P.*, or, better, of $\frac{1}{3}$ *H.P.*

The Driver 12-inch Band Saw. This is a nicely designed and sturdily built band saw and it has all of the necessary refinements to make it work smoothly and accurately. It has a tubular cast iron frame, *12*-inch disk wheels that are accurately balanced and rubber faced, and these are fitted with ball bearings.

The table is *12* by $12\frac{1}{2}$ inches on the sides with a wood extension back of it. It (the table) tilts to *45* degrees by means of a geared hand-wheel, and it is locked in position by another hand-wheel, which is shown *in Fig. 14*. For cutting straight lines a rip-fence or guide is absolutely necessary and this is made adjustable so that you can slide it anywhere along the table and screw it in place.

This band saw will not only cut light stock but it will hog its way through a *4*-inch thick butt and, it is, therefore, well adapted for building furniture and like heavy objects. It has an overall height of $33\frac{1}{2}$ inches, and a

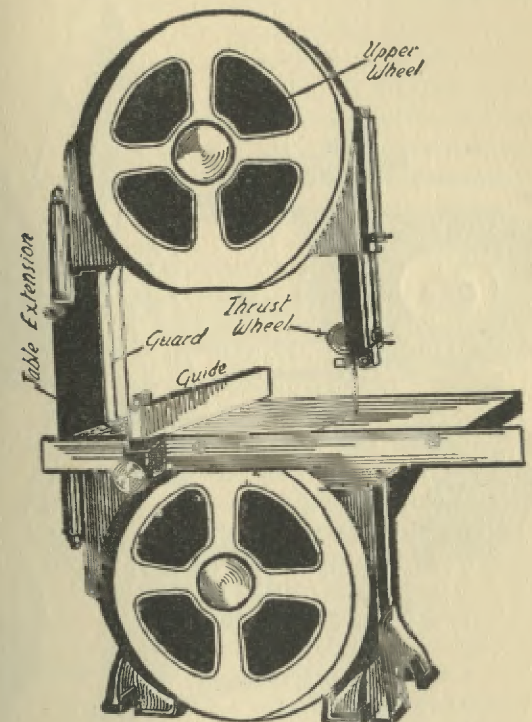


Fig. 14. The Driver 12-inch Band Saw

shipping weight of *103* pounds. It requires a $\frac{1}{3}$-*H.P.* motor to drive it, and this costs *$30.00*. This price does not include the pulley, belt or the motor.

The Delta 14-inch Band Saw. This band saw is the largest one that is built for the amateur woodworker.

FIG. 15. THE DELTA 14-INCH BAND SAW

It has a massive ribbed base and a hollow cast upper arm and this combination allows a *height attachment* to be inserted between them when you can cut materials up to *12¼* inches thick.

It consists of a 6-inch raising block accurately doweled to fit in between the base and the arm, a longer wood guard for the back of the blade, a longer bolt and an extension guard for the front of the saw blade. When the band saw is fitted with this attachment it can be used for a great variety of work such as cutting cork slabs for refrigerator linings and other insulating work, ripping wide sheets of balsa wood[1] and numerous other materials.

One of the good features of this band saw is the *blade tension gauge* which is used to indicate the proper tension that blades of various widths should have. The upper wheel adjustment with the quick reading index for the required blade tension is shown *in Fig. 15,* and this costs *$6.00* extra.

Ripping boards, which means to saw them with the grain, is an easy operation with this band saw, even with narrow blades, by virtue of the substantial support that the blade is given. Two rip gauges can be had, the only difference between them being that of capacity. The *fence,* which is an attachment to any woodworking machine to gauge the extent or location of a cut, has a micrometer[2] adjustment, or micro-set, as it is called, and this permits of very close cutting for accurate work.

A *steel stand* is made on which the band saw can be mounted, when it becomes a portable unit which can

[1] This is the wood of small trees which grow in Central America and the West Indies. It is lighter than cork and is sometimes called *corkwood.*

[2] A *micrometer* is a device that is used for making very small and accurate measurements. It is usually made to measure to .001 (1 thousandth) of an inch, but for very precise work to measure to the .0001 (10 thousandths) of an inch.

be taken to a job if it is more convenient than to take the job to it. Two different units are made and these are for (*1*) woodworking and (*2*) metal working. In the *woodworking unit* the band saw is driven by a belt direct from the motor, while in the *metal working unit* the band saw is belted to a countershaft that is driven by the motor.

The purpose of this latter arrangement is, of course, to reduce the speed of the blade and, it follows, to make it cut slower. This unit can be used to cut iron, soft steel, bronze, aluminum, transite, and various other hard and tough materials.

The band saw itself has an overall height of *50* inches, a shipping weight of *152* pounds, and costs *$14.00*. The steel stand costs *$7.00*, and the motor *$19.00* extra. The motor should be, preferably of the repulsion-induction type[3] and this can be run on a *110*- or *220*-volt, *60*-cycle current when it will develop a speed of *1725 R.P.M.*

About Band Saw Blades. *Kinds of Blades.* The best band saw blades are made of high-grade vanadium alloy steel and they are correctly tempered and properly set[4] for fast and smooth cutting in all kinds of wood. They are tough and strong and yet flexible enough to easily bend around the wheels.

Band saw blades range from $\frac{1}{8}$ to $\frac{3}{4}$ of an inch wide and have a cutting radius of from $\frac{1}{4}$ to $1\frac{3}{4}$ inches. For a *9*-inch saw the blade is about *60* inches around, and for wood cutting it has *6* teeth to the inch, and costs about *85* cents. For metal cutting the blade should have *19* teeth per inch, and one of this kind costs *$1.00*.

Most *10*-inch band saws take a blade that is *68* inches around, has *6* teeth to the inch, and costs *$1.00*, while the blade for nearly all *12*-inch band saws is *78* inches around, has either *6* or *8* teeth to the inch, and costs *$1.00* each. The blade required for most *14*-inch band saws is *93* inches around, has from *8* to *12* teeth to the inch, and for the $\frac{1}{8}$- to the $\frac{3}{8}$-inch wide blade, the cost is *$1.25* each, while the $\frac{1}{2}$- to $\frac{3}{4}$-inch blades cost *$1.50* each.

[3] You will find a detailed description of this motor in *Chapter XII.*

[4] New blades may have to be resharpened before you use them as you will presently see.

The blade that is used on the *Delta* height extension attachment is *72* inches around and costs from *$1.50* to *$1.75* each according to the width of it. Finally the hard-edge metal cutting blades for the *14*-inch band saw are $\frac{1}{2}$ inch wide and these have *14, 18* or *24* teeth to the inch, and cost *$1.75* each.

How to Sharpen a New Blade. The shape of the teeth of a band saw blade is pictured at *A in Fig. 16,* and you will observe that each tooth has a small undercut in the front edge of it. You will also note that this is a little different from that of the tooth of a rip saw, but in all other respects it is exactly like it.

Now when you buy a blade for your band saw it is supposed to be all ready to use, but if you will examine the teeth of it carefully you will find that they are smooth on one side and that there is a wire edge on the other side of them. This is due to the fact that the teeth are filed in a machine and this is performed in a single direction. This wire edge tends to make the blade move over slightly toward the side of it that is the sharpest. The way to prevent it from doing so is to file off the wire edge and so have both sides of the teeth equally sharp. To do this properly you should make a blade holder as shown at *B*.

This holder consists of a pair of disks each with a step in it, and you can either saw out the disks and turn them down, or saw out two pairs of disks, one pair of which is smaller than the other, and then glue and screw the smaller disks to the larger ones. Having the

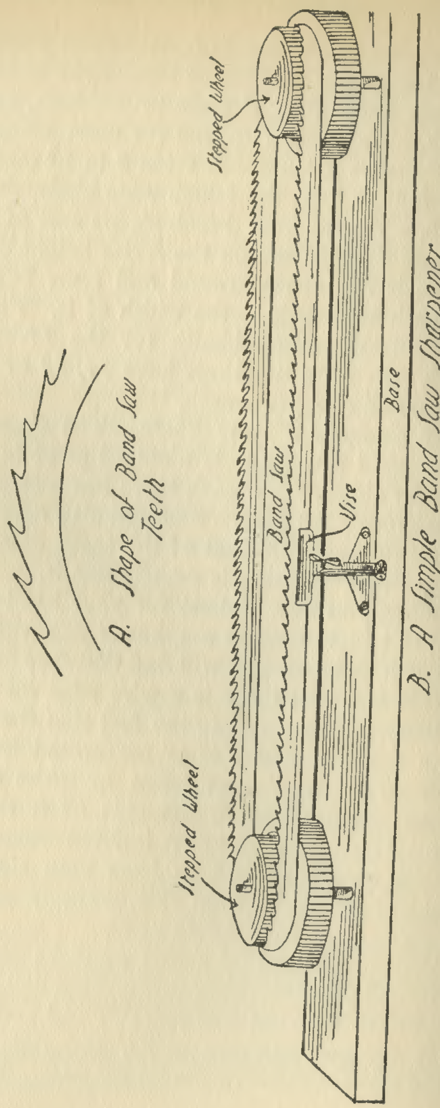


Fig. 16. How to Sharpen a Band Saw

disks, mount each one on a spindle and fix these to a wooden base. You can use a regular vise which clamps on to the base or, better, a saw vise[5] which can be screwed on to it. The complete filing outfit is shown at *B*. Now when you want to file a blade you slip it over the disks and between the jaws of the vise, and then screw it up so that the teeth project just above the upper edges of the jaws. When you put the saw on the disks you must be very careful that it does not twist to such an extent that strains are set up in it and so cause it to kink.

How to Sharpen an Old Blade. If you have used the blade until it is dull and you want to sharpen it, put it on the filing outfit as before, and then give every other tooth three or four strokes with a three-cornered file, and these, of course, must be away from you.

This done take the blade off of the disks and reverse it, that is turn it inside out and put it back on the disks; now start with one of the teeth you have not sharpened and give every other tooth three or four strokes with the file, when the blade will be properly sharpened. When it takes more than three or four strokes with the file to sharpen the tooth it is time to discard it and get a new blade.

After a blade has been sharpened a couple of times the teeth will probably have to be *reset*, that is you will have to bend the points of them alternately in opposite directions which will widen the kerfs, as the notches between the teeth are called and so prevent the saw from sticking when it is in cutting action. This you can do with a *saw set*[6] in exactly the same way that you set the teeth of a common hand saw.

[5] You can get a Sterns *No. 10* saw vise that has *10*-inch jaws for *$1.85* at any first-class hardware store or of Hammacher, Schlemmer and Co., *13th.* Street and Fourth Ave., New York.

[6] You can buy one in any hardware store that sells tools.

If you do not want to file and reset the blade yourself, and you have a mechanic do it for you, you will probably find that he will charge you almost, if not quite, as much as a new one costs, so there really is no percentage in having it done.

How to Run a Band Saw. *How to Adjust It.* As with the jig saw, the first thing to do when you are going to use the band saw is to adjust the tension of the blade, and, as in the case of the jig saw blade, there is no hard and fast rule for doing so. Generally speaking, however, the blade should be sufficiently taut to easily, quickly and smoothly cut the stock you are sawing.

The first step in the adjustment of the blade is to see that it *tracks*, that is to run exactly in the middle of both rims of the wheels, and the second step, that it does not come in contact with either the blade guide or the blade support. As a matter of fact the guides do not really guide the blade but the purpose of them is to keep the blade from turning as the stock is being fed against it. To adjust the guide pins set them in close to the sides of the blade, say with the clearance of $\frac{1}{16}$ of an inch between them, and then lock them there. This done adjust the bracket that holds the pins so that they are even with the base of the teeth of the blade.

The support for the blade which is in the rear of it is not, as many beginners in band-sawing seem to think, for the purpose of forcing it against the stock, but, instead, it serves as a backing for the blade to keep it from being forced off of the wheels when you start the work against it. Since this is the way of it you should set the support so that there will be a clearance of $\frac{1}{64}$ of an inch between the face of it and the rear edge of the blade as shown in *Fig. 17*.

The next and last adjustment is to set the table at exactly *90* degrees to the saw blade, that is at right angles to each other. Now while the index and pointer under

the table show when it (the table) is horizontal, to set it accurately you should place the tongue of a try square on the surface of the table and let the rear edge of the blade of it rest against the side of the saw blade, as pictured in *Fig. 18*. You can then see if they square up exactly, or how much they lack in doing so.

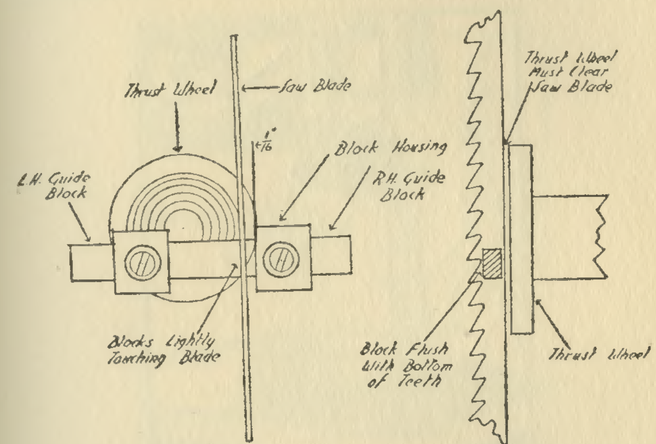


FIG. 17. HOW THE BLADE IS ADJUSTED

How to Saw with a Band Saw. When you have selected the right kind of a blade for the stock you are going to saw, put it in the band saw and made all of the other adjustments cited above, you are all set to go on with the work. Now while it is a very simple matter to saw a piece of wood with the band saw it is quite another thing to saw out a design so that it will follow the lines and make a workmanlike job of it. To do this with anything like professional skill you will need considerable practice.

The two chief things you must learn in order to use a band saw proficiently are (*1*) to saw on a *straight line* and (*2*) to saw on a *curved line*. *To saw a straight line* you must use one hand to guide the work and the other hand to feed the wood against the blade. A little more clearly, you rest your left hand on the table and let it serve as a guide for the wood and feed it along to the saw with your other hand.

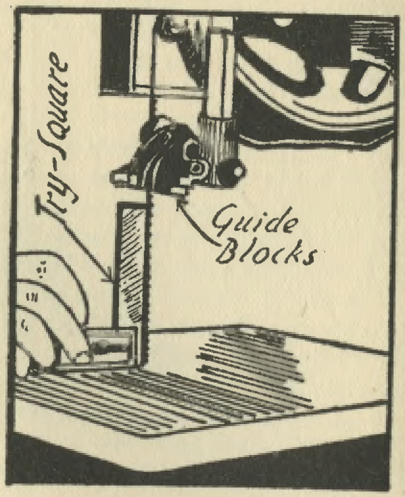


FIG. 18. HOW TO ALIGN THE BAND SAW

In feeding the wood against the saw do so evenly but with as little pressure as you can and still make it cut effectively. You will be able to do this by the *feel* of it with very little practice. If you exert more pressure than is needed you will find it harder to follow the line, and, what is worse, you may twist the blade and even break it.

Where you are ripping heavy stock, or where all of the cutting you do is straight line work you can use a *fence*, which makes it easy plus. For this kind of work you should use a blade $\frac{3}{8}$ of an inch wide, and for heavy

stock a blade $\frac{1}{2}$ of an inch wide gives the most satisfactory results. A wide blade makes it easier to follow a straight line.

To *saw a curved line* you must move the wood evenly and smoothly over the table and this will tend to keep the blade in a straight vertical line; unless you do so the

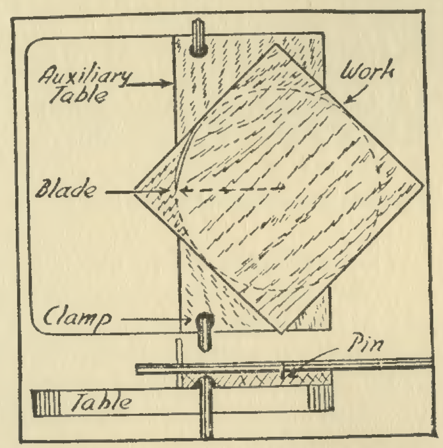


FIG. 19. HOW TO SAW OUT A DISK

blade is apt to run out of a vertical line and this may cause it to twist.

If you are sawing a small curve, that is one which is sharper than the blade will easily follow, then you must use either a narrower blade, or one whose teeth have a greater set. Generally speaking it is better to use a narrower blade for where you use one that has a greater set the edges of the cut will be coarser. When you are sawing curves and you want to make a new cut or change the blade, instead of backing the blade out of it, it is the better way to saw it out through a part of the wood that is not in the design.

It often happens that you will want to saw out the arc of a circle or the entire circle, such as a wooden disk, etc., with precision, and this you can do with the following device which you can easily make. Take a smooth board and drive a short, sharp pointed wire-nail through the middle of it. Lay the board on the table of the band saw with the nail in a line with the teeth of the blade, and then clamp the board to the table. This done press the stock you are going to saw down on the pin, as shown in *Fig. 19.* To saw the arc or cut out the circle all you have to do is simply move the stock against the blade when a true arc or circle will be produced.

Chapter IV

THE POWER CIRCULAR SAW

A *circular saw* is (*1*) a thin steel disk with teeth cut in its rim, and (*2*) a machine that has such a saw for the cutting element. What is commonly called a *bench saw* is a small circular saw that is bolted to the top of a bench or is mounted on a steel stand. The chief purpose of a circular saw is to (*a*) *rip* lumber, that is to saw it lengthwise with the grain, and to (*b*) *crosscut* it, that is to saw it across the grain. It can also be used to saw metals and many other materials, and to groove, rabbet and tenon stock.

The Parts of a Circular Saw. There are six chief parts to a circular saw and these are (*1*) the base, (*2*) the table, (*3*) the fence or guide, (*4*) the arbor, spindle or shaft, and this carries, (*5*) the pulley and circular saw, and (*6*) the adjusting devices. The last five named parts are mounted in or on the base. The table, which can be raised or lowered is pivoted on heavy trunnions, so that it can be tilted at any angle. The guide, or fence, as it is often called, can also be adjusted to any angle, and it is used to guide the work while you are feeding it to the saw. Finally, the shaft runs in either bronze or ball bearings.

The Ward 7-inch Circular Saw. This is the cheapest of the 7-inch circular saws, and it cuts to a depth of $2\frac{1}{4}$ inches. It rips, crosscuts, and miters, grooves, sands, and a few other things, and it does all of them with neatness and dispatch. It has a heavy cast iron base, and a table *10* by *14½* inches on the sides and this is machine ground.

The depth of the cut is regulated by a hand wheel and this raises and lowers the table instead of the saw which is the usual practice. The purpose of this construction is to allow the motor to be placed either behind or below the saw and it obviates the necessity of changing the tension of the belt every time you change the cutting depth of the saw. A locking device locks the table in position when you have adjusted it.

The table is mounted on trunnions so that you can tilt it to any angle between *0* and *45* degrees, and it has a positive locking action. It is fitted with a saw-guard that meets all of the requirements that the *Industrial Safety Code* calls for, in all of the states. It lifts up as you feed the stock to the saw and it can be easily swung out of the way if you care to do so.

The table has an accurately ground rip-fence, also a miter gauge with which you can do smooth cross-cutting, and a *splitter* back of the guard that prevents the saw from sticking. A straight rip or a crosscut saw, or a combination rip and a crosscut saw can be used; this is mounted on a hardened steel arbor, spindle or shaft, as it is variously called, and this runs in self-lubricating, bronze sleeve bearings.

This bench saw has a height of *8½* inches, weighs *29* pounds and costs *$10.00* without the electric motor. It can be run with a *⅓-H.P.* motor which costs *$10.00* extra, or, better, a *¼-H.P.* motor which sells for *$13.00.*

The Driver 7-inch Circular Saw. This little saw has a *7*-inch saw blade and it will cut stock that is *2¼* inches thick. It will do straight sawing, angle sawing, which means to cut the stock at an angle, *i.e.,* to bevel it; mitering, that is to saw stock so that the edges of it will match together, and *dadoing,* or the cutting of grooves in stock, and you will find a description in the way this is done as we push along.

This saw has a *10-* by *14-inch* machined cast iron

table, which is flat and not ribbed, and it can be tilted at an angle of *45* degrees. It is fitted with a heavy machined steel ripping fence, a *removable throat* for dadoing, and a splitter that spreads the saw kerf[1] slightly, which makes it easier to saw green or damp lumber; and, finally, a standard safety guard equipment which reduces to a minimum the danger of saw breakage.

The *arbor* or shaft on which the saw is mounted, is ½ inch in diameter and this runs in oilless, bronze sleeve bearings. It can be raised or lowered as the work you are doing requires. An *idler pulley*[2] is necessary when the belt that runs from the motor, or a countershaft, to the pulley of the saw is used to keep it (the belt) taut as the saw arbor moves up and down, and so varies the tension of it.

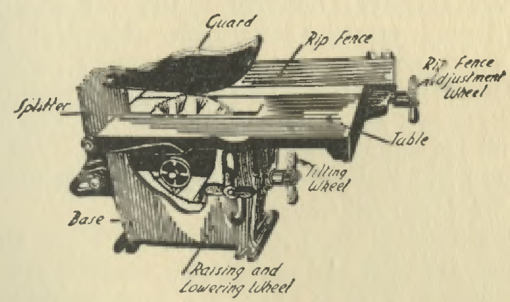


Fig. 20. The Driver 7-inch Circular Saw

If the source of power is fixed, then the idler pulley should be secured to the slot in the base, as shown in *Fig. 20,* when the belt is then run from the idler to the

[1] The word *kerf* in woodworking means the slit made in a board or other stock, by cutting it, as with a saw.

[2] *An idler wheel pulley* is also one that is placed between two others to transfer motion from one to the other without changing the direction of revolution or the velocity ratio.

source of power. However if the saw is driven by its own motor and the latter is mounted on a floating motor base you will not need an idler, and a single belt from the motor to the saw arbor will drive it in a satisfactory manner.

If you are only going to saw thin work a ¼-*H.P.* motor will develop enough power, but for work in general you should have a ⅓-*H.P.* motor, when it will cut easier, cleaner and faster. Where an idler drive is used you will need a *3*-inch pulley, and for a direct motor drive you must use a *4*-inch pulley, and either of these will cost *40* cents extra. The shipping weight of the bench saw is *35* pounds and the price of it is *$10.50* less the idler unit which costs *$1.00* extra.

The Ward 8-inch Bench Saw. There are numerous good features embodied in this saw and chief among them is an extra large table, which is *16* by *20* inches on the sides, and you can increase its width by using an extension table which is *13* by *13* inches on the sides; it can be easily attached to the fixed table by means of a slide-bar and a couple of machine bolts. The fixed table has a full *9*-inch reach ahead of the saw, and this makes for faster and better work.

As in the *7*-inch Ward machine, which I have already described, the table and not the saw is raised and lowered when you want to adjust the depth of the cut of the latter, and this you do by means of a ball crank which operates gears and these in turn work a pair of racks that are mounted on the posts.

The rip fence, which is made of a solid iron bar, has a micro-set friction adjustment. The scale of it is graduated in eighths of an inch and it (the fence) is firmly locked in position by a turn of the locking handle; this keeps it absolutely parallel to the saw blade and, it follows, the work will always be in true alignment.

An accurate *miter gauge,*[3] see *Fig. 21,* is used for cutting angles and true squares, and it is also a useful device for cutting all kinds of panels, screen frames and trim, for it fits them together to a nicety. It is mounted on a large ¾- by $\frac{5}{16}$-inch steel slide that fits accurately in either one of the grooves in the top of the table. To use it, all you have to do is to swing it to the angle you want to cut the stock at, and this is done by a finely graduated arc, which is easily read, and then tighten it up with the lock screw.

The arbor on which the saw is mounted is ⅝ of an inch in diameter, and it runs on heavy ball bearings that are automatically greased for all time. The saw is fitted with an approved guard that covers it, and yet it can be swung out of the way if you find it necessary to do so.

There is a removable insert in the top of the table so that dado heads, sanding disks, etc., can be used instead of the saw blade. A splitter is attached to the guard to prevent the saw blade from bending. Finally, there is a *chute* that delivers the sawdust to the rear of the machine, and you can either fasten a bag to it, or fix a pipe to the opening of it to carry it down to a bin.

The machine is *9* inches high to the top of the table when this is in its lowest position. It weighs *84* pounds when it is ready for use, and it costs *$30.00*. It is pictured in *Fig. 21*. For ordinary amateur shop practice you should drive it with a ⅓-*H.P.* motor, but for constant production work you should have a ½-*H.P., 110*-volt, *60*-cycle repulsion induction motor.

The Driver 8-inch Circular Saw. Several unique features enter into the design of this saw and all of them have to do with higher speed, greater accuracy and safety of performance. The normal size of the table

[3] No extra charge is made for the miter gauge, and although it is an accessory it goes with the machine.

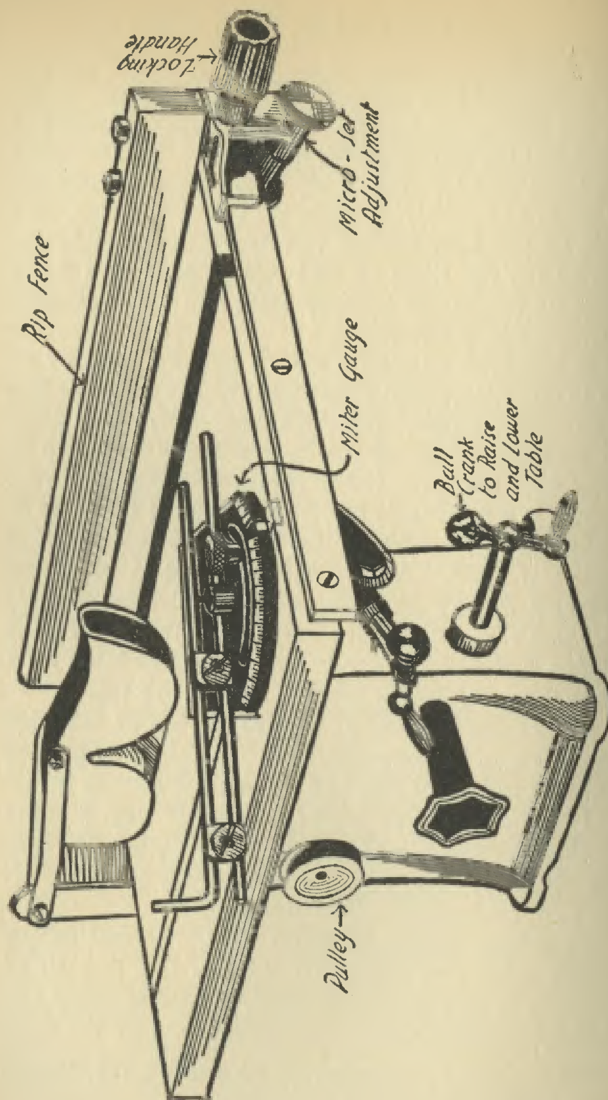


Fig. 21. The Ward 8-inch Heavy Duty Circular Saw

top is *13* by *16* inches on the sides and by using extensions it can be increased to *16* by *25* inches. The extension which is pictured at *A in Fig. 22* is fixed to the front of the table and either wood strips or rollers can be fitted in between the extension rods, and this makes

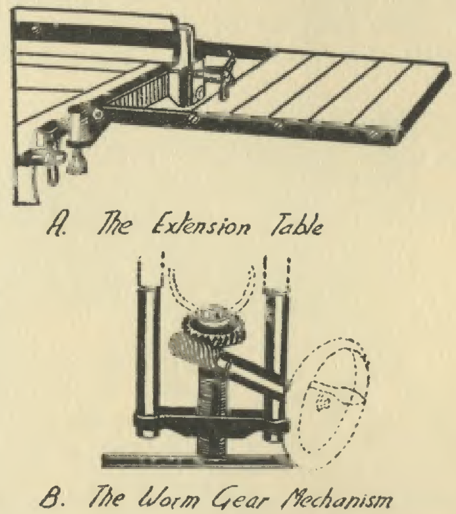


Fig. 22. Details of the Driver 8-inch Circular Saw

it easy to rip long pieces of stock. The table tilts at an angle of *45* degrees and it has a removable insert in it for dadoing, sandpapering, etc.

