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A
Comprehensive Handbook
on
Uses and Applications
of the

THE DRILL PRESS

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100 photographic illustrations
and line drawings

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