The arbor or spindle on which the saw is mounted is $\frac{5}{8}$ of an inch in diameter, runs on ball bearings, and is raised and lowered by means of a worm gear, as shown at *B*, and which is an outstanding feature of this saw. These gears are entirely enclosed in a dust proof housing, and a hand screw locks them at any point you wish. A gauge and pointer indicate the distance that the saw blade is above the top of the table, and the former can be lowered below the surface of the latter if, for any reason, you find it desirable to do so.

The *ripping guide* or fence consists of a rigid casting and this is faced with laminated wood that slides on a heavy steel bar which is graduated in fractions of an inch, and the adjustment is had by means of a micrometer. The accuracy of the construction of the various parts of it enables you to obtain very close set-

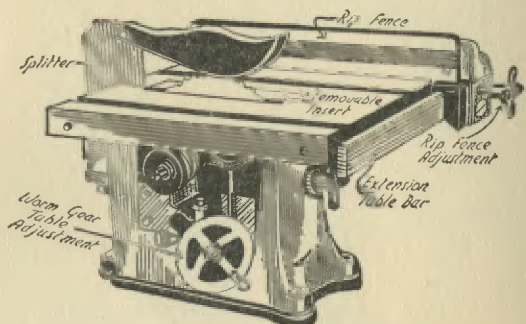


FIG. 23. THE DRIVER 8-INCH CIRCULAR SAW

tings. The machine has a sawdust chute and this makes for cleanliness and better work.

The shipping weight of the saw is *85* pounds, and without the extension tables it costs *$24.00*, while with them it sells for *$30.00*. It is shown in *Fig. 23*. You can use a $\frac{1}{3}$-*H.P.* motor that makes *1750 R.P.M.*, for sawing light stock, but you must have a $\frac{1}{2}$-*H.P.* motor that develops *3450 R.P.M.*, for doing heavy work. The various accessories that go with this machine will be described presently.

The Delta 8-inch Circular Saw. There are several unique and patented constructional features in this saw, and chief among them is (*1*) the design of the table trunnions, (*2*) the large spread in front of the saw

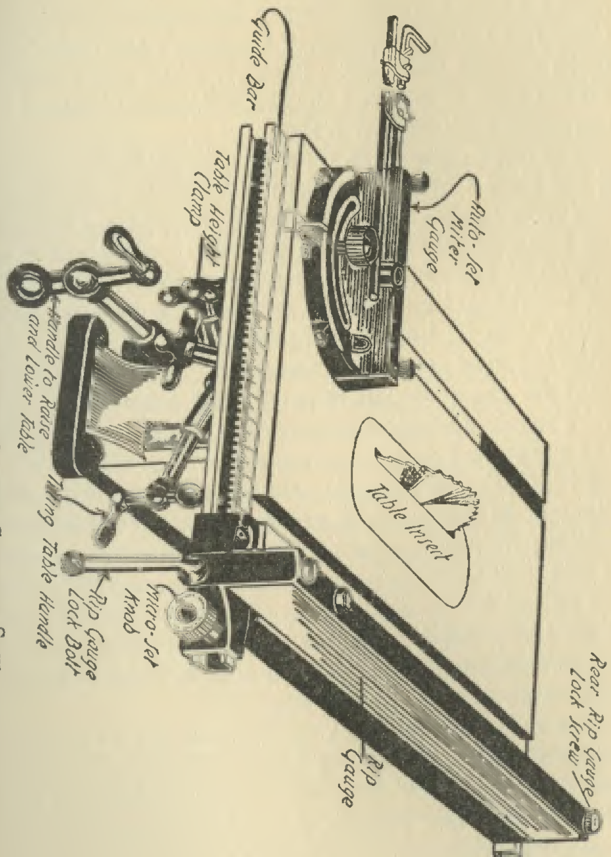


FIG. 24. THE DELTA 8-INCH CIRCULAR SAW

blade, (*3*) the rip gauge extension, (*4*) the auto-set miter gauge and (*5*) the miter gauge clamp attachment.

The *table trunnion construction* is designed so that it allows a very narrow table slot for the saw blade to be used, and it is not necessary to remove the table insert when you tilt the table. Further, when you raise and tilt the table it does not throw the rip guard out of the alignment with the saw blade.

The *large capacity in front of the saw blade,* and this is the place where it is most needed when you are cutting wide boards, together with the *rip gauge extension,* are two notable features of this saw. The latter gives you all of the advantages of a *4*-foot table and without the weight and expense of it, while the *auto-set miter gauge,* with its heavy construction and automatic stop, make it a most convenient accessory. The *clamp attachment for the miter gauge* is of great value where your work requires absolute accuracy, as it prevents the stock you are cutting from creeping away from the blade.

Finally, the rip gauge has the advantage of being self-aligning, having a finely graduated arc and adjustable pointer; its micrometer adjustment can be disengaged at will, and with its fine teeth a very close adjustment can be had for accurate work. The saw cuts stock that is *2¼* inches thick with the greatest of ease, and you can do any other kind of work with it which it is possible to do with a circular saw.

The overall dimensions of this saw are as follows: height *11* inches, width *18¼* inches and length, i.e., from the front to the back *23* inches. It has a shipping weight of *91* pounds and with an *8*-inch blade, auto-set miter gauge, rip gauge and arbor pulley, as shown in *Fig. 25,* its cost is *$33.00,* or you can get a *circular saw unit* in which the saw is mounted on an individual steel stand for *$40.35.*

The Driver 10-inch Bench Saw. This is the largest of the amateur circular saws, and with a *10*-inch saw blade in its top position it will cut stock up to *3* inches thick. The base is a heavy casting and it is enclosed to prevent the sawdust from being strewn about, while a smaller casting encloses the moving parts to keep out the dust, and this is attached to the main base.

The table is made of close-grained gray cast iron, heavily ribbed underneath to prevent warping and the top of it is carefully ground. Its normal width is *15* inches and when the extension is added, it is *31* inches, while its length is *21* inches. It tilts by a worm controlled gear which I have previously described under the caption of the *Driver 8-inch Circular Saw.*

A special feature is the *nested table insert,* and this consists of a small screw insert, a medium sized dadoing insert and a larger sized sandpapering insert. These nest together and each one can be removed singly as a unit. A splitter is attached to the back of the table and to this a standard safety saw guard is pivoted. The latter will keep the same relative position regardless of the angle or tilt of the table. The guard gives full protection when an abrasive cut-off wheel is used.

The arbor or shaft that carries the saw blade is ¾ of an inch in diameter at the bearings, and ⅝ of an inch where the saw blade and the pulley are mounted on it, and it runs on ball bearings. These moving parts are packed with enough lubricant so that they will run for a long time without any attention whatever, and they are mounted in dust-proof housings so that when metal, ceramics and other hard materials are cut they cannot be damaged by the abrasive grit that is produced.

A cut-steel worm controlled gear raises and lowers the arbor and this is operated by a hand-wheel, while the height of the saw above the table is shown by a pointer which you can easily see. The ripping fence has a face formed of laminated hard wood, and this not only gives additional rigidity to it but should the blade happen to be brought in contact with it, it would not be injured. The fence slides along the table on a heavy steel support bar, the top of which is graduated in fractions of an inch.

In setting the fence you move it to the approximate position you want to cut the stock to and then make the final adjustment with a micrometer screw. By the use

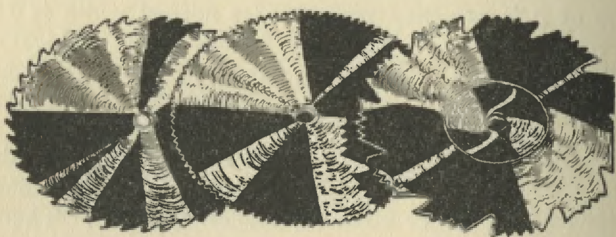


FIG. 25. KINDS OF CIRCULAR SAWS

of it you can cut strips of wood that are almost as thin as paper.

The height of the saw from the bottom to the top of the table is *20* inches, its shipping weight is *215* pounds, and it costs *$29.50*. If you use a *7*-inch saw blade, a $\frac{1}{3}$-*H.P.* motor will develop enough power to run it; an *8*-inch blade will need a $\frac{1}{2}$-*H.P.* motor, and a *10*-inch blade a $\frac{3}{4}$-*H.P.* motor.

About Circular Saw Blades. *Kinds of Saw Blades.* There are three general types of circular saw blades, and these are saws for cutting (*1*) wood, (*2*) grooving wood, or *dado heads* as they are called, and (*3*) metal. Saws for *cutting wood* are of three kinds, namely, (*a*) rip-saws, (*b*) cross-cut saws, and (*c*) com-

bination rip- and cross-cut saws, and these are shown at *A, B,* and *C* in *Fig. 25.*

You will observe that the teeth of the *rip-saw* are cut deep, and that they are spaced comparatively far apart and they are not set; the teeth of the *cross-cut saw* are not cut so deep, and they are spaced more closely together, while the *combination saw* has from *3* to *5* teeth in each segment. Their construction is such that they are especially adapted for cutting hard wood where a clean, smooth cut is required, and they will cut equally as smooth for cross-cutting as for ripping.

FIG. 26. DADO HEADS AND CUTTERS

Where you want the saw mostly for ripping one with *3* teeth to the segment is the best, and where you want it mostly for cross-cutting then one that has *5* teeth to the segment should be used. The reason, of course, that a combination saw is used instead of separate rip- and cross-cut saws is to save the price of one saw.

Grooving Saws or Dado Heads. With these saws, or *dado head cutters* as they are called, you can cut a groove, rabbet or tenon in wood from $\frac{1}{8}$ of an inch wide up to *4* inches wide and over. The dado head consists of a pair of outside saws or cutters, as shown at *A* and *B* in *Fig. 26*, and each of which is a groover in itself, and as many inside saws or cutters as may be needed to cut the groove to the width you want.

The outside cutters are $\frac{1}{8}$ of an inch thick and the inside cutters or *chippers*, are $\frac{1}{16}$, $\frac{1}{8}$ and $\frac{1}{4}$ of an inch thick respectively, and with these you can cut a groove of any width measurable in $\frac{1}{16}$ of an inch with the exception of one that is $\frac{3}{16}$ of an inch. The saws will cut a perfect groove, *i.e.,* one without a rough edge, either

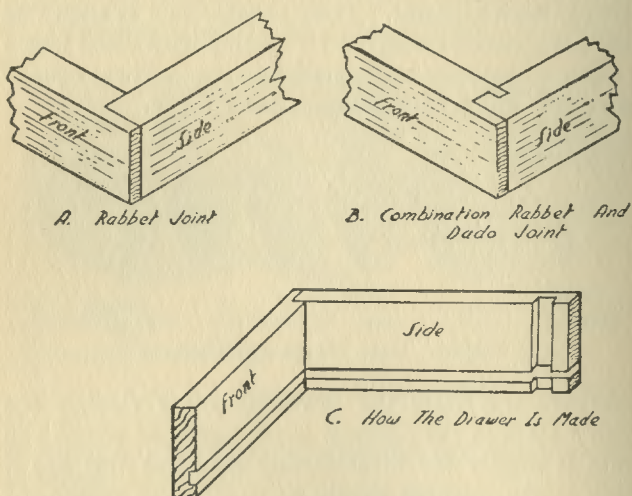


FIG. 27. SOME OF THE GROOVES THAT CAN BE CUT WITH THE CUTTERS

with or across the grain. The outside cutters can be used singly, or together with as many inside cutters as may be needed to cut the width of the groove you want. The various kinds of grooves that you can cut with these saws are shown in *Fig. 27.*

Various sets of these saws are put up by the different makers. Thus the set that goes with the *Driver* saws consist of two $\frac{1}{8}$-inch outside cutters, a $\frac{1}{16}$-, a $\frac{1}{8}$-, and a $\frac{1}{4}$-inch inside chipper, and these cost *$7.50,* while the

set for the *Delta* saws include two $\frac{1}{8}$-inch outside cutters, one $\frac{1}{16}$-, two $\frac{1}{8}$- and one $\frac{1}{4}$-inch inside cutters and these cost *$9.00.*

Circular Saws and Abrasive Wheels for Cutting Metals, Etc. Metal cutting saws are made of alloy steel and can be had in sizes ranging from *2½* to *10* inches in diameter. *Abrasive cutting wheels* are made of carborundum, and other hard electric furnace products, that are bonded together with synthetic resins into disks and wheels of various sizes.

They are very useful for the fast and free cutting of different kinds of metals, including cast and wrought iron and soft steels, and also for cutting hard rubber, porcelain, slate, tile, vitrified brick, and numerous other kinds of materials that cannot be cut with a saw.

About Sharpening Circular Saws. Circular saws are properly tempered and sharpened all ready for use when you buy them. But when the saw gets dull, as it will in due time, you will know it because it makes a rough cut and drags on the machine and motor. When this is the case it is your cue to sharpen it, and the first thing to do is to make all of the teeth of the same height, or *joint it* as it is called.

The way to do this is to hold a carborundum, or other like abrasive stone, in a line with and against the teeth as shown at *A* in *Fig 28,* and then turn the saw *by hand* slowly *backward.* When you have jointed the teeth take the saw off of the arbor and place it between a pair of boards with rounded tops and clamp it in a carpenter's vise as pictured at *B.*

This done make a pencil mark on top of the rear board at right angles to the face of the saw, *i.e.,* at *90* degrees, to it, and then make two more marks at *45* degrees across it. These marks will serve as a guide when you are filing the teeth. If jointing the saw has left it *flat* and a lot of filing has to be done to get rid of it then the teeth will have to be set and this must be done before you file it.

To *sharpen a rip saw* you must file all of the teeth at right angles to the face of the saw, that is straight across it, and file the upper edge of each tooth so that it will have an angle of *2* degrees, and the bevel of each alternate tooth will be on the opposite side of the one preced-

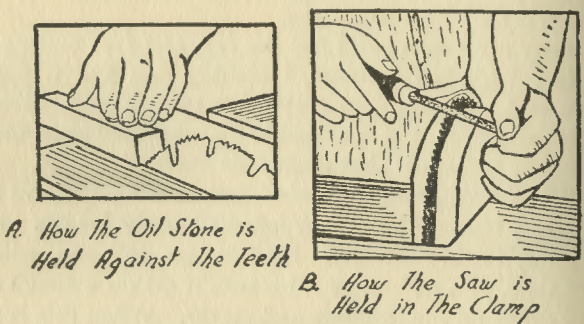


FIG. 28. HOW TO SHARPEN CIRCULAR SAWS

ing it. A rip saw sharpened this way will make it cut cleaner and faster.

To *sharpen a cross-cut* saw you file all of the teeth at an angle of *45* degrees to the face of the saw but the bevel of each alternate tooth must be opposite to the one that precedes it. To do this file every other tooth following one of the *45*-degree pencil lines, then take the saw out of the clamp, turn it around and put it back in the clamp. Now file every other tooth following the other degree line.

It usually takes about three strokes of the file to each tooth to sharpen it, but if it is very dull it may require a couple of more. Instead of giving each tooth five consecutive strokes, give it three the first time and then

when you have gone round the saw give it two the second time.

How to Run a Circular Saw. *Ripping Stock.* The first thing to do when you want to rip a board is to set the *fence* or *ripping guide* as far from the saw blade as you want the piece to be wide or thick, and this is done by sliding the fence along the graduated steel-bar to the approximate position you want it, and then to adjust it accurately with the micrometer screw.

It is important that the saw should be at the proper

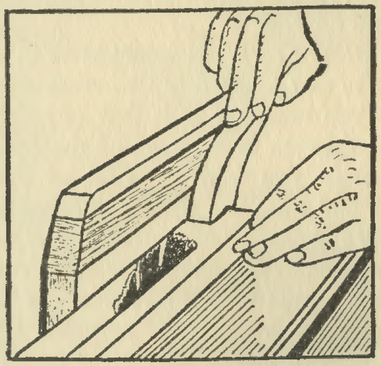


FIG. 29. HOW TO USE THE PUSHER STICK

relative height above the top of the table to the thickness of the stock you are cutting. It is easy to gauge it for all you have to do is move the saw blade, or the table, depending on the make of the machine you have, up or down, until two or three of the teeth of the saw blade that are uppermost project above the upper surface of the stock you are sawing. If this is not done the sawdust will stick between the teeth, the friction of it will cause the blade to heat, and this in turn will make it bind.

Where the stock is to be ripped to widths less than *3* inches you will have to throw the saw guard back, and to push the stock against the saw you must use a *pusher stick* to force it along between the fence and the saw blade, see *Fig. 29,* and even then you MUST BE CAREFUL.

Another thing about sawing narrow pieces of wood when the guard is thrown back, and that is to have the teeth of the saw project above the stock as little as is consistent with its cutting qualities, for the higher the teeth are above the stock the more they throw the sawdust up and on you.

Cross-cutting Stock. It would seem to be a very simple matter to saw a board in two crosswise, but to do it accurately you must see to it that (*1*) the table sets at exactly *90* degrees to the side of the saw blade, or at whatever angle you want the edge of the board to be beveled at, and then (*2*) the miter gauge is adjusted to cut the board at exactly *90* degrees to the side of the saw blade, or at whatever angle you want to cut it across.

The miter gauge that comes with the bench circular saw is usually about *7* inches long and, it follows, it is not at all easy to hold a long piece of stock against it and the saw and get anything that looks like exact results. The way to do so easily is to get a wooden board that is *1* inch thick, *2* inches high and *16* or *18* inches long; see to it that it is perfectly straight and if possible get a laminated board, that is one made up of three or more thin pieces of wood glued together to keep it from warping, and bolt it to the gauge.

When you are cross-cutting or mitering a board hold it firmly against the miter gauge with your right hand and with your left hand on the board, as shown in *Fig. 30.* Then push the board against the saw with

a firm even movement. While the different kinds of work you do on a circular saw naturally take some skill, still you will not have the slightest difficulty in doing good work with very little practice once that you have the machine.

Cutting Grooves or Dados, Rabbets and Tenons. To cut grooves or dados, rabbets and tenons the grooving saws or dado head cutters are mounted on the arbor or spindle instead of the usual saw blade. The inserts

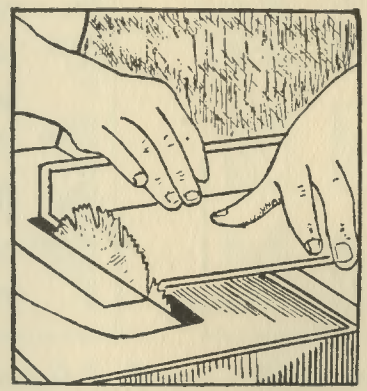


FIG. 30. HOW TO CROSS-CUT WITH A MITER GAUGE

in the table top are taken out in order to give a wider space for the cutters and chippers.

When you want to cut a groove $\frac{1}{8}$ of an inch wide you use a single cutter; to cut a groove a $\frac{1}{4}$ of an inch wide you use both of the cutters. To cut a still wider groove you put one or more of the chipper blades in between the two outside cutter blades. Do not try to use the chippers unless you have the cutters outside of them.

How to Cut Mouldings. You can make hundreds of different shaped mouldings, a few of which are shown at *A* in *Fig. 31*, with the *Delta patent moulding cutter.*[4] Different from the ordinary cope heads or costly solid

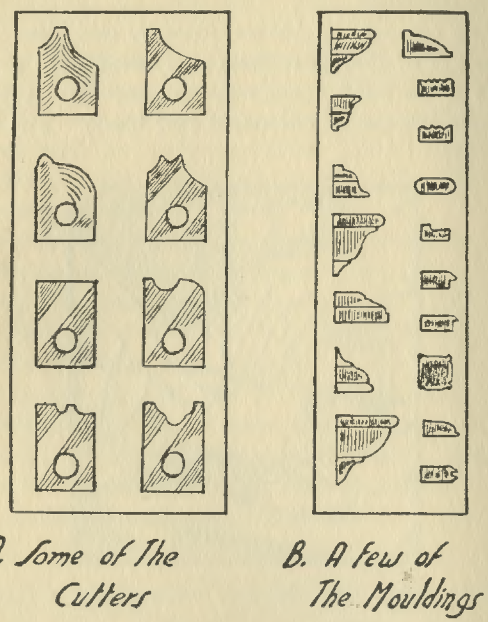


FIG. 31. MOULDING CUTTERS AND THE WORK THEY DO

cutters this moulding cutter consists of a special head in which a set of three high-speed steel knives is locked by a simple positive action. A few of the different shaped cutting blades are shown at *B*. You can use this head on the arbor of the Delta 8-inch circular saw and on nearly any other make of saw that is fitted with a double-faced fence.

[4] This is made by the *Delta Mfg. Co.,* 600 East Vienna Ave., Milwaukee, Wis.

When strips of wood are moved along against the revolving blades of the cutter head, which run at a speed of *3400 R.P.M.*, they will make *10,000* cuts per minute and this gives so smooth a moulding that it takes very little finishing before it is stained and varnished.

Chapter V

THE POWER TURNING LATHE

AND now we come to the highly fascinating craft of *wood turning*, as the shaping of a rapidly spinning stick of wood in a turning lathe is called. While the lathe is not the most essential of the power woodworking tools it is the one that will, probably, give you the greatest pleasure, for the rounding up of a piece of wood into a symmetrical shape is a delight that you will not forget no, not if you were to live a thousand years.

The Parts of a Lathe. The wood turning lathe is built up of four chief parts and these are (*1*) the bed, (*2*) the headstock, (*3*) the tailstock and (*4*) the tool rest. The *bed* is the base on which the other parts are mounted. The *headstock*, which is rigidly fixed to one end of the bed, consists of a frame and this supports the *spindle* which runs in *bearings*. The spindle carries a cone pulley and the inside end of it has a *face plate* or a *spur center* screwed on it and this holds one end of the stick that is to be turned.

The *tailstock* can be moved along the bed and clamped to it at any point; it has two adjustments, and these are (*a*) a rough adjustment and (*b*) a fine adjustment, the first of which allows it to be moved forth and back on the bed, and the second is a spindle which is threaded on one end and has a sharp point on the inner end to hold the other end of the stick that is to be turned. Finally, the lathe is bolted to a bench or, better, to a stand made for the purpose.

The Driver Lathes. *The Driver 6-inch Lathe.* This is the smallest and cheapest power lathe on the market that I know of. It has a *6-inch swing*, which

means that you can turn a piece of wood that has a diameter of *12* inches, and it is *24* inches *between centers*, which means that you can turn a piece of wood that is *24* inches long, and you can turn a longer piece by adding another section to the lathe bed. It is shown in *Fig. 32*, and the price of it is *$4.50*. The accessories, such as the *cup center* for turning small pieces, face plates, adapter for drill chuck and adapter for a sanding drum are extra.

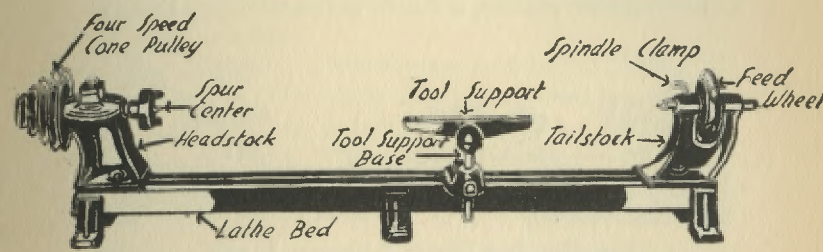


FIG. 32. THE DRIVER 6-INCH LATHE

The Driver 8-10-inch Lathe. I can't go into all of the minute details of this and the lathes which follow, suffice it to say that this one has a heavy cast-iron base that is $3\frac{1}{2}$ inches high, and it is *44* inches long. The normal swing of it is *8* inches, while the swing at the gap of the bed is *10* inches. The headstock is enclosed on the side where you stand to do the turning.

The spindle is hollow and when this is used with an independent or universal chuck,[1] dowels and other long rods of small diameter can be turned up rapidly as you do not have to lose time in changing the work. A *Morse taper* is a tapering spindle on which a buffing wheel, a sanding drum, or a grinding wheel can be mounted, and

[1] In an independent chuck the jaws move independently, while in a universal chuck they move simultaneously.

any one of which can be pushed into the end of the spindle, instead of the spur center, in a moment.

The pulley on the spindle can be locked in any position so that *fluting* can be done, while the tailstock has a *set-over* for turning tapers. A *6*-inch tool rest goes with the lathe, and an *18*-inch one can be had as an accessory. There are numerous other accessories that can be bought and chief among these are a separate *14*-inch extension bed, and with it you can turn work of extra length. Then there are face plates with spurs and changeable centers, a *3*-inch universal chuck that is

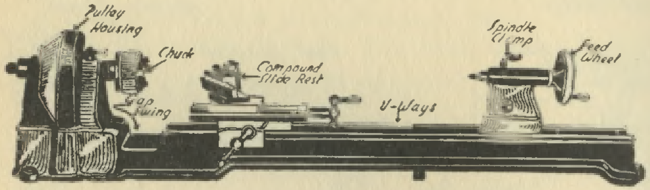


Fig. 33. The Driver 8-10-inch Lathe
(With Slide Rest for Metal Working)

self-centering and holds round and hexagonal work. It has two sets of jaws for inside and outside chucking, as shown in *Fig. 33*, and it sells for *$12.75*.

This lathe is heavy enough and made accurate enough so that you can use a *compound slide rest*[2] when it becomes a metal working lathe. With it you can turn metals, do light copper and pewter spinning, make coil springs, and coils for electrical purposes, etc. In metal turning it is often necessary to reverse the direction of the rotating spindle and this is done by installing a *motor reversing switch*. The price of the lathe is *$16.50*,

[2] This device is called a *compound slide rest* because it combines two simple motions, and so produces a compound motion. It is formed of a compound rest feed screw and a cross feed screw in the saddle.

and with the slide rest, it is *$38.75*. The shipping weight of it is *65* pounds and it takes a ¼-, or better, a ⅓-*H.P.* motor to run it.

The Driver 10-13½-inch Lathe. In all essential respects this lathe is like the one I have just described, except that it is larger, heavier built and, it follows, costs a little more. The bed, which is of gray cast iron, is *4¾* inches high, while the overall height of the lathe is *12⅜* inches; it is *54* inches long, and this can be lengthened by means of an *18*-inch extension bed, which is so designed that two or three sections can be placed together in a line.

The spindle is a hollow one and has an inside diameter of ⅝ of an inch and an outside diameter of *1* inch and this runs in *ball bearings*. It has four speeds, namely, *700, 1300, 2300* and *4200 R.P.M.*, and it takes a ⅓-*H.P.* motor running at *1750 R.P.M.*, to drive it.

It has a shipping weight of *130* pounds, and costs *$30.00*. The accessories include a compound slide rest for metal turning; all of the sliding surfaces of it are precision fitted, so that a smooth, positive action in all positions is assured. It costs *$14.00* extra and the toolholder with a high-speed steel cutting bit costs *$1.60* extra.

The Driver 10-inch Heavy Duty Lathe. This is an ideal wood turning, metal turning and metal spinning lathe. The bed, which is of gray cast iron and is carefully ground, is *54* inches long. It has a swing of *10* inches and the distance between centers is *37* inches. It has all of the features of the foregoing lathe and uses the same accessories including Morse taper spindles and arbors for holding tools for turning, drilling, buffing, sanding and grinding.

The Ward Lathes. *The Ward 10-inch Light Duty Lathe.* This inexpensive little lathe is large enough for nine out of ten amateur woodworking shops. It has an *8*-inch swing and is *27* inches between centers, and this can be lengthened to *39* inches by the use of a bed extension, which costs *$1.00* more.

The spindle runs in two large sleeve bearings and against a thrust bearing, which latter measurably reduces the power required to run it, makes for smooth, chatter-proof operation and eliminates wear. It has a *4*-speed pulley, a *6*-inch adjustable tool rest and holder, spur and cup centers, and all of these are included in the price of the lathe which is *$5.00*. A $\frac{1}{4}$-H.P. motor will run it, but a $\frac{1}{3}$-*H.P.* motor will enable you to do faster and heavier work.

The Ward Medium Duty 10-inch Lathe. This lathe is sturdily built and will take care of all work up to the limits of its capacity. It has a *10*-inch swing and is *30* inches between centers. A feature of the lathe is that the bed has one *V-way* and one *flat way* instead of the two flat ways that are usually found in the cheaper amateur lathes.

The V- and flat ways are accurately machined so that a compound slide rest can be used on it for cutting metals. The headstock has a hollow $\frac{3}{4}$-inch spindle and this runs on large self-lubricating sleeve bearings, with a thrust ball bearing at the end to reduce friction. The spindle has a $\frac{3}{8}$-inch hole in it and projects at the outer end so that outboard turning can be done. It is fitted with a *No. 1* Morse taper, and various other attachments can be used with it.

The lathe has a height of *10½* inches, an overall length of *47* inches, weighs *42* pounds and costs *$13.00*, which price includes spur and cup centers, a tool rest holder and a *12*-inch tool rest. A $\frac{1}{3}$-*H.P.* motor is needed to drive it with.

The Ward 13-inch Heavy Duty Lathe. This is a big, powerful commercial type of lathe which is shown

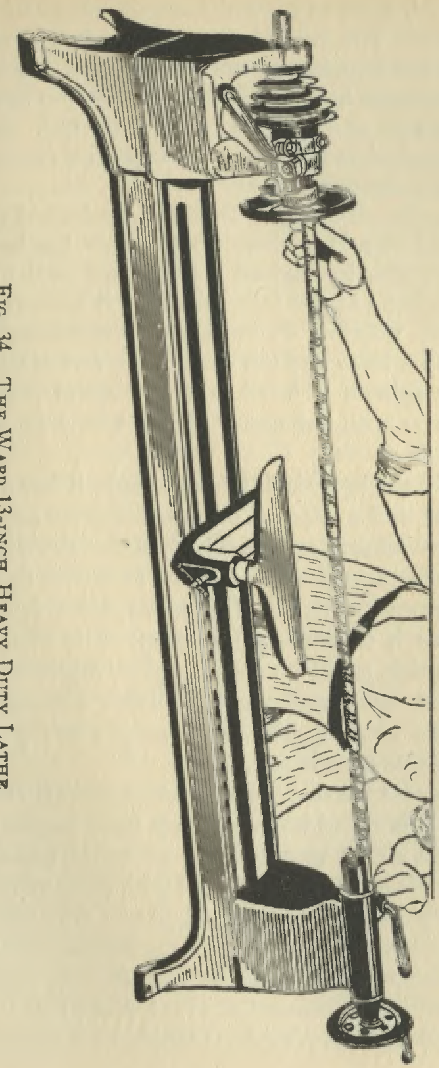


Fig. 34. The Ward 13-inch Heavy Duty Lathe

in *Fig. 34*, built to meet the requirements of the home workshop. The extra large bed which has one V way and one flat way, has an overall length of *53½* inches. It has a precision hollow spindle that runs on heavy sealed ball bearings and will take a $\frac{9}{16}$-inch rod. Instead of holes punched in the pulley it has a steel ratchet locking device for fluting, etc.

The tailstock and the tool rest are locked to the bed by means of a large handwheel under the bed of each one. Another handwheel that is fixed to the outer end of the spindle of the tailstock gives it a micrometer adjustment, while a *3½*-inch quill movement is firmly locked by a lever and the centers are self-ejecting. The rotating spindle is fitted with a *4*-speed pulley and it can be run with the motor above, below or behind the bed.

Finally the lathe is *14¼* inches high, it has a swing of *13* inches and a capacity between centers of *36* inches. A pair of *pillar blocks* can be had for *$6.75* extra, and this will increase the swing from *13* inches to *21* inches. You can run it with a ⅓-*H.P.* motor, but a ¼-*H.P.* motor will drive it to better advantage. The clutch-in-head gives a quick, positive control at your finger tips; a mere movement starts and stops the lathe without touching the power switch. The lathe weighs *104* pounds net, and the price of it is *$36.00*.

The Delta Lathes. *The 11-inch Double Duty Speed Lathe.* It is called a *double duty* lathe because you can use it for either woodturning or metal turning. The bed which is built of heavy steel with cross-pieces welded in it every *6* inches, makes it rigid and free from spring. It has a swing of *11* inches and a distance of *37* inches between centers; this can be increased by simply connecting on an extension bed to the end of it.

A novel and very useful feature of this lathe is the

indexing mechanism on the headstock which makes it possible for the accurate division of the work that is held between the centers on the face plate; this is a highly useful device for fluting, reeding, and laying out work. The spindle is *1¼* inches in diameter and this runs on tapered roller bearings which take care of the heavy end thrusts. The spindle has a ⅝-inch hole through its center, and the tailstock can be set over to align the centers of it and the headstock, or for the purpose of turning tapers and other special jobs.

The lathe is *6¾* inches wide, *12* inches high and *56½* inches long. The shipping weight of it is *82* pounds, and the price of it is *$29.00* which includes the various necessary accessories. You can run it with a ¼-*H.P.* motor or better, with a ⅓-*H.P.* motor.

The Delta Double-Duty Lathe Units. These lathe units consist of the *11*-inch double-duty lathes mounted on lathe stands as pictured in *Fig. 35*. The only difference between the lathe units is that one has a *4*-speed pulley and the other an *8*-speed pulley. These lathe units are designed not only for the serious craftsman but for industrial training classes and woodworking shops of all kinds.

The legs of the lathe stand are of heavy cast iron and there is a ledge for a shelf under the top, and under this is a shelf for the motor. In the first type of unit the lathe is driven by being belted directly to the motor, while in the second type the motor is bolted to the under top of the stand, and it is belted to the large pulley on a countershaft which is bolted to the lower shelf; and, finally, the small pulley of the countershaft is belted to the pulley on the lathe.

By using the countershaft you can get *8* speeds, namely, *300, 450, 700, 900, 1000, 1400, 2200,* and *3400 R.P.M.* The lower speeds can be used not only for pattern making and heavy-plate work in general, but when a slide rest is used the lathe becomes a practical metal working one. You can then do almost everything on it that you can do on a regular metal working lathe except screw cutting. The price of the *4*-speed lathe is *$29.00*, and the *8*-speed lathe with the countershaft is *$61.00*. The $\frac{1}{3}$-*H.P.* repulsion-induction motor, which

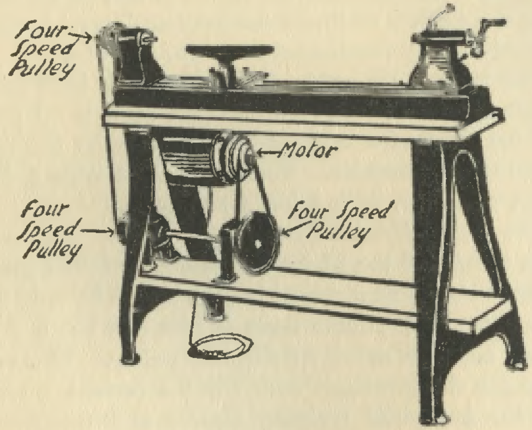


FIG. 35. THE DELTA DOUBLE-DUTY LATHE
AN 8-SPEED UNIT

is recommended to run these lathe units with, costs *$19.00* extra.

Tools for Wood Turning. The tools used for turning wood are simply *chisels* and *gouges* but they are made especially for the purpose. They are formed of the highest quality crucible steel and are correctly tempered so that they will hold a razor-sharp cutting edge. The blades are about *4* inches long and are fitted with hardwood handles *8* inches long, and they can be had in all widths from $\frac{1}{4}$ inch up to *1* inch. These chisels are made with four kinds of points, namely (*1*) the skew

point, (*2*) the round point, (*3*) the square point, and (*4*) the spear point, and all of these are shown in *Fig. 36.*

A *gouge* is a kind of a chisel with a concavo-convex cross-section and those used for woodturning come in sizes of from $\frac{1}{4}$ inch up to *1* inch. A *parting tool*, which is used to cut off a piece of turned work with, is simply a V-shaped chisel, and this can be had in $\frac{1}{2}$-, $\frac{5}{8}$-, and

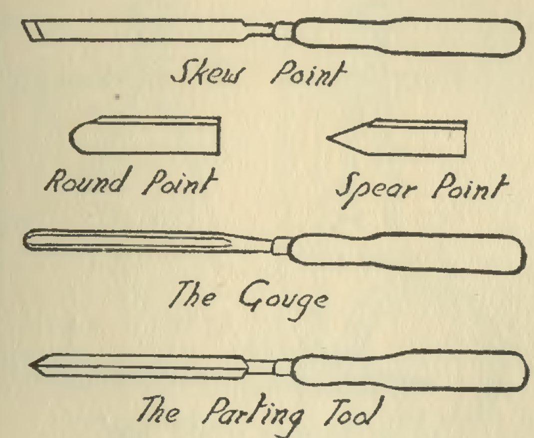


FIG. 36. A SET OF WOOD TURNING TOOLS

$\frac{3}{4}$-inch sizes. These latter tools are also shown in *Fig. 36.* You can buy turning tools of the makers of lathes, or of Hammacher, Schlemmer and Co., Fourth Ave., and *13th* Street, New York City.

Besides the above cutting tools you will need (*1*) a pair of *6*-inch outside calipers, (*2*) a pair of *6*-inch inside calipers, (*3*) an oil slip stone, and (*4*) an oiler, or oilcan, as it is commonly, but erroneously called. A *caliper*, or *pair of calipers*, as it is usually termed, is an instrument, formed of two legs, pivoted together and used for gauging the thickness of objects or the distance between points. *Outside calipers* are used for gauging the outside diameter of the work you are turning, while *inside calipers* are used for gauging the inside diameter of the work. These calipers are shown at *A and B in Fig. 37*, while a regular *sizing* tool is pictured at *C*.

How to Do Woodturning. Like everything else in the arts and crafts, to do a really good job of wood-

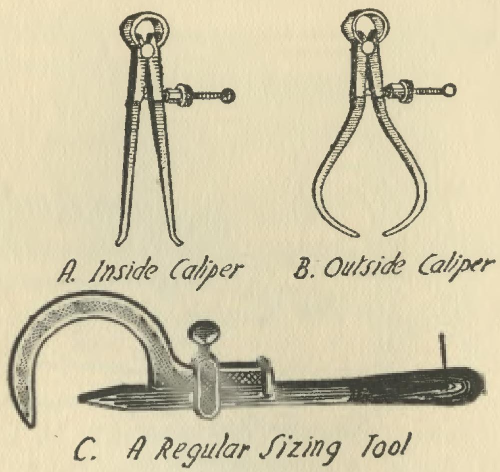


Fig. 37. Tools for Sizing the Work

turning you must have a considerable amount of practice. When you get your lathe and have it set up and belted to your motor you are ready to make your first try at turning. To do this get a round or a square stick of wood, say *2* or *3* inches thick and a foot or more long.

Next remove the spur or live center from the spindle of the headstock, place the spurs of it in the center of one end of the stick and drive them in with a mallet as shown in *Fig. 38*. This done replace the spur center

in the spindle and then set the tailstock up to within an inch or so of the opposite end of the stick and lock it there.

Now screw up the spindle of the tailstock by turning the feed-wheel until the spur center comes in contact with the end of the stick; be sure it is in the exact center of it, and then force the point of it in by slowly screwing up the spindle with the feed-wheel. When it is in

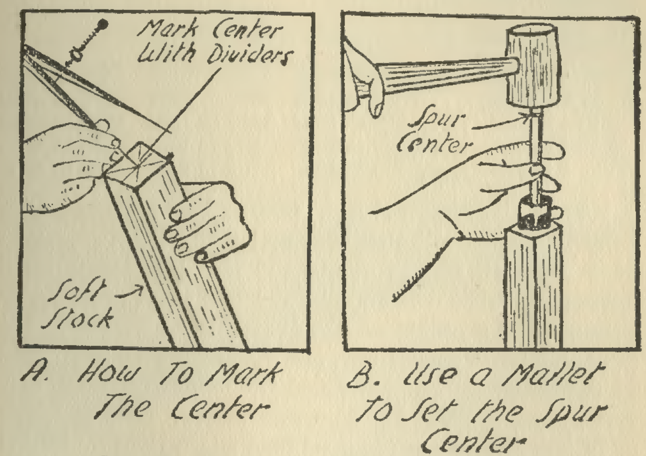


Fig. 38. Putting the Wood in the Lathe

about $\frac{1}{8}$ of an inch, ease off the pressure by turning the feed-wheel back a quarter of a revolution or so, and then lock the quill that holds the spindle in place. Put a few drops of oil on the center of the tailstock spindle to keep down the friction that would otherwise be set up.

The next and last step is to clamp the tool rest so that the inner edge of it is about $\frac{1}{2}$ of an inch from the stick you are going to turn and have it parallel with it, when you are all ready to begin your turning operations.

To do this throw the switch, when the motor will start up and it, in turn, will rotate the spindle which carries the stick or other work. Now the speed at which the work you are turning rotates is important and the following table will give you a rough idea of what it should be for the size of the stock you are going to turn and the kind of turning you are going to do, *i.e.,* roughing off, fine cutting and finishing. Another thing you want to bear in mind is that the harder the wood the lower the speed must be.

TABLE OF APPROXIMATE TURNING SPEEDS

Diameter of Stock	*Roughing Off*	*Fine Cutting*	*Finishing Off*
Up to 3 inches.......	600 to 1200	1200 to 1800	2000 to 3000
3 to 4 inches.......	600 to 1000	1000 to 1500	1800 to 2400
4 to 5 inches.......	600 to 800	800 to 1000	1000 to 1800
Over 5 inches.......	200 to 500	200 to 500	400 to 500

Nearly all fractional *H.P.* motors that are used with amateur power woodworking tools are made to develop *1750 R.P.M.*, and to obtain the above different lathe speeds you have only to shift the belt from one step or groove of the pulley on the shaft of the motor to the next smaller or larger one, and from the step or groove of the pulley on the spindle of the lathe to the one that corresponds with it on the motor pulley. Where lower or higher speeds are required than can be had by means of stepped pulleys on the motor and the lathe a countershaft must be installed between them.

How to Use the Tools. When you have the work turning at the right speed the top edge of which is, of course, moving toward you; now grip the handle of the chisel, gouge or parting tool firmly in your right hand, lay the back of it on the rest, and hold down on the blade with your left hand as shown in *Fig. 39.*

Next press it slowly and firmly against the surface of the stick, when it will begin to cut into it. In holding the chisel or other tool against the work you must tilt

the former a little above the longitudinal center of the lathe, and not in a horizontal position.

You must be very careful in roughing off work not to try to take off too large a chip at a time. Go about it very gently and as the point of your chisel begins to cut you can gradually swing the tool around until the

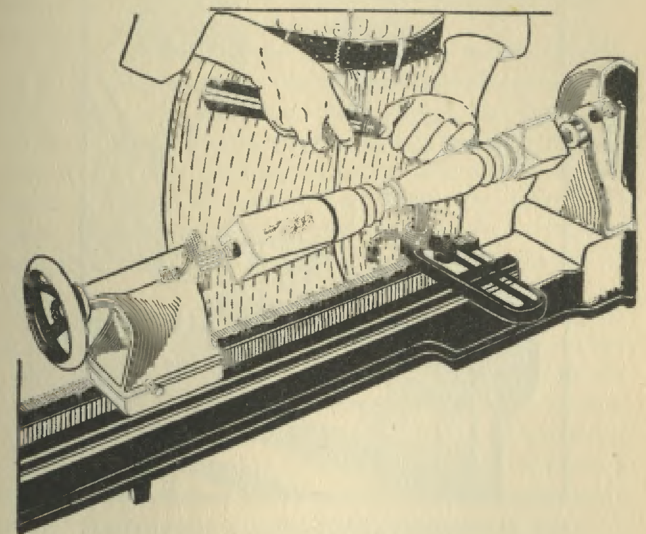


Fig. 39. How to Hold the Turning Tool

whole width of the blade is cutting. Gouges are held in the same way as chisels and with them you can turn the concave and convex parts. The parting tool is used for cutting deep V-shaped grooves and cutting off the ends of the stock after you have finished turning it.

Sizing the Work. To turn a piece of wood down to a given size you can do so by gauging it with a pair of calipers as shown in *Fig. 40,* or you can do it with a regular *sizing tool,* which I have previously described.

To *size* the work means that you gauge the diameter of it with a pair of calipers the points of which you have set with a rule for whatever thickness you want the turned part to be: then as you turn the wood you try it

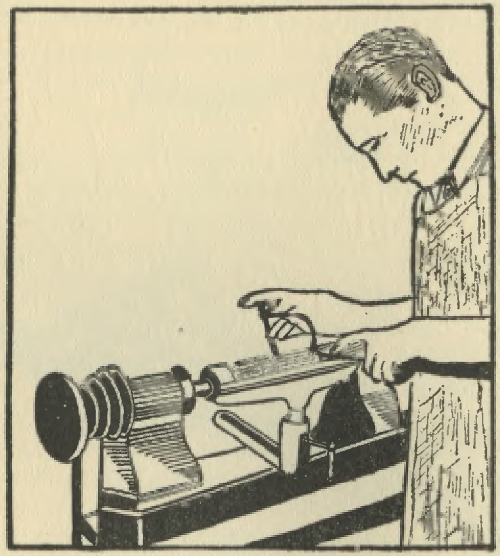


FIG. 40. SIZING THE WORK WITH THE CALIPERS

every little while until it will just slip through the points of the caliper.

How to Do Metal Spinning. The term *metal spinning* means the shaping of flat sheets of metal into various ornamental and useful articles such as cups and coasters, dish covers, card trays, vases, lamps, etc. Now I can't go into all of the details of how to do metal spinning here but I shall tell you enough about it so that you will have a very good idea of it. Further, I would say, it is not at all a difficult craft to learn and

you will find it a most fascinating hobby and, albeit, a remunerative one if you care to make it so.

To spin metal you will need a few tools and a tool rest of special design, and a ball bearing tail-center, and you can get them, together with full instructions as to how to use them, from the maker of your lathe. You can spin any of the softer metals such as pewter,[3] lead, tin, zinc, aluminum, copper and brass.

Pewter and lead are the easiest of the metals to spin and these and aluminum can be spun into shape without taking them from the lathe. Zinc, copper and brass get hot when they are being spun and this tends to harden them so that the spinning becomes difficult. For this reason you have to remove them from the lathe, then *anneal,* that is soften them, and this you do by heating them in a hot flame, and letting them cool slowly in the air.

To spin a metal article you have to fasten a block of wood on the face plate, or on to the spindle of the headstock and then turn it up to the exact shape of the article you are going to spin, and sandpaper it (the form) until it is nice and smooth. This done cut out a disk of the sheet metal to be spun with a pair of tinner's shears and place it so that its center will be in the exact center of the end of the form; now securely fix it there, either by driving a pin through it and into the form, or, better, place one end of a *thrust block* against the metal disk and the other end of it on the center of the tailstock; this done clamp it in place and screw up the tail-center.

Now clamp the special tool post in position to the lathe bed and you are all set to spin the metal disk.

[3] *Pewter* is any one of a number of alloys that has tin as its chief component. The finest kind of pewter is made of *90* per cent of tin and *10* per cent of copper. The inferior kinds are made of about *75* per cent of tin and *25* per cent of lead.

Start up your lathe and when it has gathered speed, hold the handle of the long blunt-nosed spinning tool under the pit of your arm and grip the shank of it with your hand. Press the end of the tool against the metal disk below the center of it and as you force it over the form be sure to keep it in a line which corresponds with the center line of the lathe bed.

To give the article, after you have spun it to shape, a *rolled* or *beaded edge* you must have a *beading tool,* and this consists of a long handle with a steel bar mounted in it and a little pivoted roller secured in the free end of the latter. By giving the tool a slight rolling motion, the while pressing it against the edge of the spinning article, it will roll over and a continued turning of the tool will cause it to turn under.

How to Do Metal Turning. You can make many small things of metal with your lathe but to do so you will need a set of metal turning tools and a slide rest. To cut inside and outside threads on work, you must have a *screw cutting lathe*[4] and this built especially for machinists. So if you are interested in turning metal you should read my book *The Amateur Machinist*[5] as this gives full and explicit instructions for using all kinds of metal working hand tools and how to use the screw cutting lathe.

[4] The South Bend Lathe Co., South Bend, Ind., make a full line of precision lathes.

[5] Published by D. Appleton-Century Co., New York and London.

Chapter VI

THE POWER JOINTER OR PLANER

A *plane* as you know well, is a hand tool for smoothing the surfaces of boards and other stock, and a *planer* is a power tool or machine that is used for the same purpose. The small planer that is used by amateur woodworkers and other craftsmen, is called a *jointer* because it is chiefly used for smoothing off narrow boards and the edges of stock so that they will fit together and make a good joint.

To use a jointer you lay the board or stock to be planed or jointed on the table of it, and as you feed it along it comes in contact with a rapidly rotating cutter head; this has blades fixed in it and it is these that plane off the rough surfaces and in a far more accurate way than you could do with a hand plane, in the fraction of the time and with no appreciable effort.

The Parts of a Jointer. The planer or jointer is constructed of seven chief parts and named these are (*1*) a base, (*2*) a frame, (*3*) a table, (*4*) a rip-fence or guide, (*5*)an arbor or shaft, (*6*) a cutter head, and (*7*) a guard. As in practically all other machines the table is mounted on the base.

The table is really formed of two tables, a front and rear one, and in the better jointers both of them are adjustable. The frame or guide is fitted with a graduated scale and pointer so that it can be set at any angle in the horizontal plane. The cutter head is mounted on the arbor or shaft and this runs in sleeve or ball bearings. In some machines the shaft can be moved up and down to adjust the cutter head for height and in others the table is moved up and down. The guard is used, of course, to prevent your hands from accidentally coming in contact with the rotating cutter head.

The Ward Power Jointers. *The 4-inch Jointer.* This jointer will plane stock up to *4* inches wide and to a depth of $\frac{1}{4}$ inch with one cut. The base is of goodly height and this allows the chips to be easily removed from it. The front and rear tables are *5*$\frac{1}{4}$ inches wide, and they are raised and lowered by hand-wheels, and an eccentric cam lever locks the former to any height.

The table is of heavy cast iron and accurately ground

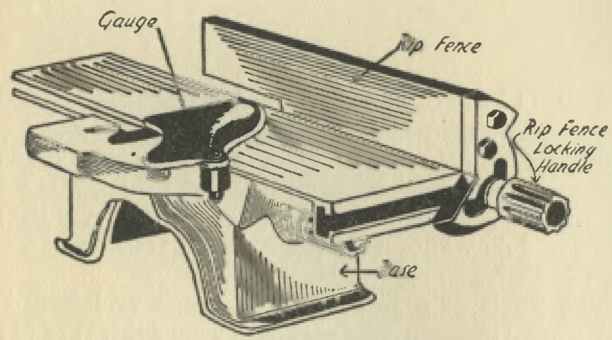


Fig. 41. The Ward 4-inch Jointer

so that it will not teeter when working up to full capacity, and it has extra long milled ways which allow it to be adjusted to the exact cutting depth. It has a sturdy rip-fence that is self-aligning, and a protector scale so that you can set it at any angle up to *45* degrees, and it is easily lengthened by a hand-knob.

The cutter head has three *4*-inch long blades made of high-speed steel[1] and these can be readily removed for sharpening. The head is mounted on a ground

[1] This is tool steel with a little *tungsten* in it. This latter metal is white, ductile and has a high melting point—about *3400* degrees Centigrade or *6000* degrees Fahrenheit.

shaft which is scientifically balanced after the blades are fixed in it and the purpose of which is to make it run true. The shaft runs at a high speed—between *4000* and *5000 R.P.M.*, thus making from *12,000* to *15,000* cuts per minute—and, it follows, a very smooth surface is produced.

The jointer has a heavy cast safety guard and this swings open as the stock moves by the cutter head, or it can be removed at will for rabbeting. The front table has a rabbeting arm and the rear table a rabbeting ledge. It (the jointer) is *5*$\frac{1}{2}$ inches high from the bottom of the base to the top of the table, a length of *20*$\frac{1}{2}$ inches and a shipping weight of *26* pounds; it is pictured in *Fig. 41* and costs *$12.50* without the motor. It can be run with a $\frac{1}{4}$-*H.P.* motor but for heavy work a $\frac{1}{3}$-*H.P.* motor is needed.

The Ward 6-inch Jointer. This jointer has a cutting capacity of *6* inches wide and a depth of $\frac{1}{2}$ an inch with one cut. It is large enough for the cabinet-maker or a small woodworking shop. The base, table tops and fence are made of seasoned gray cast iron; the table tops are ground extra smooth and after they are assembled they are tested so that they will be exactly parallel with each other, and they are raised and lowered by balanced ball cranks.

The tables slide smoothly on closely machined dovetailed ways and these are provided with adjustable gibs[2] to compensate for wear, and large knurled knobs lock them securely in place. The front table is *7*$\frac{1}{2}$ inches wide and *16* inches long; it has a *3*-inch rabbeting arm, while the rear table is *7*$\frac{1}{2}$ inches wide and *17* inches long with a *1*-inch rabbeting edge. A graduated depth gauge shows the depth of the cut.

[2] These are thin strips of metal that are used to form a bearing surface.

The fence is *4⅛* inches high and *30* inches long and has a ground surface. The construction of it is such that you can swivel it at an angle clear across the table so that a shearing cut can be made where this can be an advantage, as with curly grained wood. The fence works on an arm fixed to the back of the table instead of to the front of it and this scheme leaves no gap between it (the fence) and the rear table where it is most necessary to guide the stock.

The shaft, which rotates at a speed of *4500 R.P.M.*, runs on sealed ball bearings and, hence, gives the smoothest operation with the least amount of friction. The cutting head and the shaft is made of a single piece of solid steel and is accurately machined and properly balanced. It is fitted with three *6*-inch long blades and chips the breakers.

The guard for the cutting head is made of cast aluminum and this is worked by a strong spring that presses the guard against the stock with the result that the blades are entirely covered as soon as it moves by the cutter head, and, it follows, they are guarded all of the time.

The shipping weight of the jointer without the motor is *135* pounds, and the price of it is *$45.00*. It takes a ⅓-*H.P.* motor that develops a speed of *1750 R.P.M.*, to run it.

The Driver Power Jointers. *The 4-inch Jointer.* The base and tables of this jointer are of gray cast iron; the former is reinforced with ribs, while the latter are carefully machined, and both of them are adjustable. The width of the front table at the rabbeting arm is *8* inches, both tables are *9½* inches long and the overall length of the jointer is *23* inches.

The fence is *14½* inches long and strongly reinforced to give it the necessary rigidity and it is fitted with a

graduated quadrant. In some jointers the guide must be removed entirely when it is used for rabbeting but in this one it folds down and out of the way. It gives full protection, receding from the work as it is fed to the cutter.

The jointer has oilless, bronze sleeve bearings and the shaft and cutter head, which are formed of a solid piece of steel, is fitted with three high speed steel blades; the latter are held in the slots in the head by the latest approved methods. The shipping weight of the jointer is *36* pounds, and it sells for *$13.00*. You can run it with a ¼-*H.P.* motor, but a ⅓-*H.P.* motor will be needed if you are working it to its capacity.

The Driver 4-inch Heavy Duty Jointer. This jointer is in every way superior to the usual *4*-inch ones in that it is heavier, larger and more accurately constructed. The base is a one-piece casting with its ways and bearing supports carefully machined. The tables are made of close grained gray cast iron and these are accurately ground. Each separate casting is heat-treated or annealed, where this is necessary to prevent warping. As in the *4*-inch Driver jointer I have described above, the guard is not removed when rabbeting or when you have to adjust the blades, but are simply folded out of the way by means of a rachet.

The fence which is *24* inches long and very rigid, can be tilted a full *45* degrees either to the right or to the left, and the action is controlled by a spur gear that meshes with a spur gear segment which is secured to the fence itself. The fence can be moved across the table without changing the angle of it and it can be locked in any position.

The cutter head and shaft are integral, that is they are made of a single solid steel bar. It is *4½* inches long, dynamically balanced and is built to run at a speed of

5000 R.P.M. The knives, which are of high speed steel, are carefully honed and adjusted ready to use. Since a jointer, or any other machine for that matter, is only as good as its bearings the highest grade ball bearings are used in this one, and each of these is sealed in a dust-tight metal housing, and, it follows, they have to be greased only at long intervals.

A new *dual-purpose guard* can be used as an accessory on this jointer and with it you can plane down stock until it is thin as a ribbon and do it with absolute

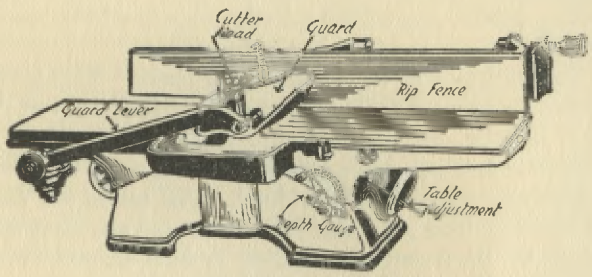


FIG. 42. THE DRIVER 6-INCH PRECISION JOINTER

safety. A *spring hold-down* on the fence and another on the table holds the work firmly against the knives and fence and in planing small strips this is not only a convenience but it makes for added safety.

The jointer has an overall length of *28* inches, a shipping weight of *95* pounds, and it sells for *$29.00.* It takes a $\frac{1}{3}$-*H.P.* motor and this, of course, is supplied at an additional cost. You can get an all metal stand, with a shaving chute to mount the jointer on for *$8.00* extra.

The Driver 6-inch Precision Jointer. The tables of this jointer are of heavy, cored castings, and have carefully ground tops. The length of the front table is $17\frac{1}{2}$ inches and that of the rear table $15\frac{1}{2}$ inches; these slide

on dovetail ways and have adjustable *gibs.* The cutter head and shaft are formed of a solid steel bar. The former is $2\frac{1}{2}$ inches in diameter and it is fitted with three high-speed steel knives. The shaft runs in ball bearings.

The fence, which is of cast iron, is *4* inches high and *28* inches long and it is fitted with a positive action, gear tilting device. The rabbeting capacity of the jointer is $\frac{5}{8}$ of an inch cut, and when you are doing this kind of work the guard folds down and out of the way.

When the jointer is mounted on a steel stand the unit makes an ideal combination not only for the amateur craftsman, but for cabinet-makers, and all others who have small woodworking shops. The overall length of the jointer is $37\frac{1}{2}$ inches, and its shipping weight is *160* pounds. It costs *$45.00* without the stand and *$53.00* with it. It runs at the speed of from *4000* to *5000* *R.P.M.*, and while you can run it with a $\frac{1}{3}$-*H.P.* motor a $\frac{1}{2}$-*H.P.* motor will give you better service. It is shown in *Fig. 42.*

The Delta Power Jointers. *The 4-inch Jointer.* This jointer, whose special features are covered by United States and Canadian patents, is $7\frac{1}{2}$ inches high, $9\frac{1}{2}$ inches wide and *23* inches long overall. The front table is $5\frac{1}{4}$ inches wide and has an additional *3*-inch rabbeting ledge. The rear table is also $5\frac{1}{4}$ inches wide with a $\frac{1}{4}$- by $\frac{3}{4}$-inch rabbeting ledge.

The cutter head is made of solid steel and is integral with the shaft. The jointer is equipped with three high speed steel knives that are sharpened and jointed ready for use, while the latter runs in self-sealed ball bearings. The fence moves through an angle of *45* degrees in both directions, and a flip of your finger takes the automatic stop-link out of the way when you want to tilt it.

After the fence has once been set square with the table and the adjustable pointer has been moved to the *0* mark on the quadrant scale it never needs to be calibrated again, as the stop-link always sets the fence absolutely square after it is tilted in place. The jointer is fitted with an aluminum flap guard and this entirely covers the front of the knives. The guard can be instantly detached when you are going to use the jointer for rabbeting, and it hangs by a swivel spring.

The shipping weight of the jointer is *43* pounds, and the price of it is *$24.50* without the guard which costs *$1.50* extra. The *jointer* unit consists of the above machine, which is bolted to a steel stand, and this costs *$6.25* extra. A $\frac{1}{3}$-*H.P.* motor should be used to run it with.

The 6-inch Ball Bearing Precision Jointer. This jointer is an enlarged edition of the *4*-inch one which I have just described. The base is heavily ribbed and the tables are held in absolute alignment. The length of the front table is *13*$\frac{3}{4}$ inches, that of the rear table is *12*$\frac{7}{8}$ inches, while the overall length of the jointer is *28* inches. The fence is also of rigid construction so that it will not spring sidewise when the work is being fed through. Its chief feature, however, is the automatic *45, 90* and *135* degree stops.

When the dual control handle is pushed in it engages the tilting lock when a mere turn of it tilts the fence; when the handle is pulled out it engages the bracket and you can then move the fence bodily across the table. The shipping weight of the jointer is *120* pounds, and it sells for *$45.00*. A *6-inch jointer unit* includes the above machine and also a steel stand which costs *$6.85* extra. It is pictured in *Fig. 43*. And now let's see just how these jointers work and how to use them.

How to Use the Jointer. *About the Knives.* While knives made of high-speed steel hold their cutting edges longer than those made of common steel still in time they will get dull and have to be resharpened. You will know when they need it because *(1)* it takes more power

to operate them, and *(2)* after the wood has been planed the surface of it has a blurred look.

Curiously enough the wood that you plane does not dull the knives as much as the dust and grit that forms a film on it, so before you run the work through the jointer clean it off either with a cloth or brush. You will probably not have to sharpen the knives oftener than every two or three months unless you are using the jointer constantly.

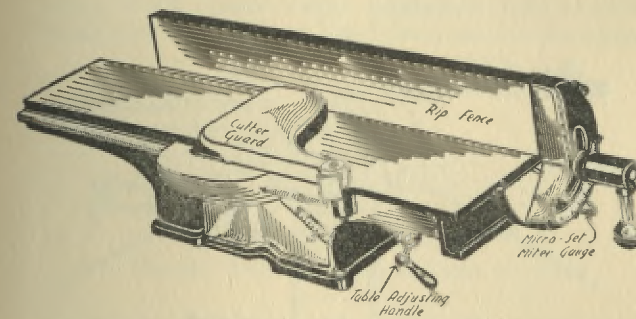


FIG. 43. THE DELTA 6-INCH PRECISION JOINTER

How to Sharpen the Knives. You can sharpen the knives without removing them from the cutter head and this is the way to do it: Lower the rear table until it is just a shade below the edge of each knife when it is in its uppermost position. Now take a large oil stone and wrap a sheet of paper around it leaving a third of one end of it exposed, the purpose of which is to prevent it from rubbing the top of the table.

Now lay the stone on the table with the free end of it resting on the edge of the knife, hold the latter with one hand so that it will not turn, then press down on the oil stone and rub it round and round over the edge. Having sharpened the first knife repeat the operation with the other two. When the knives have become so dull that honing with the oil stone will no longer properly sharpen them you must remove them from the cutter head and grind them on an abrasive wheel.

The Adjustment of the Tables. Both the front and the rear tables of the jointer are adjustable but for very different purposes. The *front table* is lowered so that you can take a cut from the wood of whatever thickness you want it to be, and the lower it is below the upper-

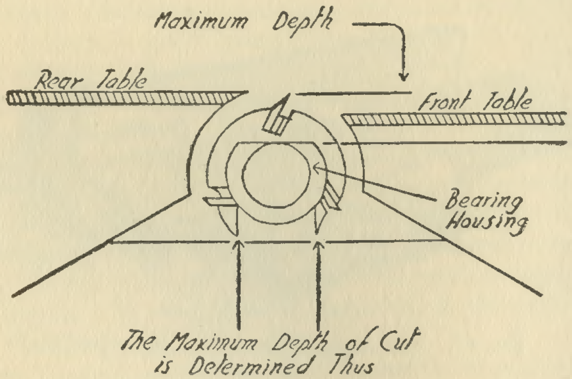


FIG. 44. HOW THE TABLES ARE ADJUSTED

most height of the edges of the knives the deeper will be the cut.

The *rear table* is adjusted so that the surface of it is exactly in line with the height of the edges of the knives when they are in the uppermost position. When the rear table is correctly adjusted you will not have to readjust it until the knives are worn down by repeated sharpening. The cut shown in *Fig. 44* illustrates the positions of the front and rear tables with respect to the edge of the knives.

How to Plane Stock. To plane a board that is ½ an inch thick or more you have only to hold it down on the

table by pressing on the top of it with your fingers, and then pushing it slowly and steadily along against the knives. You can tell by the *feel* when you are feeding it fast enough. Where the board is less than ½ an inch thick you should use a *pusher block* unless the jointer has a *spring clip* to hold it down.

The pusher block is, simply, a wooden block of the shape shown in *Fig. 45*; you will note that a thin slice of the bottom is cut away except at one end—and it is fitted with a handle. Now when you want to plane a board that is less than a ½ inch thick you set the rabbeted

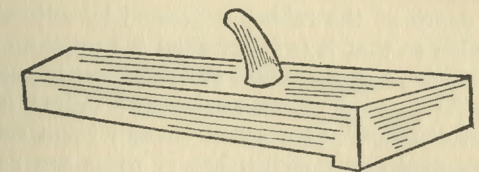


FIG. 45. HOW THE PUSHER BLOCK IS MADE

edge of the block against the end of it and hold it down by the handle while you are feeding it. CAUTION. *Never let your fingers* rest on or grip the edges of the work you are planing, or the knives may strike them and if this should happen your woodworking days will come to an abrupt end.

In planing wood you must, of course, cut it *with* the grain of it, just as you do with a hand plane, and not against it. Where the grain does not run uniformly in parallel lines, as in cherry and some other woods, then you must have the blades as sharp as possible, the table adjusted so that they will make a very thin cut, and slowly feed in the wood.

The fence is used where you are planing the edges of a strip or board to make a joint; in this case you must hold the work against the fence just as firmly as you hold it down on the table. To make a *square joint* the fence must set in a vertical position, *i.e., 90* degrees to the top of the table, and to make a *bevel* joint you must set the fence at whatever angle will give you the bevel you want.

How to Rabbet Stock. To *rabbet* a board or other stock means that you cut a recess or piece out of the surface of it, and this is one of the things that you can do with a jointer. To rabbet stock the jointer has a *rabbeting ledge* attached to the front table, and its purpose is, simply, to make the latter a little wider to carry the work.

The *depth* of the rabbet is gauged by adjusting the front table so that it is lower than the uppermost edge of the knives, and the *width* of the rabbet is gauged by sliding the fence across the table and setting it at the required distance. One cut is enough for a rabbet of ordinary depth and width, but if these are as great, or nearly so, as the capacity of the jointer it is the better way to make two cuts.

Some Other Uses for the Jointer. Besides planing, beveling and rabbeting there are several other things you can use your jointer for and chief among them are making (*1*) mouldings, (*2*) taper cuts and (*3*) chamfering. It is easy to make *mouldings* where all of the cuts on it are flat or beveled. *Taper cuts* are useful in making table legs and the like, while *chamfering,* which means cutting small grooves in the stock, can also be done on it.

Chapter VII

THE POWER SPINDLE SHAPER

A *vertical spindle shaper, spindle shaper,* or just *shaper* as it is called for short, is a woodworking machine that has a *cutter head* mounted on the upper end of a vertical rotating spindle which projects above a flat table, and it is used for cutting mouldings and other irregular shapes. When it is fitted with a regular sanding drum it is a very useful machine for smoothing up inside and outside curves of various kinds of work.

The Parts of a Spindle Shaper. A spindle shaper consists of seven chief parts, and these are (*1*) the base, (*2*) the table, (*3*) the vertical spindle, (*4*) the cutter head, (*5*) the stationary guide, (*6*) the adjustable guide, and (*7*) the guard. In some shapers the table is adjustable and the spindle is stationary, and in others the spindle of it and the shaft of the motor are directly connected, and they can be swung around to different angles so that the various contours of the moulding can be made.

The Ward Spindle Shaper. The base, table and fences of this shaper are made of seasoned gray iron castings. The table is *8½* inches high, *11* inches wide and *14* inches long, and it is machined smooth so that the work will move across it without bucking. The spindle is mounted on grease-sealed ball bearings, and it takes cutters having either a $\frac{5}{16}$-inch or a ½-inch bore.

It rotates at *7500 R.P.M.*, and since there are three blades on each cutter, it follows that it makes *22,500* cuts per minute, and this it does smoothly and without vibration. This high speed gives a perfectly smooth finish and one that is free from ripples and cuffing.

There is a micrometer on the front guide face so that the depth of the cut can be adjusted. It takes one complete turn of the ball-crank to raise or to lower the spindle $\frac{1}{32}$ of an inch, while a positive lock-wheel locks the spindle in position.

The shaper, which is shown in *Fig. 46*, has a shipping weight of *38* pounds, and the cost of it is *$15.00*. This

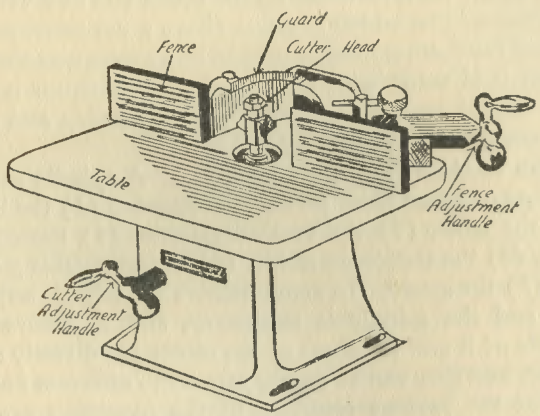


FIG. 46. THE WARD SPINDLE SHAPER

price does not include the cutters and depth collars. A single cutter can, however, be had for a dollar or less, a set of seven of them costs *$4.00* and a set of twenty-four sells for *$10.00*.

The Driver Spindle Shaper. The table, which is a machined gray cast iron one, is *10* inches wide and *14* inches long, and the overall height of the shaper is *15½* inches. The spindle can be raised and lowered through a vertical distance of *1¼* inches. One end of the spindle is $\frac{5}{16}$ of an inch in diameter to take cutters that have a bore of this size, and the other end is ½ inch in diameter to take cutters that have this sized bore.

Either end of the spindle can be used by simply inverting it, and this can be done without removing the ball bearings in which it runs. These bearings are sealed in dust-proof cases and are self-lubricating. An advantageous feature of the shaper is that the spindle can be run in either direction, and this is done by simply

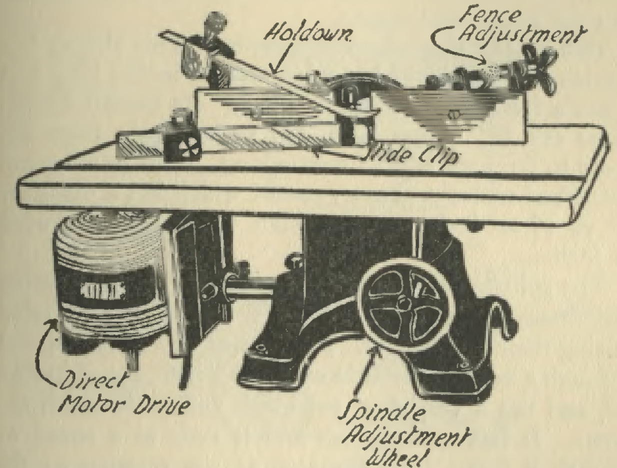


FIG. 47. THE DRIVER SPINDLE SHAPER

throwing the handle of the reversing switch which changes the direction of the motor. It can be operated with either a direct or a countershaft drive and at speeds of from *6000* to *8000 R.P.M.*

The front guide has a fine screw adjustment, and *hold-downs* of steel are provided which are very handy when you are shaping thin stock. These spring hold-downs come as an accessory to the shaper and cost *$1.50* extra for the set.

The shaper, which is pictured in *Fig. 47*, can be had with a table that is *10* inches wide and *14* inches long, and which sells for *$20.50*, or with one that is *15* inches wide and *21* inches long, and the list price which is *$25.00*. An all-steel stand for the shaper sells for *$8.00* extra, and together they form a handy, compact and efficient set-up. A $\frac{1}{3}$-*H.P.* motor that runs at a speed of *3450 R.P.M.*, or $\frac{1}{2}$-*H.P.* motor that runs at the same speed, and both of which have reversing switches, can be used to run the shaper.

The Delta High-Speed Shaper. This shaper has a table that is *15½* inches wide and *18* inches long and it has a fence that is *25* inches long. Its overall dimensions are *10½* inches high, *15½* inches wide from the front to the back and *25* inches long. Two spindles are furnished with the shaper, one of which has a diameter of $\frac{5}{16}$ of an inch, and the other one a diameter of $\frac{1}{2}$ an inch.

The spindle that is used is carried in self-lubricating double-sealed ball bearings and these will remain oiled during their normal life. It (the spindle) can be moved through a vertical distance of $\frac{3}{4}$ of an inch, see *A* in *Fig. 48*, and has a very fine, yet quick and positive adjustment. It has no backlash and it runs at a speed of *10,000 R.P.M.* The direction of the rotation of the spindle can be reversed by the simple expedient of using a reversing switch which changes the direction of the current, and, it follows, of the motor.

The shaping of end-grain wood work has been heretofore a more or less dangerous operation because it has almost no pressure against the fence, with the result that it is easily pulled out of the hands of the operator, and which may make them come in contact with the rotary cutter. This danger is now obviated by the *sliding jig*, and it makes the shaping of end-grain work a perfectly safe operation for amateurs, and even school shop boys.

The jig is formed of a ground steel plate and this is fitted with a key to slide in the groove of the table. A patented *miter gauge head* is secured to the plate and can be set at any angle up to *90* degrees from either of the horizontal sides. The plate also has a pair of clamp rails and each one has a screw clamp that can be slipped along them as shown at *B*.

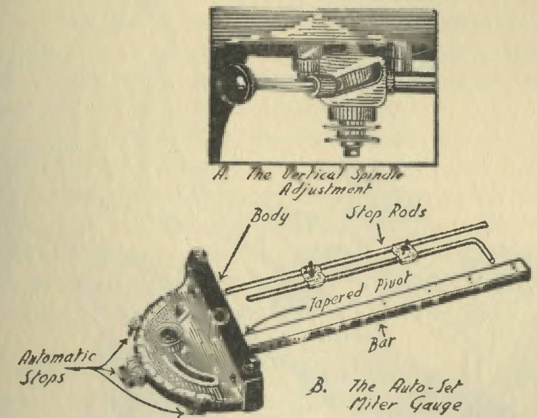


Fig. 48. Details of the Spindle Adjustment and Miter Gauge

The work which you are going to shape is clamped against the miter gauge head and down to the plate when the whole jig can be moved along the cutter. Your hands are kept at a goodly distance from the cutters and the work is held firmly against them without the slightest danger of its getting out of control. Not only does the jig insure safety to yourself but it also makes more perfect mouldings.

The shaper, which is pictured in *Fig. 49*, has a shipping weight of *57* pounds, and costs *$25.75* without the cutters or collars, or motor pulley, and the jig, see

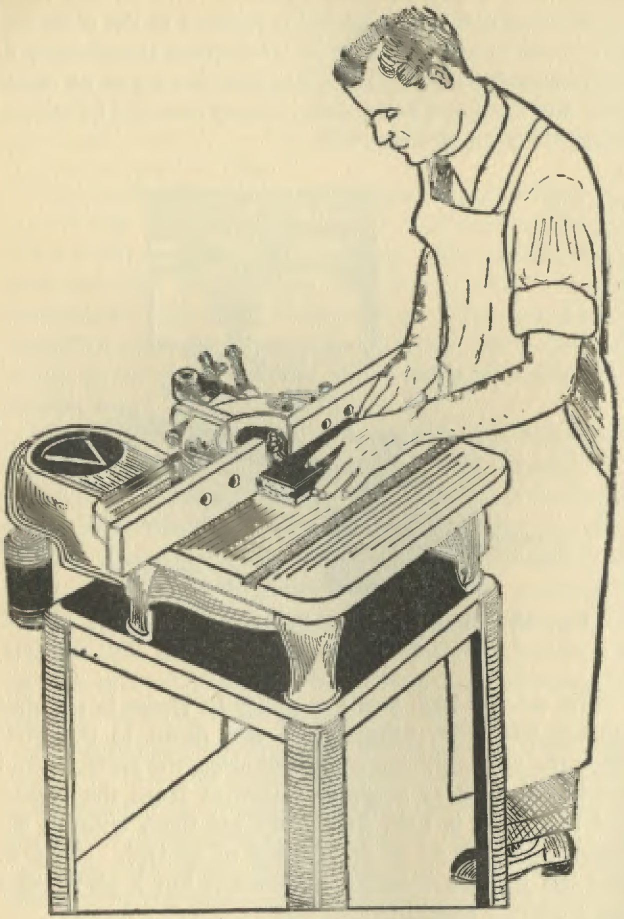


FIG. 49. THE DELTA HIGH SPEED SHAPER

B, costs *$6.50* extra. The *Delta Shaper Unit* includes the shaper, a steel stand, belt guard and motor bracket, a flanged motor pulley, a V-belt, and the price of it complete is *$39.50*.

About the Cutters. *Kinds of Cutters.* Cutters are of two kinds and these are (*1*) the solid head kind, and (*2*) the loose cutter kind. In the *solid head kind* the head and the cutter are integral, that is, they are made of a solid bar of tool steel and they (the cutters), are given the contours of mouldings you are going to make. It is the kind that is used on all of the amateur wood working shapers as it is the safest to use.

In the *loose cutter kind* the cutters are secured to a solid head either with screws or lock studs, and this is the kind that is used on professional woodworking shapers. The cutters are made of chrome vanadium tool steel and they are carefully tempered and sharpened so that they will keep a razor-sharp edge for a much longer time than those that are made of carbon tool steel.

It is not necessary to have a large number of cutters as they can be used in combination with each other and so you can produce numerous designs with a comparatively small number of them. Thus with a set of *7* cutters you can make upwards of *60* designs which are about all that the amateur woodworker is likely to have use for. The most popular shapes of the cutters are known as (*a*) the fluting cutter, (*b*) the cove cutter, (*c*) the corner rounding cutter, (*d*) the straight face cutter, (*e*) the surface head cutter, (*f*) the matched tongue and groove cutters, (*g*) the male and female cabinet cutters, and (*h*) the male and female sash cutters, and some of these are shown in *Fig. 50*.

How to Sharpen Cutters. It is highly necessary to keep the cutters of the shapers as sharp as you possibly can in order that the moulding shall be cut perfectly smooth. Now you can sharpen cutters by (*1*) rubbing an oil stone over the back edges of them, (*2*) by filing the back edges of them, and (*3*) by grinding them.

To keep the cutters sharp you should use the oil stone on them frequently. When they get a little dull you can file the back edges until you have removed the roughness and then hone them with an oil stone. When the cutters are quite dull you must grind the rough edges

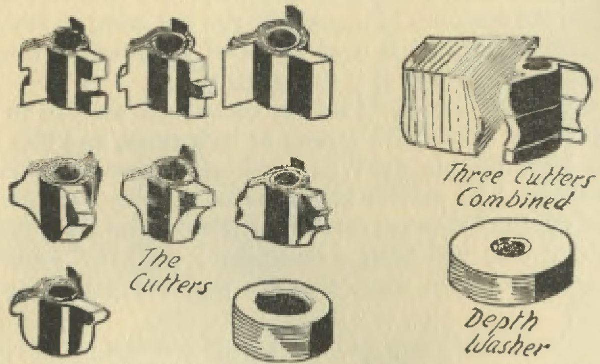


FIG. 50. SOME OF THE NUMEROUS SHAPER CUTTERS

down with an alundum or a carborundum grinding wheel;[1] this is a very particular job and one that is more or less involved since it takes several operations to do it.

Named these operations are (*a*) annealing the cutter to take the temper out of it, (*b*) making a *template,* which is a thin metal pattern that has the contour of the edge of the cutter, (*c*) various grinding operations, and (*d*) rehardening it. To anneal the cutter it must be heated in a gas flame until it is a deep cherry red, and then allowed to cool gradually in the air.

The template must now be made, and the edge of this

[1] Carborundum grinding wheels are made by the *Carborundum Company, 13* Laight St., New York City.

is cut and filed out to follow the lines, both straight and curved. This is laid on the cutter and the contour line of it is scratched on it (the cutter) so that the latter can be accurately ground down to it. To do this the grinding wheel itself must be carefully *dressed down*[1] until the edge of it conforms to that part of the template line on the cutter. To grind cutters that have various contours you should have several different grinding wheels. After you have ground down the cutter to the contour line that you made with the template, file it smooth and then sharpen it on an oil stone.

The final operation is to temper the cutters, that is to reharden them. To do this grip the cutter head with a pair of pliers and heat it in a gas flame until it is a deep cherry red. Now quickly take it out and plunge it into a bucket of cold water, remove it and plunge it in again and let it stay there until it is cold, when it is ready to use. The grinders for doing this and other kinds of work will be described in a later chapter.

How to Use the Shaper. There are two kinds of ordinary shaping and these are (*1*) straight shaping, and (*2*) curved shaping. *Straight shaping* consists of shaping strips of wood into moulding, square table tops and any other kind of straight edge work. *Curved shaping* includes the shaping of curved table tops, and other round and oval edge work.

An example of straight edge work is shown in *Fig. 51,* and this represents a cross-section of a conventional picture frame moulding. To make it you use a strip of wood that is $1\frac{1}{8}$ inches thick and $1\frac{5}{8}$ inches wide, or whatever thickness and width you want it to be. The first thing to do is to cut a rabbet on the back of the strip, and having done this you secure the cutters that will give you the shape you want on the spindle.

The next thing is to adjust the spindle so that the cutter head projects above the table top to the proper height; this done set the guide so that when you run the strip of wood along it the cutters will cut in to the right depth. These adjustments are easy to make, and to check up on them you need only to take a short strip of wood and feed it through the shaper when you can at once see if the cutters are shaping it to your satisfaction.

In feeding a strip or other work against the cutters be sure to hold it down evenly and firmly on the table and against the guide. Unless you do so the variations of the speed with which it moves along and the pressure you apply to it may cause it to take on a ripple-like

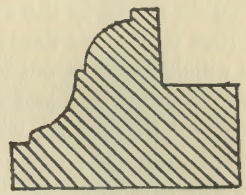


FIG. 51. A CONVENTIONAL STRAIGHT-EDGE MOULDING (A Picture Frame Moulding)

effect. To obtain an even pressure steel spring clips that are fixed to the guide are very useful, since they hold the strip down with exactly the same force the whole length of it.

For *curved shaping* the guide is not used but a *depth collar* is employed instead of it (the guide). The specific purpose of a collar is to limit the depth of the cut and the way it does this is by coming in contact with the lower edge of the work when, it follows, the cutters are prevented from cutting in any farther; in other words it is the difference between the diameters of the collar and the cutter that determines the depth of the cut, as shown in *Fig. 52.*

Another way to do curve shaping is to use a template,

or pattern, and this you can make of some kind of hardwood and sandpaper the edge of it perfectly smooth. You then fix it to the face of the wood you are going to shape with some brads. The collar is set on top of the cutter on the spindle as at *B*.

Where the work is to be turned out in large numbers the template can be made of hard fiber as this can be used over and over without showing any appreciable signs of wear. By rubbing paraffin wax on the edge of the wood or fiber template it will take on a high polish and this will make it work easier and last longer.

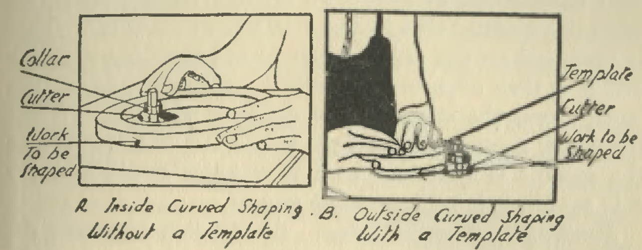


FIG. 52. HOW CURVED SHAPING IS DONE

Some Other Uses of the Shaper. There are several other useful operations that can be done on the shaper besides those of shaping plain and curved work. Chief among these are (*1*) matched tonguing and grooving, or *coping* as it is called; (*2*) fluting and reeding; (*3*) paneling, and (*4*) sanding.

Cutting Tongues and Grooves. In carpentry *matched, tongued* and *grooved* boards are used for doors and flooring, and in cabinet-making for tight fits, and also for many other purposes. For tongued and grooved work you must have three cutters—a single one for cutting the groove, and a double one with a washer between them for cutting the tongue.

Cutting Flutes and Reeds. The word *fluting* means a groove or channel that is cut lengthwise in a table leg or other work to give it a more artistic look, while the word *reeding* means a convex ridge cut on a piece of work, and it is, therefore, just the reverse of fluting. To do either fluting or reeding you need only to have cutters that are made for the purpose and you use them in precisely the same way as you do ordinary moulding cutters.

Cutting Panels. In cabinet-making a *panel* is generally understood to mean a thin board, say ½ inch thick or so that is cut down along the edges to, say, ¼ of an inch thick more or less. To do this on a shaper you must use a cutter that is *3* or *4* inches in diameter. This is mounted on the spindle just as is an ordinary cutter and it is then adjusted for height so that it will cut the work along the edges to the required thinness. Since the work must be done in a single cut it is clear that the spindle is subjected to a very great strain and for this reason it is seldom made use of.

Sanding or Sandpapering. By *sanding* is meant the smoothing off of rough surfaces with sandpaper, or its equivalent. *Sanding spindles* and *sanding drums* are made so that you can fix them on the spindle of your shaper and with them you can smooth work of whatever shape in far less time than you could sandpaper it by hand, and with practically no physical effort, and, what's more, it gives the work a factory look that you can't begin to get by doing it manually.

In using sanding spindles and drums the shaper spindle should run at the comparatively low speed of *1750 R.P.M.*, or the friction of the sand against the wood becomes so great it heats it to the kindling point, the abrasive paper becomes glazed, and together these untoward factors cause the work to be very poorly finished.

Chapter VIII

THE POWER DRILL PRESS

THE *drill press* is a machine tool for drilling holes in wood, metal and other materials, the drill or bit, being pressed into the work by means of a lever or a screw. A *bench drill press* is one that is made to set on a bench, while a *floor drill press* is one that sets on a column the base of which rests on the floor. While the drill press is, as the name indicates, designed primarily for drilling, there are many other jobs that it can do with equal facility, and chief among these mortising, shaping, routing and sanding.

The Parts of a Drill Press. A drill press consists essentially of (*1*) a base, (*2*) an upright support called a column, (*3*) an adjustable table, and (*4*) a movable head; the latter carries a movable steel quill, (*5*) a vertical steel spindle, that runs on ball bearings in the quill, and whose lower end carries (*6*) a chuck, (*7*) a stepped pulley, and, lastly, (*8*) a bracket that is fixed to the head and to which the motor is secured.

The Ward Drill Presses. *The Utility Drill Press.* This is the cheapest of the amateur drill presses, costing as it does the small sum of *$11.00*. It has a distance of *6* inches from the center of the drill to the column, and it will, therefore, drill to the center of a *12*-inch circle. The greatest distance of the drill chuck to the table is *7¾* inches, and its overall height is *26* inches.

The base, column, table and head are made of gray iron castings. The table is *8* inches in diameter, machine ground and slotted. The quill has a positive action lock, and the spindle, which is accurately ground, runs in self-lubricating, bronze sleeve bearings. The spindle is mounted in the quill, and it is fitted with a *3*-inch

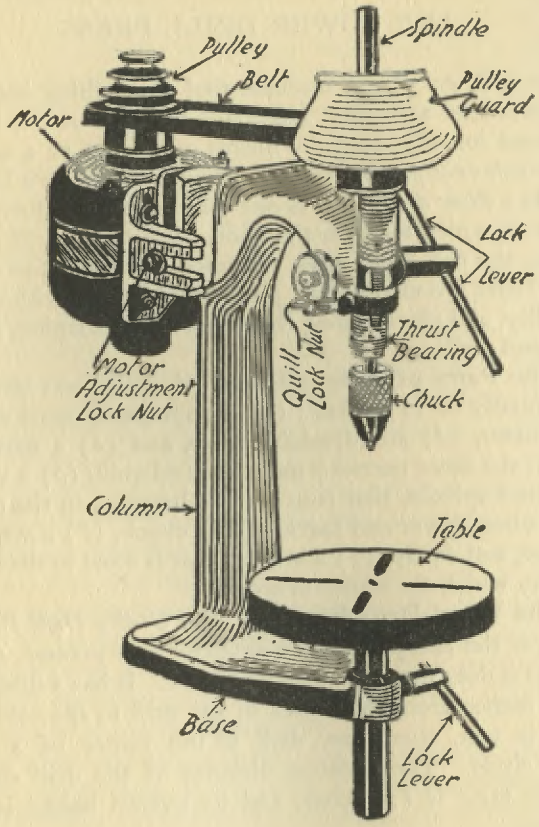


FIG. 53. THE WARD UTILITY DRILL PRESS

jaw chuck, which will hold drills and other drill press tools, whose shanks are from $\frac{1}{16}$ to $\frac{1}{2}$ an inch in diameter. The spindle has an up and down travel of

3$\frac{1}{2}$ inches, and the depth of the cut is indicated by a gauge on the quill in fractions of an inch.

For all ordinary work a $\frac{1}{4}$-*H.P.* motor will develop enough power to run the drill press, but to get the greatest service out of it you will need a $\frac{1}{3}$-*H.P.* motor. Uncrated and without the motor, the drill press weighs *32* pounds. It is pictured in *Fig. 53*, and the price of it, without the motor, *4*-speed pulley and belt, is *$11.00*.

The Heavy Duty Drill Presses. Two models of this drill press are made and these are (*1*) the bench press,

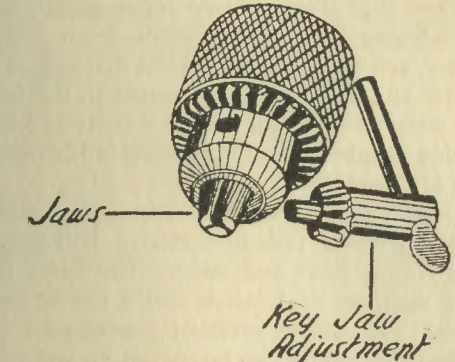


FIG. 54. JACOB'S KEY CHUCK

and (*2*) the floor press. The mechanical construction of these models is identical; the difference in them is that the *bench model* has a square base, a table top that is *8* by *8* inches square and it will drill to the center of a *16*-inch circle; its column is *2* inches in diameter, and it has an overall height of *36* inches. The *floor model* has a round base, a table top that is *11*$\frac{1}{2}$ inches wide and *12*$\frac{1}{2}$ inches long, and it will drill to the center of a *23*-inch circle; it has a column that is *2*$\frac{1}{2}$ inches in diameter and an overall height of *68* inches. The table of either of these models can be swung to an angle of *45* degrees in either direction.

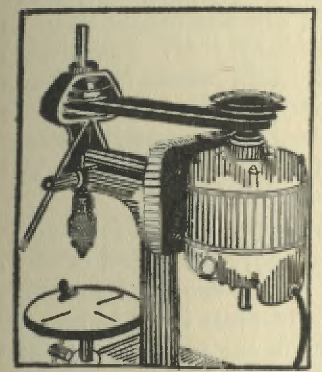
The quill is machined from a solid steel bar and ground within accurate limits; it has a depth gauge stop so that repeat work can be done with micrometric precision. The spindle is accurately ground and perfectly aligned. It is $\frac{5}{8}$ of an inch in diameter and has self-aligning, bronze sleeve bearings. It is fitted with a thrust ball bearing and this considerably reduces the power that is needed to run it.

The spindle is fitted with a *Jacob's key chuck*, see *Fig. 54*, and this gives a more rapid action, a greater grip and a longer life. It takes drills from $\frac{1}{16}$ to $\frac{1}{2}$ inch in diameter, and these fit any spindle that is $\frac{5}{8}$ of an inch in diameter and which has *16* threads to the inch. Its shipping weight is *78* pounds and it costs *$25.00*, while the shipping weight of the floor model is *123* pounds and the price of it is *$30.00*.

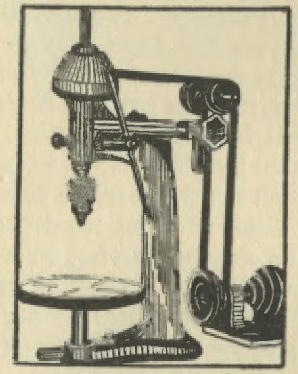
The Driver Drill Presses. *The Driver 500 Model Bench Drill Press.* This inexpensive drill press has a cast iron frame, head and table. The latter is round and has a diameter of *8* inches and it can be moved up and down. The quill is made of a solid steel bar with teeth milled in it and it can be moved up and down and locked in position. The spindle is $\frac{5}{8}$ of an inch in diameter and runs in oilless, bronze sleeve bearings with a ball thrust bearing at one end. An ordinary chuck that holds $\frac{1}{2}$-inch drills and bits, or a *Jacob's key chuck* can be used with it.

Both the spindle and the motor are fitted with *4*-stepped cone pulleys and this provides four speeds without changing the tension of the belt. These speeds are *760, 1300, 2250* and *4000 R.P.M.*, with a motor that has a speed of *1750 R.P.M.* The tension of the belt, and, hence the speed, can be varied by moving the motor bracket in and out of the frame.

Two kinds of drives can be used and these are where the motor is (*a*) belted directly to the spindle, and (*b*) to a countershaft which, in turn, is belted to the spindle, as pictured in *Fig. 55*. In the countershaft drive model the *idler pulleys*[1] are mounted on a pivoted bar so that they can be adjusted to keep the belt uniform in length.



A. A Direct Drive



B. A Countershaft Drive

FIG. 55. KINDS OF POWER DRIVES

While this drill press is not intended to do routing or shaping on a production basis it performs these operations in a satisfactory way where a job turns up that requires them. The shipping weight of the drill press is *32* pounds, and the price of it fitted with an ordinary chuck is *$11.00*, or with a Jacob's key chuck *$15.00*.

The Driver 700 Bench Drill Press. The steel column that supports the head and table of the drill press is *2* inches in diameter; the table is *8* inches wide and *9*

[1] These are the pulleys that change the direction of the belt from the vertical to the horizontal.

inches long, and it is grooved so that a guide or fence can be secured to it. The quill[2] is mounted in a pair of ball bearings, and, likewise, the spindle. The latter which has six splines instead of the usual single key-way, is $\frac{5}{8}$ of an inch in diameter and has a travel of *3½* inches.

The spindle is tapered at the end so that a Jacob's key chuck, which is a standard part of the equipment, can be used with it. The speeds at which the spindle can be run are *765, 1350, 2275* and *4000 R.P.M.* The distance from the center of the chuck to the column is *6½* inches and, hence, a hole can be drilled in the center of a circle that is *13* inches in diameter. The greatest distance from the chuck to the top of the table is *11½* inches, and from the chuck to the base is *17* inches.

Beside drilling, the drill press can be used for mortising, shaping, carving, routing, dovetailing, and sanding, and all of these operations will be described presently. The overall height of the drill press is *38* inches, the shipping weight without the motor is *95* pounds, and the price of it is *$27.00.*

The Driver 900 Model Drill Presses. Two of these models are bench drill presses and two of them are floor models. The mechanical equipment of the heads of all of them is alike. The table and the base are of the same size, *i.e., 9* inches wide and *10* inches long, and the former is adjustable so that it can tilt at any angle. The steel column is *2¾* inches in diameter, and the head, which is of close grained cast iron, is very rigid and machined to close tolerances. The belt guard is an integral part of the head, and a cap over the exposed upper end of the spindle keeps the oil from splashing out and it also serves as a safety factor.

The steel quill has a diameter of *1$\frac{3}{16}$* inches with teeth

[2] This is a hollow spindle or sleeve.

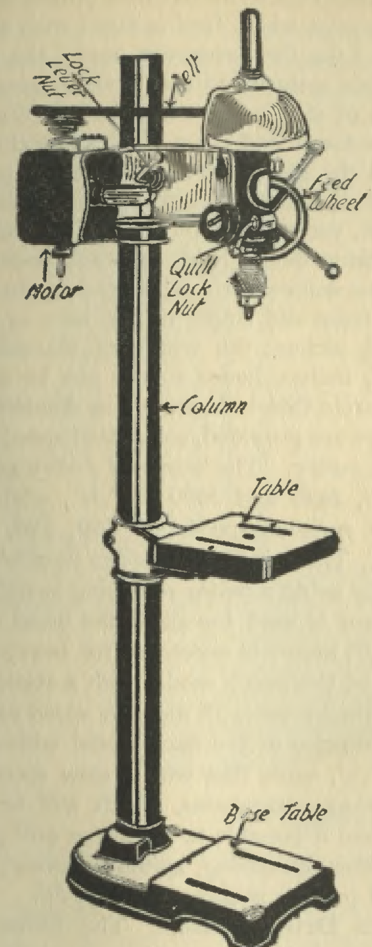


FIG. 56. THE DRIVER BALL BEARING PEDESTAL DRILL PRESS

cut in it to match those of the feed pinion which mesh with it. The pilot wheel feed is fitted with a calibrated depth stop. Like the foregoing model the spindle of this one has six splines and this tends to greatly reduce the vibration of it. It is ⅝ of an inch in diameter and tapered at the lower end for a Jacob's key chuck. Both the quill and the spindle are fitted with a pair of ball bearings, and the latter has a travel of *4* inches. There is a very soft, yet positive return spring action and an improved locking device holds it in any position.

The greatest distance from the chuck to the table is *12* inches, and from the chuck to the base of the bench model is *17½* inches; the center of the chuck to the column is *7½* inches, hence a hole can be drilled in a center of a circle that is *15* inches in diameter.

Two pulleys are provided, a standard speed pulley and a slow speed pulley. The *standard pulley* gives speeds of *600, 1250, 2440* and *5000 R.P.M.,* while the slow speed pulley runs at speeds of *480, 940, 1300* and *2900 R.P.M.* The spindle can be run in either direction for shaping by using a motor reversing switch. A ¼- or a ⅓-*H.P.* motor is used for all of the usual operations, while a ½-*H.P.* motor is necessary for heavy work.

The price of the bench model with a standard pulley is *$35.00,* while the one with the slow speed model pulley is *$37.00*; the price of the floor model with a standard pulley is *$37.50,* while that with a slow speed pulley is *$39.50.* Various accessories, which will be explained presently, make it possible to use these drill presses for shaping, routing, mortising, spindle carving, etc. One of these drill presses is shown in *Fig. 56.*

The Delta Drill Presses. The Delta Company makes an even half dozen different models of drill presses from one suitable for the small workshop to a double-spindle drill press for production work.

The Double-Duty Bench Drill Press. This drill press is designed and built for the small workshop, and you can use it for various operations. It has a table that is *8* inches square, and a height from the chuck to the

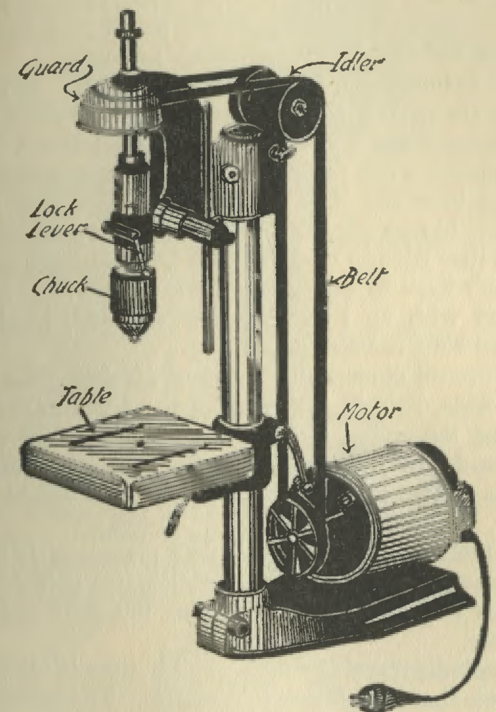


Fig. 57A. The Delta Double-Duty Drill Press

table of *11½* inches. The chuck will take drills and other bits up to $\frac{15}{32}$ of an inch, and it will drill the center of a circle that is *11½* inches in diameter, while its overall height is *34* inches.

The regular spindle is fitted with a Delta grip chuck, and this costs *$3.25* extra, but you can get a special spindle with a ½-inch Jacob's geared chuck and key for *$6.75* extra. The spindle is ball bearing and the way it is mounted in the quill as shown in *Fig. 57*. It has six speeds, to wit, *750, 1300, 1050, 1825, 2225* and *3150 R.P.M.* It has a shipping weight of *50* pounds and it sells for *$18.75* without the chuck or motor.

The Triple-Duty Drill Presses. These two drill presses are exactly alike except that one of them has a short column and a square base, and, it follows, it is a *bench model*, while the other one has a long column and a round base and it is, therefore, a *floor drill press*. Each one has an adjustable tilting table, a free floating spindle that runs in double-sealed ball bearings, so that you don't have to worry about oiling them. It is also provided with an adjustable depth model, graduated quill and a micrometer depth stop.

The overall dimensions of the bench drill press is *10* inches wide, it is *21* inches from the front to the rear including the motor, and *36½* inches high. The width, front, and rear dimensions of the floor model are the same as the bench model, while its overall height is *68* inches.

The table of either of these drill presses is *10* by *10* inches square, and the vertical table travel of the bench model is *11½* inches, while that of the floor model is *43* inches.

The spindle travel is *4* inches and it drills to the center of a circle that is *14* inches in diameter. The spindle has four speeds and these are *590, 1275, 2450,* and *5000 R.P.M.* The shipping weight of the bench model is *110* pounds and that of the floor model is *145* pounds. The first named drill press costs *$27.75*, and the last named *$32.85*. These prices do not include their respective motors. The floor model is shown in *Fig. 58*.

The Slow Speed Drill Presses. Where metals are to

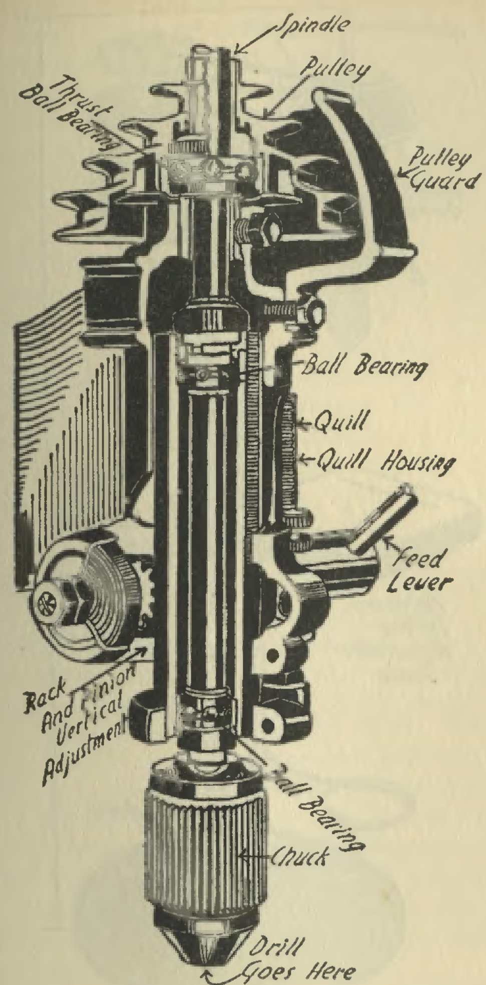


FIG. 57B. HEAD OF THE DELTA DRILL PRESS

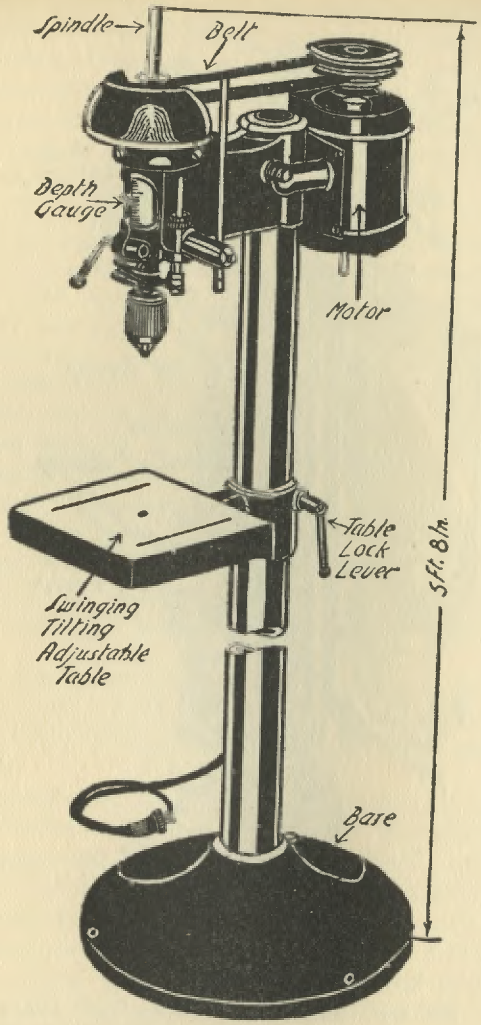


FIG. 58. THE DELTA TRIPLE DUTY DRILL PRESS

be drilled a much slower speed must be used than with wood. Again, these two drill presses are identical except that one is a bench model and the other is a floor model, and they are made exactly like the models of the triple-duty drill press that I described above except the spindle of the former has a range of speed of from *590* to *5000 R.P.M.*, while in the latter it runs from *390* to *2050 R.P.M.* The bench model sells for *$29.85*, and the floor model for *$35.00*.

The Double-Spindle Sensitive Drill Press. This drill press consists of two identical units mounted side by side on a single base, and it is made especially for production work. These units can be had for woodworking, *i.e.*, high-speed models, or for metal working, *i.e.*, slow-speed models. The price of the high-speed drill press complete with two $\frac{1}{2}$-inch geared chucks, two $\frac{1}{3}$-*H.P.* alternating current repulsion-induction motors, built in switches and switch rods, cords, plugs, counterweights, chains, and ball bearing rollers, on a heavy cast iron base, is *$137.50*.

About Bits and Drills. What we call a *bit* is specifically a tool that is used for boring holes in wood and to do this it is used in a brace or a drill press. A *machine bit* is a bit that has a pointed end and two cutting lips, and these cut the fibers of the wood you are boring and make perfectly smooth holes. Now there are several kinds of machine bits and chief among these are (*1*) the center or spur bit, (*2*) the extension lip bit and (*3*) the Forstner bit. The *spur bit*, see *Fig. 59*, is made with either plain or extension bits, and these are the kind that are generally used with amateur press drills; they have $\frac{1}{2}$-inch round shanks to fit the standard $\frac{1}{2}$-inch machine chucks, and they will bore holes from $\frac{1}{4}$ to $\frac{3}{4}$ of an inch in diameter.

The *Forstner bit* will bore smooth round or square holes and it is used for scroll and twist work. It will bore any kind of a circle and is especially useful for working hardwood. It is guided by a circular rim instead of its center and, it follows, it can be guided in any direction regardless of the way the grain runs or the knots there are in the stock.

The *hollow chisel and bit* is a combination that enables you to make square end mortises. It consists of (*a*) a

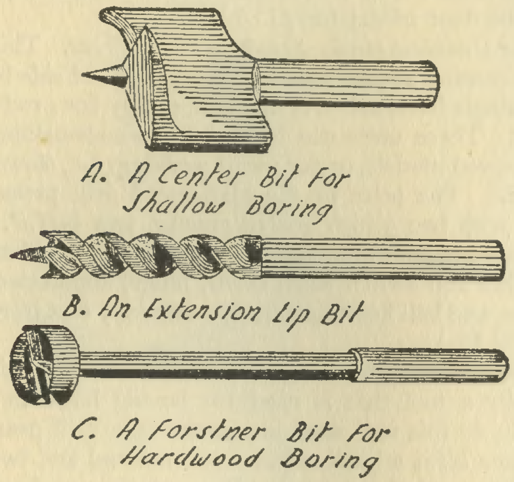


FIG. 59. KINDS OF WOODWORKING BITS

hollow chisel, (*b*) a hollow chisel bit and (*c*) a chisel holder. The bit operates inside of the chisel and is driven by the drill press spindle, while the chisel itself is held stationary in the holder, and all of which is shown in *Fig. 60*.

The *router bit*, see *D*, is used for routing, carving, round-end mortising, and grooving work of all kinds. It is made of high grade tool steel and is carefully tempered. Finally the *plug cutter* is a tool for making short dowels and plugs for screw holes. It is largely

used by signmakers for cutting periods and dots for *i's*, and by boat builders for cutting deck plugs.

Drills for Metals. There are three chief kinds of drills for drilling holes in metals and other hard substances, and these are (*1*) flat drills, (*2*) fluted drills and (*3*) twist drills.[3] *Flat drills* are useful for drilling tile and marble. *Fluted drills* are especially adapted for drilling brass, copper and softer metals in general, as

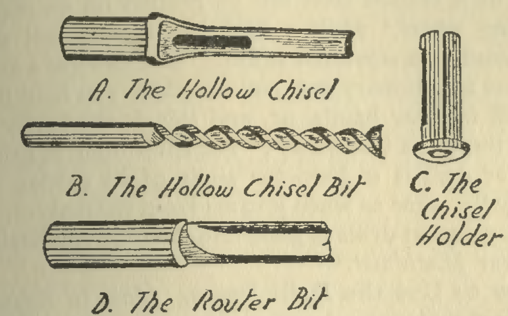


FIG. 60. THE HOLLOW CHISEL AND BIT AND THE ROUTER BIT

they will neither run ahead nor grab, as it is called. There are several kinds of *twist drills* and these are used for drilling iron, soft steel, etc.

The *reamer* is shaped very much like a twist drill but it is slightly tapered and usually has fluted cutting edges. It is employed to enlarge holes that have been made with a drill. The *countersink* has a cutting point very like (*a*) a flat metal drill, or (*b*) a rose point with deeply milled cutting edges. It is used for making a flaring enlargement of the mouth of a hole. Lastly, the *counterbore* is used for enlarging a part of the length of a hole.

[3] All of these drills are described in detail in my book *The Amateur Machinist* published by the D. Appleton-Century Company, New York and London.

How to Sharpen Bits and Drills. To sharpen a bit or a drill by hand is a very ticklish job if you grind it. Where the bit or the drill is only a little dull you can, of course, sharpen it by simply rubbing the cutting edges with an oil stone, or file them a little and then hone them with an oil stone.

But when a bit or a drill becomes quite dull you must grind it on a grinding wheel. A bit or a drill that is made of a carbon steel can be ground on an *alundum* grinding wheel,[4] while a high-speed steel drill should be ground on a *crystolon* wheel.[5] You can use a grinder that has a stationary rest and on which you hold the bit or drill in your hands, or, and this is the better way, clamp them in a tool holder. The chief thing in grinding a bit or drill is to keep the angle of its cutting edges exactly the same as when it came from the makers. The way to sharpen drills is gone into detail in my book *The Amateur Machinist.*[6]

How to Use the Drill Press. *How to Adjust It.* The first thing you do when you are going to use the drill press is to adjust *the table* to the proper height for the work you are going to do. This is done by turning the ball-crank counter-clockwise until it releases its hold on the table bracket, and then sliding the table up or down; when it is in the right position turn the ball-crank up tight. Should you want to set the table at an angle, unscrew the nut that is under it, take out the pin, then tilt it to the right or left at whatever angle you want it to be, and screw the nut up tight again.

The *spindle* can be moved up and down through a certain limited distance by a lever that has a small

[4] These grinding wheels are made by the Morton Co., 53 Park Place, New York City.

[5] *Ibid.*

[6] This is published by D. Appleton-Century Co., New York and London.

pinion on the end of it and which meshes with the rack that is cut on the quill. To hold the spindle at a given point you have only to screw up the ball crank that operates the feed lock and this greatly facilitates the operation when you are using the router.

Should you want to drill a number of holes to the same depth you can do so by means of the stop collar or the feed lock, and to use either one accurately you have only to raise or lower the movable pointer until it rests on the mark of the scale which is on the quill, when it will indicate the depth the drill will cut.

How to Lubricate it. Where the spindle runs in ball bearings they are packed with vaseline and this will lubricate them for *200* hours or more of constant running. At the end of this time you must repack them with pure, acid-free vaseline. To do this you have to release the set-screw on the collar, then slip the latter up on the spindle and repack the upper bearing with vaseline. This done, lower the spindle, repack it with vaseline and then slip it back into place and tighten up the screw on the collar. *Never put any kind of a lubricant but vaseline on ball bearings.* Finally, rub a little vaseline on the quill and the rack teeth of it once in a while.

Boring Wood and Like Materials. As I have previously mentioned you should use a *machine spur bit* to bore holes in wood, fiber, and other more or less soft materials. This kind of a bit makes a perfectly clean-cut and round hole, whereas if you use a drill that is made for drilling metals, it will usually cut a larger hole than its own diameter, and instead of being perfectly round it will be oval-shaped. The best speed at which the spindle should run when boring wood with a machine spur bit is *400* or *500 R.P.M.*

Mortising with the Drill Press. It is not at all hard to mortise, *i.e.,* cut a square hole in a piece of work with a drill press if you use a square hollow chisel, a bit that fits inside of it and a holder. The bit is mounted in the chuck and it is rotated by the spindle just as an ordinary bit is, while the chisel remains stationary.

The bit has no point to guide it and the end of it spreads out so that it fits closely into the square end of the tapering hollow chisel. There is a slot cut in one side of the chisel to let the chips come out, and you must see to it that it does not get clogged up. In order to make a clean cut mortise without having to use much pressure on the cutting edges, the chisel must be as sharp as possible. To keep the chisel sharp you can use a little tapering grinding stone and this you mount in the chuck of the drill press and run it at a high speed. The chisel must be sharpened only on its *inside edges*, and to do this you hold the cutting end of it up and over the stone.

To use the mortise chisel and bit the work is placed on the table so that the spot you want to mortise is directly under the chisel and bit and then run it at a speed of about *500 R.P.M.* Pull down on the lever or turn the wheel that moves the quill and the spindle firmly and slowly when the bit will bore out a round hole and the chisel will cut away the corners and make a square hole of it.

How Tenoning Is Done. A *tenon* is a reduced end of a piece of wood that fits into a mortise. To make a tenon with a drill press you use a *router*, that is a revolving cutter which you mount in the chuck and this routs, that is, cuts out the surface of the wood. To make an accurate tenon with a router you must first saw the end of a piece of wood to the required depth on the sides and then cut away the wood with a router.

Other Router Jobs. There are numerous other operations you can perform with a router mounted in the chuck of a drill press, the chief ones of which are

mortising without a chisel and bit, shaping, rabbeting, fluting, carving, heading, making ornamental rosettes and buttons, moulding, dovetailing, and sanding with a disk or a drum.

When you use your drill press for *shaping* you must put a large enough pulley on the shaft to give the spindle a speed of *5000 R.P.M.*, or higher, while for *router jobs* the router should have a speed of *7000 to*

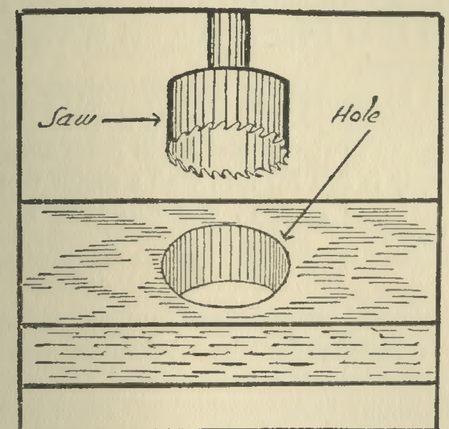


FIG. 61. HOW TO SAW OUT DISKS AND CIRCULAR HOLES

8000 R.P.M. You can do ordinary straight shaping by clamping a guide on the table, but for special shaper work you must have a larger table and you can make one of sheet steel or wood, and bolt it to the iron table of your drill press. You will also need an adjustable guide and guard and, likewise, a hold-down.

In using your drill press for doing any of the above jobs the chuck must screw on to the end of the spindle, and do not use one that fits on a taper spindle. The reason for this is because at high speeds a chuck on a taper spindle will work loose. If, therefore, your drill press has a taper spindle you can get an *adapter* for it and a *collet chuck*, which is especially made to hold router cutters, and which are safe at high speeds.

Finally, How to Saw Circular Holes. The *hole saw* is a very useful tool for your drill press for with it you can saw out holes having a diameter of 6 inches or so. It is made in two different ways and these are (*a*) a hollow disk with a thin edge in which teeth are cut as pictured in *Fig. 61*, and (*b*) a solid disk with a circular groove cut in its lower surface and in which the saw blade is secured.

It must be operated at a comparatively low speed, say in the neighborhood of *100 R.P.M.* In order to reduce the speed of the ordinary drill press whose lowest speed usually is *500 R.P.M.*, with a motor that runs at a speed of *1750 R.P.M.*, you will have to install a countershaft.

Chapter IX

POWER SANDERS AND GRINDERS

THE word *sandpaper* is used to mean (*1*) a paper that is covered on one side with pulverized sand which is glued to it, and (*2*) to smooth or polish a piece of work with sandpaper. The verb *sanding* has, in recent years, come to be used instead of *sandpapering* and, it follows, a *sander* is a *sandpapering* machine.

Now sanding or sandpapering by hand is a long and tedious process, and since power woodworking tools have become so popular it is all but an absolute necessity. The lathe, shaper, drill press, or almost any kind of power tool that has a rotating spindle or a shaft, can be used for sanding work, and sanding spindles and drums are made to be employed with them.

Where you have any considerable amount of sanding to do a *belt sander* will make a far better job and in a smaller fraction of the time than it would take you to do it by hand, or even with an accessory sander; moreover, it makes a flawlessly smooth surface, it keeps the lines sharp and the edges square, and, like the man on the flying trapeze, it does the job with the greatest of ease.

The Ward Belt Sanders. *The Stationary Belt Sander.* This sander consists of a sanding belt that runs over non-slip rubber covered wheels, and these are held in alignment by a pair of adjustable steel rods which are secured to a heavy cast iron base. The steel shafts of the wheels run in long self-lubricating sleeve bearings and these rotate at a speed of *1200 R.P.M.*

The table is made of heavy cast iron and this is held in place by a pair of large upright steel rods. The top of it is surface ground so that it is absolutely true and there is the smallest amount of friction between it and the moving belt. The table is *4* inches wide and *8* inches long and it uses a sanding belt that is *3* inches wide and *30* inches long.[1] It is pictured in *Fig. 62*, and it costs *$5.00*.

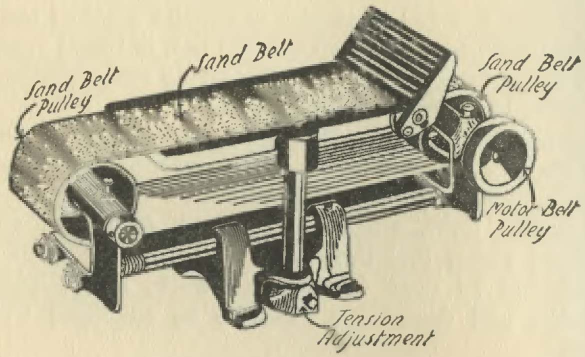


Fig. 62. The Ward Stationary Belt Sander

The Portable Belt Sander. As its name indicates this sander can be moved about wherever you want to use it. It is operated by a flexible shaft that runs from a motor and it is made very like the sander I have just described but it is fitted with a knob and a handle, and looks and works somewhat like a jack-plane. Instead of holding the work on top of the sanding belt you push the sander over it just as you do a plane. To get the best results the belt should run at a speed of *1750 R.P.M.* It has a length of *17* inches, a shipping weight of *14* pounds, and it sells for *$9.00*.

The 6-inch Belt Sander. This sander can be used as a *disk sander* or a *belt sander* and, it follows, any

[1] Sanding belts for this machine can be had in fine, medium and coarse grain for *35* cents each.

kind of work can be sandpapered with it. A feature of it is that the sanding belt can be run either vertically, horizontally, or at an angle. Thus the table can be taken off and the sander can be used horizontally for sanding long pieces of work with the grain, or it can be used vertically for butt sanding or sanding joints.

The table is $6\frac{1}{2}$ by *10* inches on the sides and it is pivoted to a trunnion so that it can be tilted *15* degrees one way and *45* degrees the other. It has a pointer that

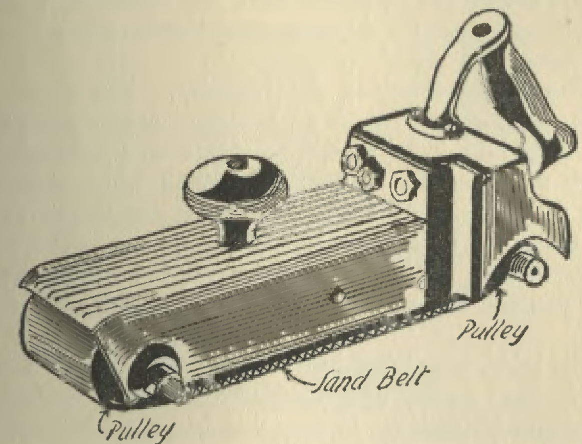


Fig. 63. The Ward Portable Belt Sander

moves over a graduated scale and this enables you to tilt the table with accuracy and, hence, you can sand straight angles. By tilting both the table and the miter gauge you can sand angle joints and tapers on patterns.

The shafts run on self-lubricating ball bearings which are provided with oil reservoirs, and balanced rubber covered wheels are rigidly keyed to them. The sanding belt[2] is *6* inches wide and $44\frac{1}{2}$ inches round, and there

[2] Fine, medium and coarse belts can be had for *90* cents each.

is an adjustable belt device, see *Fig. 63*, that is worked with a hand-knob on each side, and by means of which you can easily align the belt and give it the proper tension.

The sander is fitted with a $2\frac{1}{2}$-inch pulley, and for all ordinary sanding operations it should be run at *1200 R.P.M.* or thereabouts. To run it at this speed with this sized pulley the motor must have a $1\frac{3}{4}$-inch pulley on it and make *1750 R.P.M.* The overall dimensions of the sander are $8\frac{1}{2}$ inches high, $15\frac{1}{2}$ inches wide and *22* inches long. Its shipping weight is *35* pounds and the price of it is *$18.75*.

The Delta Sanding Accessories. *The Sanding Disk and Table.* This is an accessory device that you can use with a lathe, or lacking this, with a lathe headstock that you can buy separately and which doesn't cost very much. The complete device consists of (*a*) the table, (*b*) a lathe headstock, (*c*) a short U-bed for the headstock, (*d*) a sanding disk, and (*e*) a miter gauge, and you can buy all of these parts separately[3] or as a unit.

The table, which is *5* inches wide and *12* inches long can be used on any of the lathe beds that are made by the *Delta Company*. In case you haven't a lathe you can get a four-speed, *9*-inch lathe headstock with a $\frac{1}{2}$-inch spindle, and mount it and the table on a short U-bed that is *19* inches long. The sanding disk, which

[3] The pieces of the separate parts are as follows:
(a) Sanding and boring table only, *$5.25*.
(b) Four-speed *9*-inch lathe headstock only, *$7.85*.
(c) Four-step motor pulley, *$1.25*.
(d) Short U-bed for headstock, *$3.00*.
(e) Miter-gauge, with graduated head, *$1.25*.
(f) Sanding (Garnet) disk, fine or coarse, per dozen, *$1.25*.
(g) Delta Distic for cementing sanding disk to face of rotating disk, per stick, *$0.60*.

is $8\frac{1}{2}$ inches in diameter, has a machined surface and it will fit any $\frac{1}{2}$-inch spindle. The disk is secured to the surface of it with a cement that is made for the purpose. Finally, the miter gauge has a graduated head and it is made to fit the sanding table.

The Band-Saw Sanding Attachment. This is the ideal sander for smoothing the edges of scroll and band-saw work for all you have to do is move the edges of the work along and against it at about the same speed

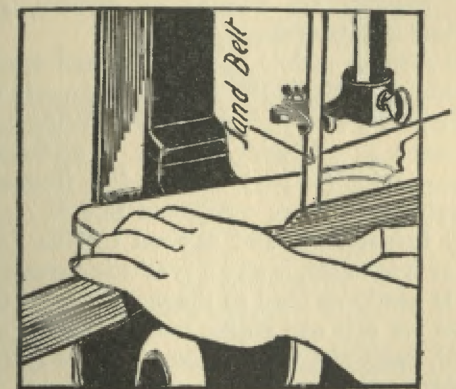


FIG. 64. DELTA BAND SAW BELT SANDING ATTACHMENT

as if you were sawing it, the while pressing it gently against the sanding belt.

The attachment, which is shown in *Fig. 64*, consists of a sanding belt $\frac{1}{2}$ an inch wide and of the same length as the regular *10*-inch band saw blade. The belt runs in a special guide which is used instead of the regular band saw blade guides. Two different kinds of guides are furnished—one for flat work and one for curved work. The sanding attachment for the *10*-inch band saw including two guides, guide bracket and one belt, sells for *$2.00*. The sanding bands, each of which are *66* inches long, cost *$1.25* for half a dozen.

Kinds of Sanding Paper. *Sandpaper,* which is made of *sand,*[4] is seldom used at the present time by woodworkers, as *garnetpaper* has taken its place. This latter paper always retains its razor-edge and, hence, it does not take any great amount of pressure to produce the desired results. For this reason it is by far the best abrasive for wood; it cuts cleanly and quickly, leaves no grooves or scratches and does not burn the work. *Garnets* are formed of calcium, aluminum, silicon and oxygen ($Ca_3Al_2(SiO_4)_3$).

Flint paper is mainly used on belt and drum sanders for finishing soft woods. *Flint* is an impure variety of quartz and is a very hard substance. What goes by the trade name of *Electric Abrasive* is *alumina,* that is, aluminum oxide (Al_2O_3) which is free from impurities, is a high temperature compound that is made in the electric furnace. It and calcium carbide (CaC_2), or *Obrac* as it is called, is also a synthetic furnace abrasive, and it is nearly as hard as the diamond. It is an ideal abrasive for soft and plastic materials, such as leather, celluloid, paint and varnish films and the softer metals.

Power Polishing Heads and Grinders. *The polishing head* is employed chiefly for polishing, buffing and brushing metals, and it can also be used for sharpening small tools, and sawing and drilling operations. The *grinder* is a much larger machine and is intended for grinding metals, tool sharpening and rag wheel buffing.

Polishing heads and grinders are very simple machines, and they are made exactly alike in that both of them consist of a spindle or shaft that runs in bearings and these are mounted on a base. The chief difference between a polishing head and a grinder is that the former is very small and used for exceedingly light work, while the latter is large and is used for heavy work.

[4] *Sand* is fine, loose grains of *quartz* and this, in turn is formed of *silica,* that is *silicon dioxide* (SiO_2).

About Polishing Heads. *The Standard Polishing Head.* This polishing head has a gray iron base, a ½-inch machined steel spindle with a threaded tapered holder on one end of it that will take wheels whose holes are from ¼ to ½ an inch in diameter, and a threaded arbor with nuts and flanges, that will hold wheels having holes ½ inch in diameter, and on the end of which you can screw a little *3*-jaw ¼-inch chuck.

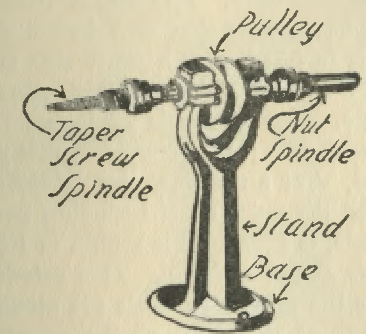


FIG. 65. THE STANDARD POLISHING HEAD

It will hold wheels up to *6* inches in diameter but *4*-inch wheels are the size that is generally used on it, and these will be described presently. It has a shipping weight of *3* pounds, and costs *$1.00* or less with the chuck. It is pictured in *Fig. 65.* You can get a *saw table* that can be attached to the top of the polishing head, that is *8* by *8* inches on the sides, made of stamped steel together with a miter gauge for *50* cents extra, and a *4*-inch saw will cost you *30* cents additional.

The Heavy Duty Polishing Head. This is a far heavier polishing head than the one I have just described and, it follows, it has a much greater capacity.

The base acts as a belt guard and the spindle can be driven from behind or below it. The shaft is $\frac{1}{2}$ inch in diameter and runs in self-lubricating sleeve bearings. It has a $2\frac{1}{4}$-inch pulley fixed to it and it is driven by a *3*-inch pulley on the motor or line shafting, and this should run at *1750 R.P.M.* The shipping weight of the polishing head is *9* pounds, and it costs *$3.00* including a grinding wheel that has a $\frac{1}{2}$-inch face and is *4* inches in diameter, a *4*-inch buffing wheel and a cake of polishing compound.

The Ward Grinders. *The 6-inch Bench Grinder.* This grinder has a base that is *5* inches wide and *6* inches long, it is fitted with a shaft that is $\frac{1}{2}$ inch in diameter and *8* inches long, and which runs in bronze sleeve bearings. The pulley is $1\frac{3}{4}$ inches in diameter and has a $1\frac{3}{4}$-inch face; it is grooved so that you can use either a round, V or a flat belt. Its shipping weight is *18* pounds and the price of it including two vitrified[5] grinding wheels, is *$5.00*. It is shown in *Fig. 66*.

The Electric Bench Grinder. This grinder is *direct driven*, that is the grinding wheels are mounted on the projecting ends of the shaft of the armature of the motor. It is large and powerful enough to do all kinds of bench grinding, for not only the amateur craftsman but for garages and small production shops. The motor is wholly enclosed and is sealed against dust, grit and grindings, and as it will develop its full rated *H.P.*, it will not heat up. The rotating element is accurately balanced and it runs without vibration where it is idling or under load.

The shaft is $\frac{3}{4}$ of an inch in diameter and *8* inches long and it runs in heavy oil-packed bronze sleeve bearings. The right-hand wheel guard and tool rest are fixed, while

[5] Vitrify means like glass and wheels of this kind resemble glass.

the left-hand wheel guard and tool rest are adjustable. The grinder is made in two sizes, *i.e.*, one of which has a $\frac{1}{3}$-*H.P.* motor, and this costs *$19.50*, and the other a $\frac{1}{2}$-*H.P.* motor, the price of which is *$22.50*. These prices include a fine and a coarse grit vitrified grinding wheel, a toggle switch in the base, and a *3*-conductor

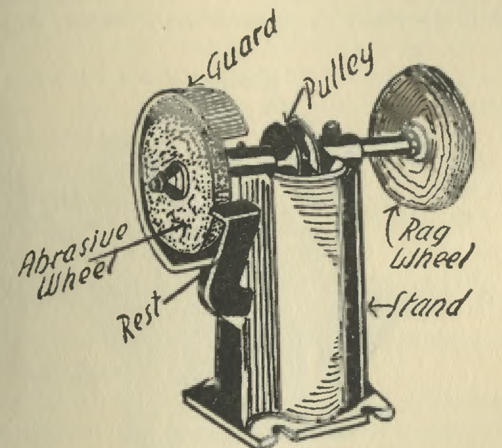


Fig. 66. The Ward Heavy Duty Bench Grinder

cord with a plug. In either case the motor runs on a *110*- or *120*-volt, *60*-cycle alternating current only.

The Driver Grinders. *The 4-inch Bench Grinder.* The shaft of this grinder is $\frac{1}{2}$ inch in diameter and runs on bronze sleeve bearings. The grinding wheels have $\frac{1}{2}$-inch faces and are *4* inches in diameter. The grinder has fixed rests and can be driven from above, below or behind. It costs the small sum of *$2.00* without the wheels.

The 6-inch Bench Grinder. This grinder has a shaft that is $\frac{5}{8}$ of an inch in diameter and it is turned down at the ends to $\frac{1}{2}$ inch so that it will take any of the standard driver accessories. The bearings are $\frac{5}{8}$ of an inch in diameter and are provided with grease reservoirs. The guards and tool rests are adjustable so that you can use them with either *4*- or *6*-inch wheels. The price of this grinder without the wheels is *$2.75* and with them *$4.75*.

A feature of this grinder is the *cut-off wheel unit* which is provided as an accessory. When this attach-

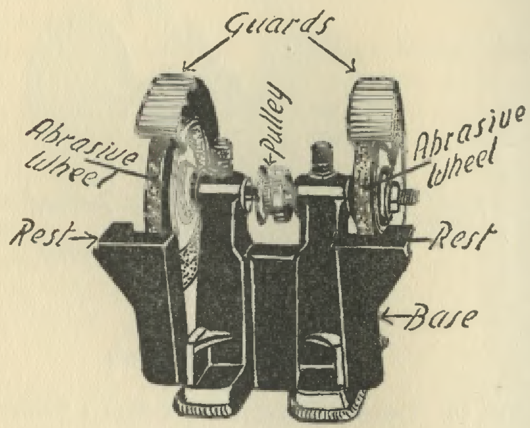


FIG. 67. THE DRIVER 6-INCH BENCH GRINDER

ment is secured to the frame of the grinder you can cut iron, steel, brass and copper rods, also tubing, springs, etc., as well as tile, brick, terra cotta, and like materials. The cut-off unit includes a base, a clamping attachment for the bracket, an *8*-inch cut-off wheel for tile and ceramics in general, and an eye-shield made of non-shattering glass. It is shown complete in *Fig. 67*, and the list price of it is *$5.90*.

The Ball Bearing 6-inch Bench Grinder. This grinder is built to precision standards and it will remain accurate for an indefinite length of time. The ball bear-

ings are protected by dust caps which prevent abrasive dust and dirt from getting into them. They are also fitted with spring oilers which make the lubrication of them a simple matter. The spindle is $\frac{1}{2}$ an inch in diameter at each end to take the various *Driver accessories*.

The tool rests are fully adjustable, are accurately fitted and properly positioned. The guards are close fitting, and the right wheel, guard and tool rest can be easily taken off and a sanding table and disk put on in the place of them when it is converted into an excellent sanding machine.

The grinding wheels have $\frac{3}{4}$-inch faces and are *6* inches in diameter. The regular equipment includes a *3*-speed V-pulley and a *42*-inch endless belt. The overall dimensions of the grinders are *10$\frac{1}{2}$* inches high and *11* inches long. The price of the grinder, less the grinding wheels, guards, rests, etc., is *$5.00*, with all of the above attachments it is *$8.00*, and the sanding attachment unit is *$4.00* extra.

The Electric Bench Grinders. Two different sizes of this grinder are made and, it follows, they are differently priced, but in construction they are practically alike. The grinder is fitted with guards that conform to the latest requirements of the *Industrial Safety Code*. The glass shields are made of non-shatterable glass and the cooling caps are standard equipment. It has large grease-sealed ball bearings, and these and the motor are fully enclosed and protected from dust. It is shown in *Fig. 68*.

The *No. 1* size has a *110*-volt, *60*-cycle, alternating current motor that develops $\frac{1}{3}$ *H.P.*, and runs at a speed of *3450 R.P.M.*, and it costs *$26.00* without the abrasive wheels, or *$28.50* with them. The *No. 2* size has a *110*-volt, *60*-cycle, alternating current motor of the *capacitor type*, that is, it has a condenser mounted on it, and this is permanently connected in circuit, both when it (the motor) is being started up and when it is running and under load; this gives it an overload capacity that is sufficient to enable it to do all kinds of heavy work without the danger of the motor burning out. This grinder runs at a speed of *3500 R.P.M.*, and develops $\frac{1}{2}$ *H.P.* It has a high efficiency and, it follows, a low

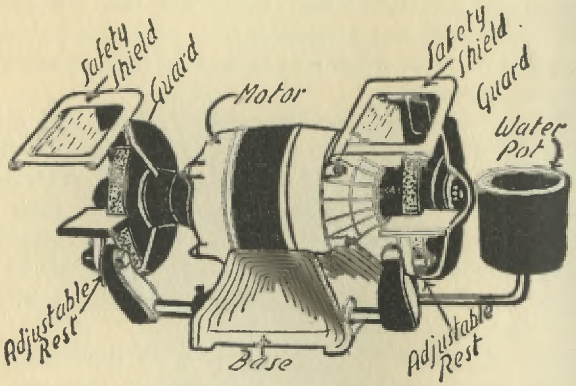


FIG. 68. THE DRIVER HEAVY DUTY DIRECT DRIVEN BENCH GRINDER

current consumption. The price of the grinder is *$37.50* without the grinding wheels.

The Delta Grinders. *The Belt Drive Bench Grinder.* This grinder has a substantial cast iron base and drive housing. It is equipped with precision double-seal ball bearings and they will remain oiled as long as they last. A long spindle that is $\frac{7}{8}$ of an inch in diameter at the center, is used so that there is plenty of room between the wheel guard and drive housing.

The housing is so designed that you can use a single or a double belt and pulley, and it can be driven either

from below or behind. The purpose of using a double belt is, of course, to provide more positive power. Very substantial and efficient tool supports are fitted to the guards and you can adjust them to suit any kind of free-hand grinding. The construction of the supports is also such that you can grind on the face of the wheel or on either side of it. They are finely machined, adjustable for wear and can be detached in a moment should you want to use any other attachment in their place. The wheel guards are efficiently designed to conform to the *Industrial Code* and only the actual section of the wheel where the grinding takes place is exposed. It has a built-in dust chute which discharges the abrasive particles to the rear of the grinder. A cast iron water pot, $4\frac{1}{2}$ inches high and $4\frac{1}{2}$ inches in diameter, is mounted in a swing bracket.

The abrasive wheels furnished with this grinder are of the highest grade, and are precision balanced to the $\frac{1}{100}$ of an inch-ounce, which insures their running without vibration and this goes a long way toward enabling you to do accurate grinding. The face of the wheels are $\frac{3}{4}$ of an inch and they have a diameter of *7* inches.

You can use this grinder anywhere at any time regardless of the extraneous lighting conditions as it has a *Twin-Light* lamp attachment. This consists of a pair of bayonet-type bulbs, each with a polished reflector, and which sets in a compartment at the end of the safety shield. These lamps flood the wheel and the work you are grinding with light on top and both sides of it. Each shield has a double-thick safety-glass panel in it which is held in with spring clips, and in case of breakage it can be easily and quickly replaced. The construction of it is such that it gives you an unobstructed view of the work you are grinding.

A flexible armored cable leads the current from the feed-wires to the lamp sockets, and there is a toggle-switch for controlling the lamps. Since this is a belt-driven grinder it follows that you can use a direct or alternating current motor to drive it with.

The grinder has a shipping weight of *58* pounds, and costs complete, except for the pulley, V-belt and lamp bulbs, *$25.75*. The V-belt for it sells for *85* cents, and a *5*-inch motor pulley for *75* cents. With a motor pulley of this size a motor that has a speed of *1725 R.P.M.* should be used and the grinder should run at a speed of not more than *3400 R.P.M.* For the average job a $\frac{1}{3}$-*H.P.* motor can be used, but for heavy work a $\frac{1}{2}$-*H.P.* motor is required to drive the grinder.

The Direct Drive Bench Grinder. The mechanical construction of this grinder is in all essential respects exactly like that of the *Belt Drive Bench Grinder* which I have just described. The differentiating feature between them is that in the latter the motor is mounted directly on the base and that a single shaft serves for the armature and the grinding wheels and, hence, there is no loss of power. *The Direct Drive Bench Grinder* with a $\frac{1}{3}$-*H.P.*, *110*-volt, *60*-cycle alternating current motor, complete with two $\frac{3}{4}$- by *7*-inch *Aloxite* wheels, and all of the other accessories except the electric bulbs, costs *$42.50*.

The Direct Drive Pedestal Grinders. The head of this grinder is virtually identical with the type I have described above. It is an accurately built general purpose grinder and was designed primarily for the school shop and light production work. The base, which is of cast iron, is *14*$\frac{1}{2}$ inches wide by *15*$\frac{1}{2}$ inches long, and it is cast integral with the column.

It has a tool tray *12* by *18* inches on the sides and in this are two *4* by *4*-inch water pots. The tool rests, which are *39* inches from the floor, are fully adjustable both vertically and horizontally. Three models of this grinder, see *Fig. 69*, are made, and all of them are struc-

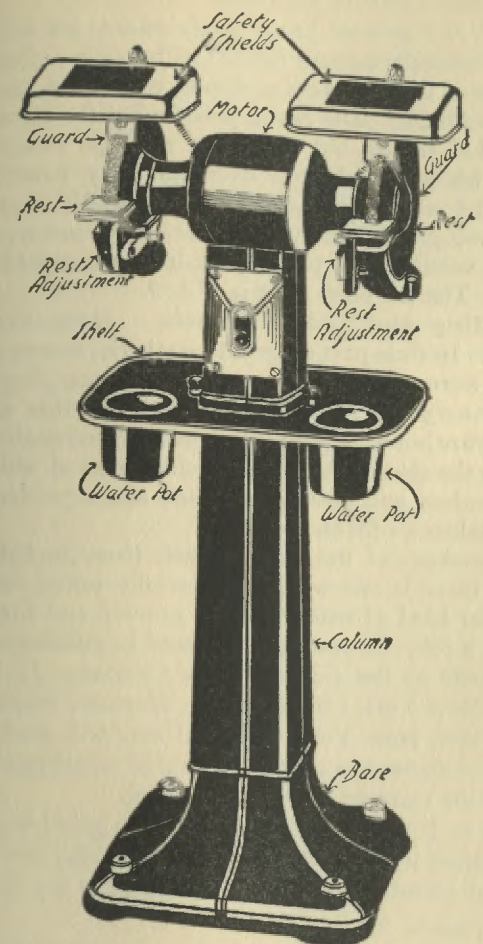


FIG. 69. THE DELTA DIRECT DRIVE PEDESTAL GRINDER

turally and mechanically alike but the electrical equipment differs a little in each one.

The *No. 1* grinder has a *single phase, 110-volt, 60-cycle* alternating current motor[6] with toggle switch, and the price of it completely equipped, except for the lamp bulbs, is *$59.50*. The *No. 2 grinder* has the same kind of an *A.C.* motor, but instead of a toggle switch it is fitted with a push-button overload relay switch, and this model sells for *$66.85*. Finally, the *No. 3 grinder* has a *three-phase*,[6] *220*-volt, *60*-cycle *A.C.* motor, and it is fitted with a three-phase push-button overload relay switch. The list price of it is *$72.50*.

Grinding and Other Wheels. *About Grinding Wheels.* In time past all grinding wheels, except grindstones, were made of emery,[7] and, hence, they were called *emery wheels*. Wheels made of this natural abrasive are but little used at the present time as abrasives made in the electric furnace, the chief ones of which are *carborundum* and *aloxite, alundum* and *crystolon* have all but taken its place.

The makers of the above wheels have graded them so that there is one which is especially suited for each particular kind of material to be ground, and for every kind of a job. If you are interested in grinding operations write to the *Carborundum Company, 13* Laight Street, New York City, or to the *Morton Company, 53* Park Place, New York City, and they will send you a chart that shows at a glance the kind of wheel you should use for the material you want to grind.

How to Use a Grinding Wheel. To grind work you must adjust the rest so that it will clear the face of the wheel by about $\frac{1}{8}$ of an inch; if the rest is too far from

[6] See *Chapter XI*.

[7] *Carborundum* is native alumina, *i.e.*, aluminum oxide (Al_2O_3); *emery* is a common, dark granular variety of carborundum.

the wheel the work may get caught in it and so injure the work, the wheel or, worse yet, yourself. In grinding run the wheel toward the work, and do not exert too great a pressure on it as it will tend to make the particles that are ground off of the work fill up the pores of the wheel when it will glaze, and this will impair its cutting qualities.

About Polishing Wheels. To give metal work a smooth, bright surface polishing wheels of various kinds are used, and chief among these are (*1*) wooden wheels, (*2*) felt wheels, and (*3*) rag wheels. What is called a *wooden wheel* is one that is made of wood and this is covered with leather. A fine abrasive of some kind such as powdered carborundum, crocus, rouge or whiting, is glued to the surface of it.

Felt wheels are made of white Spanish or Mexican felt, and these are largely used for finishing. The edges of them can be turned to any shape. Finally, *rag wheels* are made of disks of unbleached muslin, canton flannel and cloth, and these are largely used for finishing brass, cast iron and steel work.

Chapter X

SOME OTHER POWER TOOLS

IN THE foregoing chapters I have explained in detail all of the various power tools that are used for doing woodworking jobs, and here are a couple of supplementary devices that are useful both for wood and metal working. They are (*1*) portable electric hand drills, and (*2*) flexible shaft units. These are time, labor and money saving tools and enable you to do jobs that you can't get at with the regular stationary power tools.

Portable Electric Hand Drills. *The Ward Utility Model.* This tool consists of a *universal motor* that

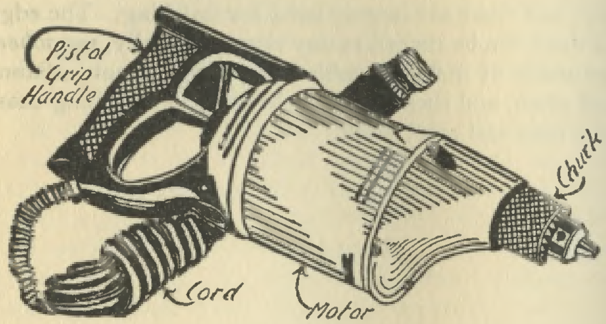


FIG. 70. THE WARD PORTABLE HAND DRILL

operates on either a direct or an alternating current. The spindle, which runs on radial thrust ball bearings, is fitted with double reduction gears that are made of heat treated, chrome vanadium steel which are helical cut and this insures great strength and, hence, long life.

The free end of the spindle is fitted with a Jacob's self-tightening and key release chuck, and this takes

straight shank drills up to $\frac{1}{4}$ inch in diameter. The case housing is made of cast aluminum and to one end of which a handle is secured. A *10*-foot safety cord, formed of three flexible conductors, is protected at the case by a coil spring, and this and the toggle switch in the body, meets the *Underwriters Code.* The shipping weight of the drill is *5* pounds, and the price of it is *$16.00.* It is pictured in *Fig. 70.*

The Ward Pistol Grip Model. This is a heavy duty drill especially adapted for garages and general shops. It is twice as heavy as the *Utility Model* I have just described, and it has a more powerful motor in it. It is made in two sizes, the first of which takes $\frac{1}{4}$-inch drills, and costs *$30.00,* while the second takes $\frac{3}{8}$-inch drills, and the price of which is *$34.75.*

The Ward Breast Drill Model. If you have a garage machine shop and are doing frame and body work this is the kind of a portable drill you want, for it will bite through the hardest wood and the toughest metal with equal facility.

It has a combination breast plate and handle, and the side handle is removable for close drilling. It is also fitted with a pistol grip and double-pole trigger switch. It is made in three sizes, *i.e.,* the first, which takes $\frac{1}{2}$-inch drills, and costs *$46.00*; the second, which takes $\frac{5}{8}$-inch drills, and sells for *$52.50,* and the third, which takes $\frac{3}{4}$-inch drills, the price of which is *$56.00.*

The Ward Flexible Shafts. *A flexible shaft* is one that can be attached to the end of a motor or a line shaft, and the rotational force of which is transmitted to it however it may be curved. Flexible shafts are made of either (*1*) wire wrapped around a tube in alternate opposite layers, or (*2*) formed of a series of small universal joints. Whichever kind of a rotating element is used it is enclosed in a sheath or casing. A flexible shaft is a mighty handy accessory to have as you can drill, sand, grind and polish jobs where the work cannot be held on the wheel of a stationary machine.

The Utility Flexible Shaft Unit. The rotating flexible element of this shaft is made of a tempered spring steel core and it has a polished sheath or casing. The inner core couplings are brazed instead of pressed fitted, and this adds to the strength of the shaft. It is fitted with a ¼-inch, *3*-jaw chuck and a grinding wheel

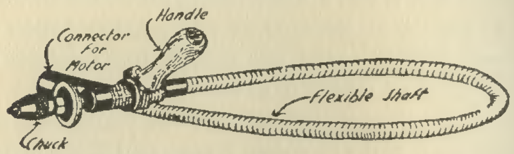


FIG. 71. THE WARD FLEXIBLE SHAFT UNIT
(Couple to Either a Motor or a Line Shaft Unit)

arbor. It has a length of *46½* inches and the price of it is *$5.00*. A *flexible shaft extension* that you can couple on to the above flexible shaft adds *37* inches to it, and this together with the coupling can be had for *$2.85* extra. It is shown in *Fig. 71*.

The Driver Flexible Shafts. *The Direct Motor Drive Shaft.* This shaft can be used on any motor that has a ½-inch shaft. The hand piece and motor coupling are fitted with ball bearings. The overall length of the shaft is *49* inches and it sells for *$5.00*.

The Heavy Duty Shaft. This is a much heavier shaft than the foregoing and it is suitable for regular production work. It has a direct connector for a ½-inch shaft. The core of the shaft is ⅜ of an inch in diameter, and the overall length of it is *5* feet *4½* inches. The price of it is *$5.00*.

The Portable High Speed Shaft Unit. This unit consists of (*1*) a high speed motor, and (*2*) a flexible shaft. The motor operates on either direct or alternating current and it runs at a speed of *18,000 R.P.M.* It is fitted with a hinged bracket so that it can be supported in any position. The price of the unit, which includes the motor and shaft, is *$26.65*. Numerous accessories such as collet chucks, guide washers and depth collars, carving burrs, dovetail routers, sanding drums, grinding wheels, etc., are sold separately.

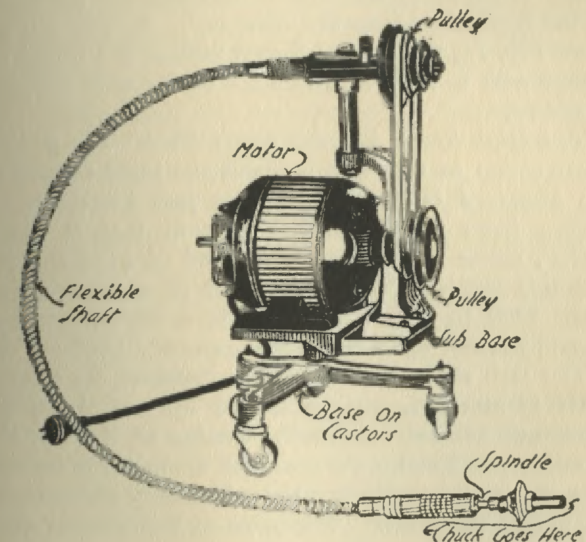


FIG. 72. THE DRIVER PORTABLE FLEXIBLE SHAFT UNIT

The Standard Flexible Shaft Unit. This is a general purpose unit and a very useful one to have in your home whether you are a woodworker or not, as it will come in handy for doing many odd jobs that would otherwise be tedious and difficult. Thus with it you can do various jobs in wood and metal, besides removing paint, waxing floors, polishing furniture, and the like. It is also a useful device for the production shop and the industrial plant.

The unit consists of a ½-*H.P.* motor pivoted to a tripod base that rests on castors and this enables it to be easily and quickly rolled about, indoors and out, wherever the job may be. A curved standard supports a drive pulley and also a short hexagonal column which, in turn, supports a jack shaft; an opposed pulley is keyed to one end of this and the connector of the flexible shaft to the other end. As you will see from *Fig. 72*, the pair of *4*-step pulleys are belted together with a V-belt. The price of the unit complete is *$24.40.*

The High Speed Flexible Shaft Unit. The general construction of this unit is about the same as that of the *Standard Unit* which I have just described. It differs from the latter, however, in that it has a ½-*H.P.* motor which runs at a speed of *3450 R.P.M.*, and this rotates the flexible shaft at speeds ranging from *5000* to *10,000 R.P.M.* If a higher speed is needed you can use a motor that runs at *18,000 R.P.M.*

The jack shaft, that is the one to which the flexible shaft is attached, can be moved up and down the hexagonal column so that the tension of the belt can be adjusted. Finally, the casing of the motor is covered with heavy woven fabric which effectually prevents the leakage of the grease. The price of this flexible shaft unit including the motor, ball bearing, hand piece, jack-shaft and three collet chucks, is *$39.50.*

Chapter XI

FRACTIONAL H.P. ELECTRIC MOTORS

A *motor* is any kind of a mechanism that will change energy into mechanical motion. An *electric motor* is a mechanism that changes electric energy into mechanical motion, and a *fractional horse-power electric motor* is, as its name indicates, one that will develop mechanical motion of less than *1 H.P.*, and this is the kind that is used to drive amateur power woodworking tools.

Kinds of Electric Motors. There are two chief kinds of electric motors and these are (*1*) the direct current motor, and (*2*) the alternating current motor. What is called a *universal motor* is one that will run on either a direct or an alternating current.

The Direct Current Motor. *How the Motor is Made.* A *direct current* is one of which every part of the electric energy of it flows in the same direction, like water flowing through a pipe. Now the chief parts of an electric motor are (*1*) the field magnet, (*2*) the armature, (*3*) the commutator, (*4*) the brushes, and (*5*) the case or housing.

The *field magnet* is nothing more or less than an ordinary electromagnet in that it is formed of a pair of cores and each of these end in a curved pole-piece, or *polar projection* as it is called. The cores and pole pieces are usually cast integral with the cylindrical case or housing and are of soft iron. The cores of the field magnet are *shunt-wound*,[1] that is they are wound with fine wire, and the ends of the coils are connected with the brushes of the motor.[2] The shunt-wound field

[1] In a *universal motor* they are *series-wound.*

[2] Motors are *series-wound* where a powerful torque is needed at starting, as in motor-car starters, street cars and electric

motor gives a very constant speed and, hence it is used for running woodworking and other kinds of power tools.

The *armature*, which is the revolving element, is made by winding a large number of turns of wire on a slotted soft-iron cylindrical core. The *commutator* is formed of a ring of longitudinal parallel copper bars or segments, and these are insulated from each other with strips of mica. The armature and the commutator are mounted on a shaft and the ends of the wires are connected with the bars of the latter.

The brushes consist of a pair of short graphite rods or blocks, and each one is held in a *brush holder*, which in turn is secured to, but insulated from, the end shields of the case or housing. The shaft runs in bearings that are mounted in the end of the case or housing, while the armature rotates between the pole-pieces of the magnet, and all of which is shown in *Fig. 73*.

How the Motor Works. Now when an electric motor is energized by a direct current from a battery or the feed lines of a power plant, the current flows into the upper brush and out of the lower one. The current divides in the armature, half of it flowing in and through the coils on one side, and the other half of it out and through the opposite side.

The action of these currents in the armature is to make each half of the case or housing a magnet with its north pole at the top and its south pole at the bottom. It is the alternate attraction and repulsion between the poles of the armature and those of the field

locomotives. The *compound-wound* motor is likewise used where a large initial torque is required as for elevators, punch presses, etc. If you are interested in details of these motors see my book *How to Understand Electricity*, published by J. B. Lippincott Co., Philadelphia and London.

magnet that pulls and pushes the armature around and makes it rotate.

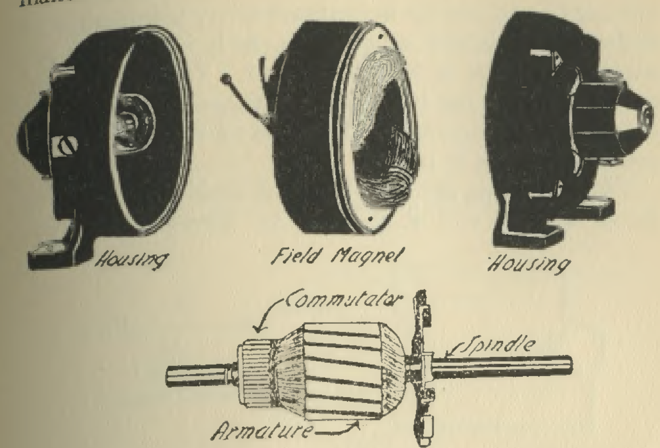


Fig. 73. The Parts of a Direct Current Motor

The Starting Switch. When a motor is connected with the feed lines of a commercial circuit, *i.e.*, one

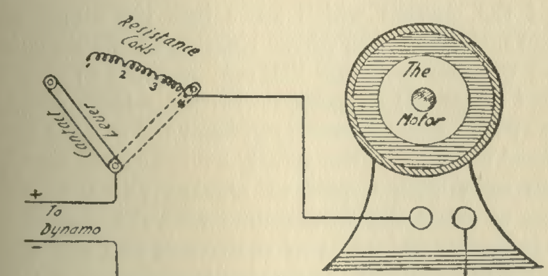


Fig. 74. How the Starting Switch Works

that delivers a *110-* or *220*-volt current, a *starting switch* must be connected in it (the circuit) as pictured in *Fig. 74*. The switch, or *rheostat* as it is also called, is a device for regulating the strength of the current and this it does by means of resistance coils; as these are cut in and out by the contact lever, the amount of resistance is varied accordingly, and, it follows, the current strength is likewise varied. The purpose of the switch is to cut in enough resistance to prevent the current from burning out the coils of the motor when you are starting it up.

The Reversing Switch. This is a double-pole, double-throw switch, and it is used to reverse the direc-

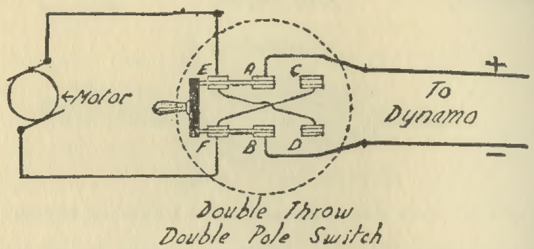


FIG. 75. HOW THE REVERSING SWITCH WORKS

tion of the current which flows into the motor and, it follows, the direction of the rotation of the armature. As you will see from the diagram pictured in *Fig. 75*, the feed wires are connected with the middle contacts of the switch, and to these is pivoted the contact lever. The fixed contacts of the switch are connected together at both ends with a pair of crossed wires, and the contacts at one end are connected with the motor.

By following the wires of the circuit you will easily see that when the lever is thrown to the right the current will flow directly into the motor, and when it is thrown to the left the current will cross over and it will flow into the motor in the opposite direction.

Kinds of Alternating Currents. An *alternating current* is one in which the electric energy that forms it

reverses its direction in the circuit periodically, and the number of times it does so in a second is called its *frequency*. A *single phase current* is a simple alternating current as shown at *A* in *Fig. 76*, and it is the

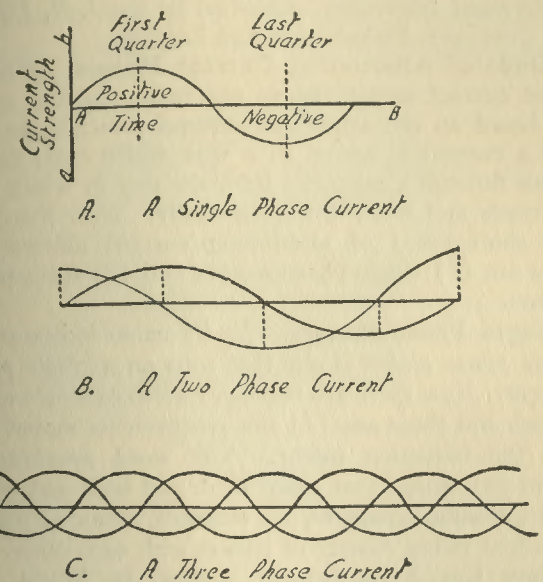


FIG. 76. KINDS OF ALTERNATING CURRENTS

kind that is generally used for light, heat and power purposes.

A *two-phase current* is formed of two simple alternating currents that are set up by a generator and both of which flow over the same line. These two currents, however, *differ in phase*, that is they follow each other at an angular distance of *90* degrees, as shown in *B*. Lastly a *three-phase current* is formed of three simple alternating currents that are set up by a generator and all of which flow over the same line, and they follow each other at an angular distance of *120* degrees, as pictured at *C*. I can't go into the theory of alternating currents here but if you are interested in it you will find it explained in detail in my book *How to Understand Electricity*, published by the *J. B. Lippincott Company*, Philadelphia and London.

Kinds of Alternating Current Motors. While a direct current motor and an alternating current motor are based on the same fundamental principle, to wit, that a current is set up in a wire which cuts, that is passes through a magnetic field, the way in which they are made and work differ materially. Now there are two chief kinds of alternating current motors and these are (*1*) single phase motors and (*2*) three-phase motors.

Single Phase Motors. As its name indicates the *single phase motor* is one that runs on a *single phase current*. Now there are two chief kinds of single phase motors and these are (*1*) the synchronous motor, and (*2*) the induction motor. The word *synchronous* means two things that move forth and back and which have the same *period*, as, for example, a pair of pendulums that swing exactly in unison with each other.

How the Synchronous Motor Is Made and Works. A *synchronous motor* is so called because it rotates at exactly the same speed as does the generator which sets up the current that drives it. A synchronous motor is built like a direct current motor except that instead of the armature, or *rotor* as it is called, having many coils of wire on it, and the ends of which are connected with the segments of the commutator like an armature, it has one continuous coil on it and the ends of it are connected with a pair of *slip rings* as pictured in *Fig. 77*. Also as in the direct current

motor the current which is delivered to the brushes flows through the coil on the rotor.

The untoward feature of the synchronous motor is that it will not start up of and by itself but it must be brought up to its running speed by some kind of an accessory device and the chief ones of these will be described presently. When the motor has gathered

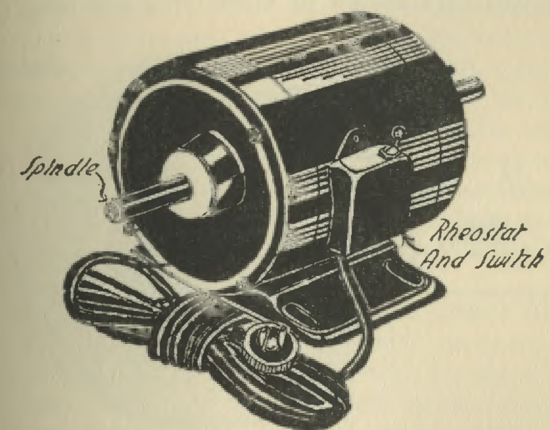


Fig. 77. A Single Phase Synchronous Motor

speed and is running synchronously with the alternator it will then develop its rated *H.P.*

How an Induction Motor Is Made and Works. The *induction motor* in its simplest form consists of only two chief parts, and it is the kind that is generally used for driving amateur woodworking tools. Named the parts of this motor are (*1*) the stator, and (*2*) the rotor. The stator is the field magnet, and the rotor, as the revolving element is called, corresponds to the armature of a *D.C.* or an *A.C.* synchronous motor.

Different from these last named motors whose field magnets have two or four magnetic poles, the field magnet or *stator* as it is called, of the induction motor has a large number of them as shown at *A* in *Fig. 78*. The rotor is formed of a cylindrical soft iron, mild steel, or silicon steel core, and cut lengthwise in its circumferential surface is the same number of parallel slots that there are poles on the stator. Copper or aluminum bars are set in these slots, and they (the

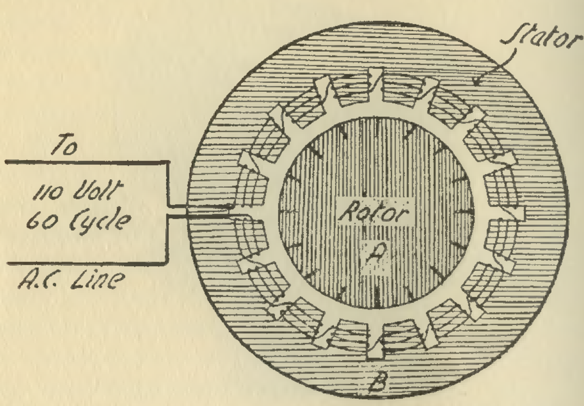


Fig. 78. Diagram of an Induction Motor

bars) are secured to a pair of end disks, made of the same metal,[3] at the ends of the core, as pictured at *B*.

How the Induction Motor Works. Now the way in which the magnet cores of the stator is wound, is such that when an alternating current flows through them it makes each alternate one a positive and a negative pole. When the rotor is running the copper or aluminum bars cut the alternate positive and negative magnetic fields and the lines of force of the latter set up alternating currents in the former so that the cor-

[3] In some induction motors the bars and end disks are cast in one solid piece.

responding poles between them are of the opposite sign. The attraction between them pulls those of the rotor toward those of the stator that are nearest to each other, and so changes the magnetic energy into rotary motion.

When at the start the alternating current flows through the stator windings and energizes the field poles, no currents are set up in the bars of the rotor because they are not moving and, hence, they do not cut the lines of force of them. For this reason the induction motor will not start of and by itself and, it follows, some kind of an auxillary device must be used to start it with. Once that it is started and gets up to speed the starting device can be cut out and it (the motor) will run at a practically constant speed and remain almost as high on full load as it does on no load.

Single Phase Motor Starting Devices. As I have previously said, where a single phase current is used for driving a synchronous or an induction motor it will not start up of and by itself and, hence, it must be given an initial impulse by some special scheme or device. When, however, a two-phase or three-phase current[4] is used the difference in the phases will cause the motor to start. Now there are five chief ways by which a single phase motor can be started and these are (*1*) by hand, (*2*) a split-phase current, (*3*) separate direct current winding and a commutator, (*4*) a repulsion magnetic field and (*5*) a compensator.

Starting by Hand. To do this the motor has to be *cranked* just as the old time automobile engine was

[4] A *single phase* current requires a *pair* of feed wires; a *two phase current* must have *four* feed wires, while a *three phase* current needs only *three* feed wires. Since this is the case two-phase motors are not used.

cranked. This way is obsolete and the motor is now cranked by some one of the above automatic methods.

The Split-Phase Method. To start a motor with a *split-phase* current the stator must be so wound that the driving current will flow through two separate coils which are wound parallel with each other and one of which has more *inductance*[5] in it than the other. The additional inductance in one of the coils produces a lag in the phase of the current and this makes it the equivalent of a two-phase current.

The coil that has the added inductance in it is called the *starting winding* and when the motor gets up to the speed it (the winding) is cut out of the circuit. This is done by either (*a*) a two-way switch that is operated by hand, or (*b*) automatically with a centrifugal cut-out that works on the principle of a fly-ball governor on a steam engine, or some equivalent device.

The Separate Winding Method. This way is largely used for starting single phase induction motors, and it consists of having as many coils for the commutator as there are inductor windings or bars on the rotor, a cross-section of which is shown at *A* in *Fig. 79.* Now when the motor is started the single-phase current flows through the direct current windings (see the text on *Universal Motors*) and it starts up the rotor. When the latter is running up to its normal speed the brushes are automatically lifted from the commutator and it then runs as an induction motor.

The Repulsion Magnetic Field Method. To start a motor with a *repulsion magnetic action* the rotor is fitted with a commutator and a pair of brushes exactly like the armature of a direct current motor. The

[5] This is produced by having more turns of wire in one of the coils than in the other.

brushes are not, however, connected with the alternating current feed lines but, instead, they are joined together so that the coils of the rotor are short-circuited.

The stator is connected with the source of alternating current, and when it is energized by it currents are induced in the rotor and it begins to run as a direct current motor. When the rotor gets up to speed a centrifugal cut-out short-circuits the commutator and

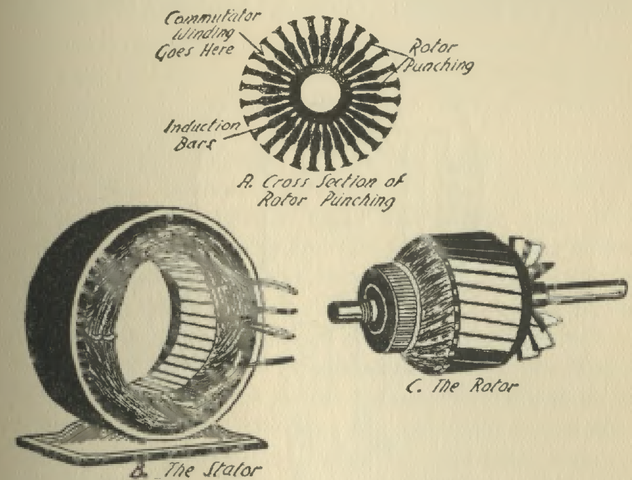


FIG. 79. SINGLE PHASE REPULSION-INDUCTION MOTOR

the brushes are automatically lifted up from it. This action not only prevents the wear on them but eliminates the friction that they set up.

The Compensator Scheme. A *three-phase motor* will start of and by itself but it is usually fitted with a starting device called a *compensator.* This consists of a combined transformer and a double-pole switch. The purpose of this device is not to start the motor, but to permit only a small amount of the initial current to flow through the windings when it (the former) is switched on and so prevents the latter from being burned out.

How a Universal Motor Is Made. The term *universal motor* is used to mean a motor that will run equally well on a direct or an alternating current. A motor of this kind has a *series wound* field magnet, instead of a *shunt wound* one, and, hence, it is not as efficient as the latter. It has an armature commutator

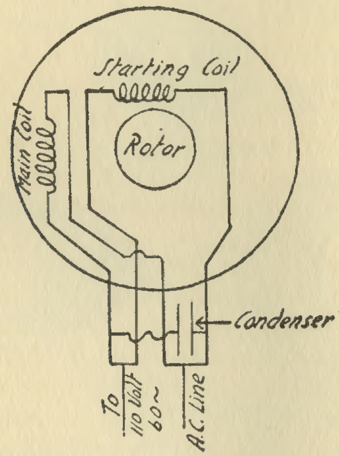


FIG. 80A. DIAGRAM OF CONNECTIONS OF THE CAPACITOR-START MOTOR

and brushes exactly like a direct current motor. The speed of the universal motor is considerably higher than that of either a shunt-wound or an alternating current motor, running as it does at about *5000 R.P.M.*

How a Single Phase Reversible Motor Is Made. To change the direction of rotation of a single phase motor the field magnet must have four poles and these are wound with coils and connected together in the

usual way. A resistance coil is provided for each field coil and each one has a different value of resistance. These latter coils can be cut in and out of the field coils by a centrifugal switch device.

Now to make the rotor turn in a clockwise direction the field coils are connected with the resistance coils and these with the feed lines as shown at *A* in *Fig. 79.* To make the rotor turn in a *counter-clockwise direction* the resistance coils are connected with the field coils as pictured at *B*. For clockwise rotation the feed wire marked *T* is connected with *T4*, and *T2* with *T3* (see *A* again), while for counter-clockwise rotation the feed line *T1* is connected with *T4*, and *T2* with *T3*, as at *B*.

These resistance coils of different values split up the single-phase current into currents having different phases, when, it follows, they will follow each other and form a rotary magnetic field and so start the motor. When the motor has been brought up to the speed the centrifugal switch mechanism cuts out the resistance coils and it runs as a single phase induction motor.

How a Single Phase Capacitor-Induction Motor Works. A *capacitor-motor* is especially adapted for driving high-speed tools as, for example, the shaper. The chief advantageous feature of it is that it can be run on any A.C. house lighting circuit, as it is fitted with a condenser which absorbs the initial inrush current.

The capacitor-motor consists of (*1*) a single-phase constant speed induction motor and (*2*) a capacitor, which is a condenser, usually of the electrolytic type. The capacitor-motor is built quite like a split-phase motor in that the stator has two windings. There are two kinds of capacitor-motors and these are (*a*) the capacitor-start motor, and (*b*) the capacitor-start and run motor.

In the *capacitor-start motor* the capacitor and its windings remain in the circuit only until the motor has gotten up to a speed and it is then cut out by a centrifugal switch of some kind. In the capacitor-start and run motor the capacitor and its windings are kept in the circuit all of the time the motor is running, and, it follows, the cut-out switch is eliminated.

The windings and connections of a capacitor-start motor are shown at *A* in *Fig. 80,* and the motor itself is pictured at *B*. Some of these motors are made for *110*-volt current only, and these are reversible, while

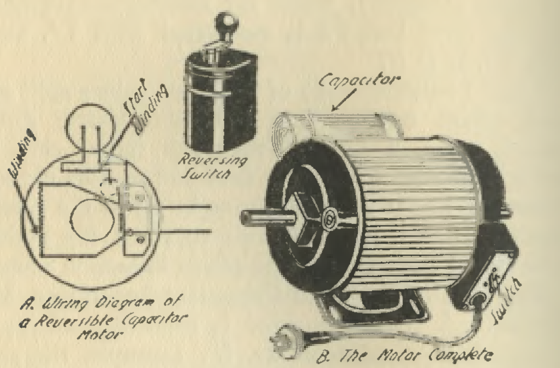


FIG. 80B. A SINGLE PHASE REVERSIBLE-CAPACITOR MOTOR

others are dual-voltage motors, that is they are made for both *110* and *220* volts and these are non-reversible.

How Three-Phase Motors Are Made and Work. The *three-phase motor* is made for heavy duty work, and the smallest of these that are used for driving amateur woodworking tools is $\frac{3}{4}$ *H.P.* The advantage of the three-phase motor over the single-phase motor is that it has a rotary magnetic field and, it follows, it is self-starting. While it can be connected with a lighting circuit it is better adapted to be used on a

power circuit. To connect it with the latter it must be equipped with a three-phase overload relay-switch, and this work should be done by a licensed electrician.

Now the way the three-phase motor is made is like this: The stator has a number of poles and each principal one is divided into three parts; these are wound with three separate wires, as shown in the diagram in *Fig. 81,* which pictures the magnetic field ring as it would be if cut at one point and straightened out flat when you would see the faces of the different poles.

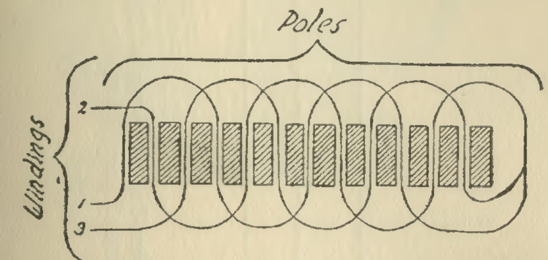


FIG. 81. DIAGRAM OF WINDINGS OF A THREE PHASE FIELD MAGNET

By winding the wire in this way a continuous rotary motion of the magnetic field is set up by the poles round the ring[6] and this moves over the distance between two like poles in the time of one complete period of the alternation of the current. In this case if the current has a frequency of *60* cycles per second the magnetic field will make *30* revolutions per second.

Fig. 82 shows how the windings of a three-phase

[6] Do not confuse the *rotary field magnet* of an *alternating current generator* with the *rotary magnetic field* of a *three-phase induction motor* for they are two very different things. Thus in the alternating current generator the field magnet *actually revolves,* while in the three-phase induction motor the field magnet remains stationary but the magnetic field set up by it moves progressively around so that it revolves.

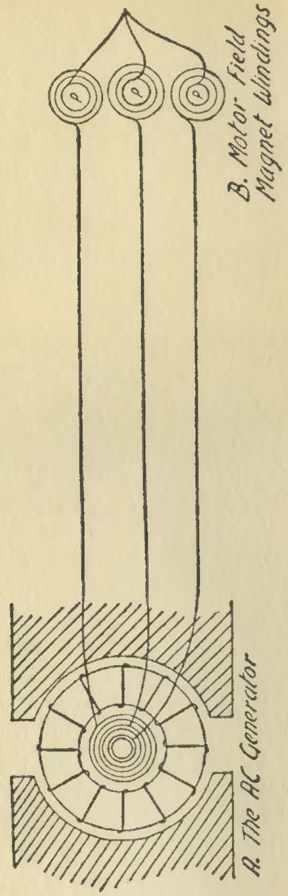


Fig. 82. How a Three-Phase Motor is Connected with a Three-Phase Generator

motor are connected with a three-phase generator, while a three-phase motor complete is pictured in *Fig.*

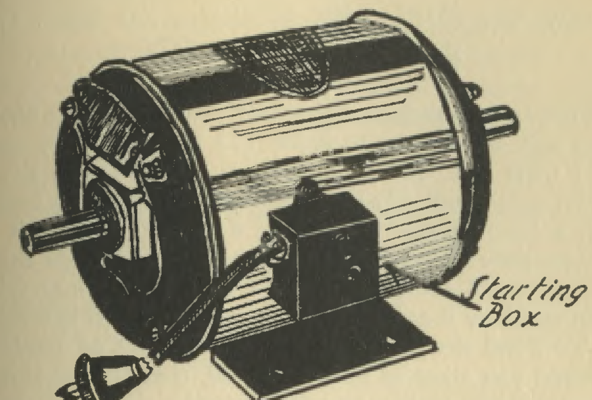


Fig. 83. A ¾-H.P. Three-Phase Motor

83. It has a speed of *1725 R.P.M.*, and the price for a *220*-volt, *60*-cycle alternating current motor is in the neighborhood of *$40.00.*

Chapter XII

HOW TO FIND THE SPEED AND SIZE OF PULLEYS, GEARS, ETC.

IN OPERATING motors and power tools of various kinds you will often want to know (*1*) how fast they run, (*2*) what sized pulleys and gears are needed to get a given speed, and (*3*) the size a belt should be to transmit a given power to the best advantage. Now it is my purpose to tell you in this chapter how to do these three several things, together with a little about friction and how it acts on sliding, roller and ball bearings.

To Find the Speed of a Motor, Shaft or Pulley. Should you want to find the *speed*, that is how fast a motor, shaft, pulley, or other rotating element is running, it is a very simple matter for all you have to do is to contact it with a *speed indicator*. This little device consists of (*a*) a spindle with threads cut on it, (*b*) a gear whose teeth mesh with them, and which together form a *worm gear*, (*c*) a hand or pointer that is fixed to the pinion of the gear, and this rotates over (*d*) a dial which is secured to (*e*) the case of the indicator.

To Find the Axial Speed. By *axial speed* is meant the speed of a rotating element at its axis, which is the exact center of it. To find the axial speed, or just *speed* as it is called for short, set the indicator hand on the dial at *0*; this done note the position of the second hand on your watch, and press the pointed end of the spindle of the indicator on the center of the end of the shaft of the rotating element whose speed you want to find, as shown at *A* in *Fig. 84*.

Now when the second hand has made one complete revolution remove the indicator spindle from the shaft,

and then read the number on the dial where the hand has stopped and this will be the number of revolutions the shaft has made in one minute.

To Find the Surface Speed. The *surface speed* is the lineal number of feet the *periphery* or *surface* of a wheel travels in *1* minute. To find the surface speed of a pulley or other rotating element you slip a small

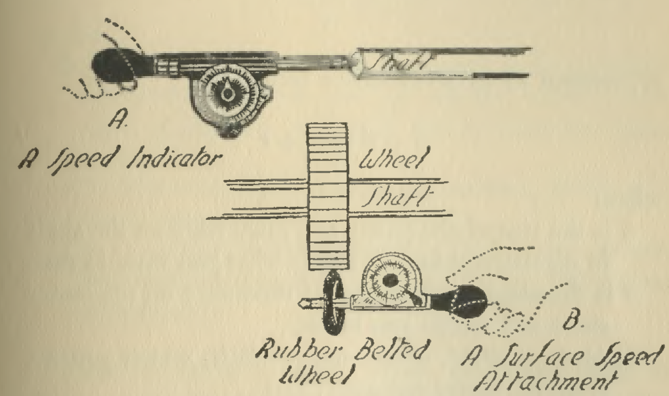


FIG. 84. THE SPEED INDICATOR

rubber-covered wheel over the spindle of the indicator, and set the hand of it at *0* as before.

This done hold the rim of the indicator wheel in contact with the face of the pulley, see *B*, for *1* minute, and then divide the number of revolutions, as shown by the dial, by *2*. Since each revolution of the dial indicates a distance of *6* inches, and twice around the dial indicates a distance of *1* foot, the quotient will be the number of feet the surface of the pulley is traveling.

How to Find the Size of a Pulley. Having found the speed of your motor you will quite likely want to know what sized pulley you must have on the shaft of the motor, and also on the spindle or shaft of the power tool in order to make the latter rotate at the required speed.

To do this you need only to use the following simple algebraic formula,

$$S = \frac{dR}{r},$$

or, written as an arithmetical formula,

$$S = d \times R \div r$$

where

S is the size of the pulley you must have on the shaft in diameter in inches, and is what you want to find,
d is the diameter in inches of the pulley on the motor shaft and which you know,
R is the *R.P.M.* of the motor shaft, which you get from the speed indicator, and
r is the number of *R.P.M.* that you want the pulley on the shaft of the power tool, which is belted to the motor pulley, to rotate at.

How to Find the Proper Sized Belt. After you have found the speed of the motor and the sizes of the pulleys you need to produce the speed that you want the power tool to run at, you will want to know the width of the belt that should be used to transmit the required power to the best advantage.

If the belt is too narrow it will slip, break and misbehave in general, while if it is too wide it will not only cost more but it will result in the loss of power.

You can roughly find the size of the belt you should use from this formula:

$$W = \frac{H.P.}{7}$$

or

$$W = H.P. \div 7$$

where

W is the width of the belt (assumed) to be traveling at the rate of *4000* feet per minute, which is the most economical belt speed and is what you want to know,
H.P. is the horsepower to be transmitted, which you know, and
7 is a *constant*, that is a number of fixed value which has been previously determined by experiment or calculation.

How to Splice a Belt. There are three ways to splice a belt and these are (*1*) to lace it, (*2*) to cement it and (*3*) to steel lace it. To *lace a belt*, that is to join the ends of them together you will need some *belt lacing*, and this is made of strips of leather or of rawhide of different widths. Butt the ends of the belt together, see *Fig. 85*, and then punch two rows of holes in each end as shown at *B*. This done begin at the middle of the ends of the belt and lace them over to one edge, then to the other edge, and back to the center again. Lace it so that the lacing is parallel on the back of the belt, and crosses over the face of it, as at *B*.

To *cement a belt* make a cement of two parts of liquid fish glue, and *1* part of Russian liquid isinglass. Bevel off the edges of both ends of the belt, then smear the cement on them while it is hot, and peg it with shoemaker's pegs so that they will be ½ inch apart. When properly done a cement splice makes the best job and, it follows, it gives the least trouble.

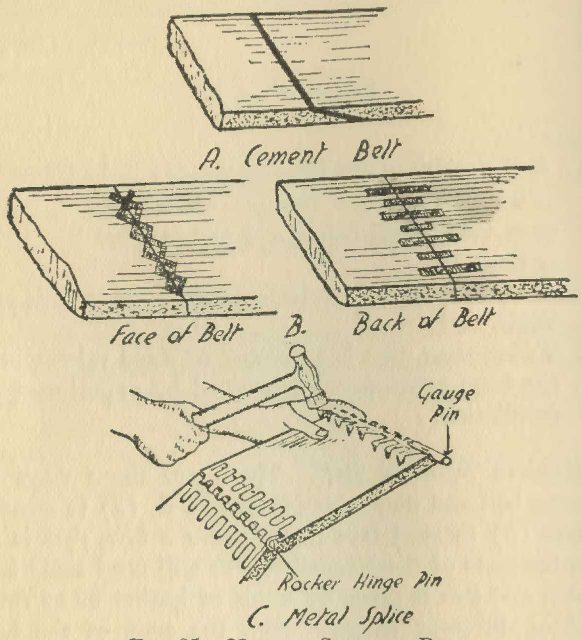


FIG. 85. HOW TO SPLICE A BELT

To *splice* a belt you can use *steel lacing,* which is a punching with sharp points bent over on it as shown at *C.* To use it you have only to butt the ends of the belt together, set the lacing evenly over both ends of it, and then drive the sharp ends through them. This done turn the belt over, hammer the points down and into the belt.

A Good Belt Dressing. The purpose of a *belt dressing* is to increase the friction between the belt and the pulley it drives and so reduce the slippage. To make a belt dressing (*a*) mix *30* per cent of tallow with *37* per cent of boiled linseed oil, and then (*b*) mix *6* per cent of beeswax with *27* per cent of lubricating oil. Heat the two mixtures separately to *360* degrees Fahrenheit,[1] then stir them together, and apply a thin coat to the belt.

How to Find the Size of Gears. A *gear,* or a *cog wheel* is, as you probably know, a wheel with teeth cut in its rim or periphery, as the face of it is called, so that it can mesh with another gear. There are several kinds of gears but the three chief ones are (*1*) spur gears, (*2*) miter gears, and (*3*) bevel gears.

A *spur gear* is the commonest kind and it has teeth cut in its periphery. *Miter gears* consist of a pair of gears which have exactly the same diameters. They set at right angles to each other with their teeth meshing together at *45* degrees. Finally, *bevel gears* are formed of a pair of gears of different sizes and these set at right angles to each other, and whose teeth mesh at any other angle than *45* degrees. (*1*) Now when you want to find *the number of teeth a gear must have to revolve at a given speed* when it is run by another gear the number of whose teeth you know, you have only to divide the number of teeth of the known gear by the rate of speed of the driven pulley that you want to find the number of teeth of, and the quotient will be the answer.

As an example, if you want to find the number of teeth a driven gear must have so that it will run twice as fast as the gear that has *40* teeth, divide *40* by *2* and the quotient, which is *20,* will be the number of teeth the gear must have.

[1] *Caution:* Be very careful when you heat the mixtures that they do not catch on fire.

(2) If you want to find *the speed that a driven gear will make with a gear whose number of teeth you know,* all you have to do is to divide the number of the teeth on the gear whose speed you do not know but want to know, into the number of teeth on the gear whose rate of speed you do know.

Thus, if a driven gear has *40* teeth and you want to know its speed when it meshes with another gear that has *80* teeth and which makes *20* revolutions per minute, divide *80* by *40* and the quotient *2* will be the number of times the driven gear will rotate to every complete revolution of the gear with *80* teeth; or 2×20, or *40,* will be the number of times it rotates per minute.

About Friction and Bearings. *What Friction Is.* In mechanics the word *friction* means a resistance to motion due to the act of one member rubbing against another member. A lot of power is used up in machines overcoming friction and so reduces the efficiency of them. Now friction is of three kinds and these are (*1*) sliding friction, (*2*) rolling friction, and (*3*) ball bearing friction. Here are some very simple experiments that clearly show the difference in the amount of power that it takes to overcome the above three kinds of friction.

Sliding Friction. Lay a book on the top of a table, press down on it with your hand and slide it along. You will find that it takes considerable effort to do so since their rough surfaces strongly oppose each other.

Rolling Friction. Having made this experiment lay two round lead pencils on the table and place the book on them. Now put the tips of your fingers and thumb on the book when you will find that you can easily push it along. This is because you are working against

rolling friction instead of sliding friction, and this very greatly reduces the resistance between them.

Ball Bearing Friction. Next lay four marbles on the table and put the book on them, then place the tip of your forefinger on the middle of the book and press down on it. The slightest effort will be enough to move the book, and this shows that a ball bearing is better than a roller bearing, for it still further reduces the friction.

Sliding Bearings. Bearings of this kind are used in the less expensive kinds of machines, and one of the elements should be harder than the other to reduce the friction as much as possible. For this reason steel shafts are made to run in *babbit* or *bronze bearings.* The following are a couple of *anti-friction alloys,* as they are called, that are largely used for bearings.

KINDS OF ALLOYS

Name of Alloy	*Copper*	*Antimony*	*Tin*	*Lead*
Babbit Metal.....	4	7	89	
Bronze...........	80		10	10

When a small amount of phosphorus is added to the above bronze alloy the mixture makes what is called a *standard phosphorous bronze bearing metal.*

Roller Bearings. Since roller friction offers far less resistance than sliding friction, *roller bearings* are used in machines in which severe strains and stresses are set up. A roller bearing is formed of a number of steel rollers placed parallel with each other and each one of which is pivoted to a pair of steel end rings. These rings are secured to the frame of the machine and the shaft runs on the inside of the rollers.

Ball Bearings. As *ball bearings* offer a still lesser resistance than roller bearings, they are used in various lighter machines. A ball bearing consists of an outer ring which is fixed to the frame of the machine and an inner ring to which the shaft is secured. Between the two rings is a *separator* with circular compartments in it, and in each one is a steel ball that runs on the outer surface of the inner ring and the inner surface of the outer ring.

INDEX

F

G

H

I

J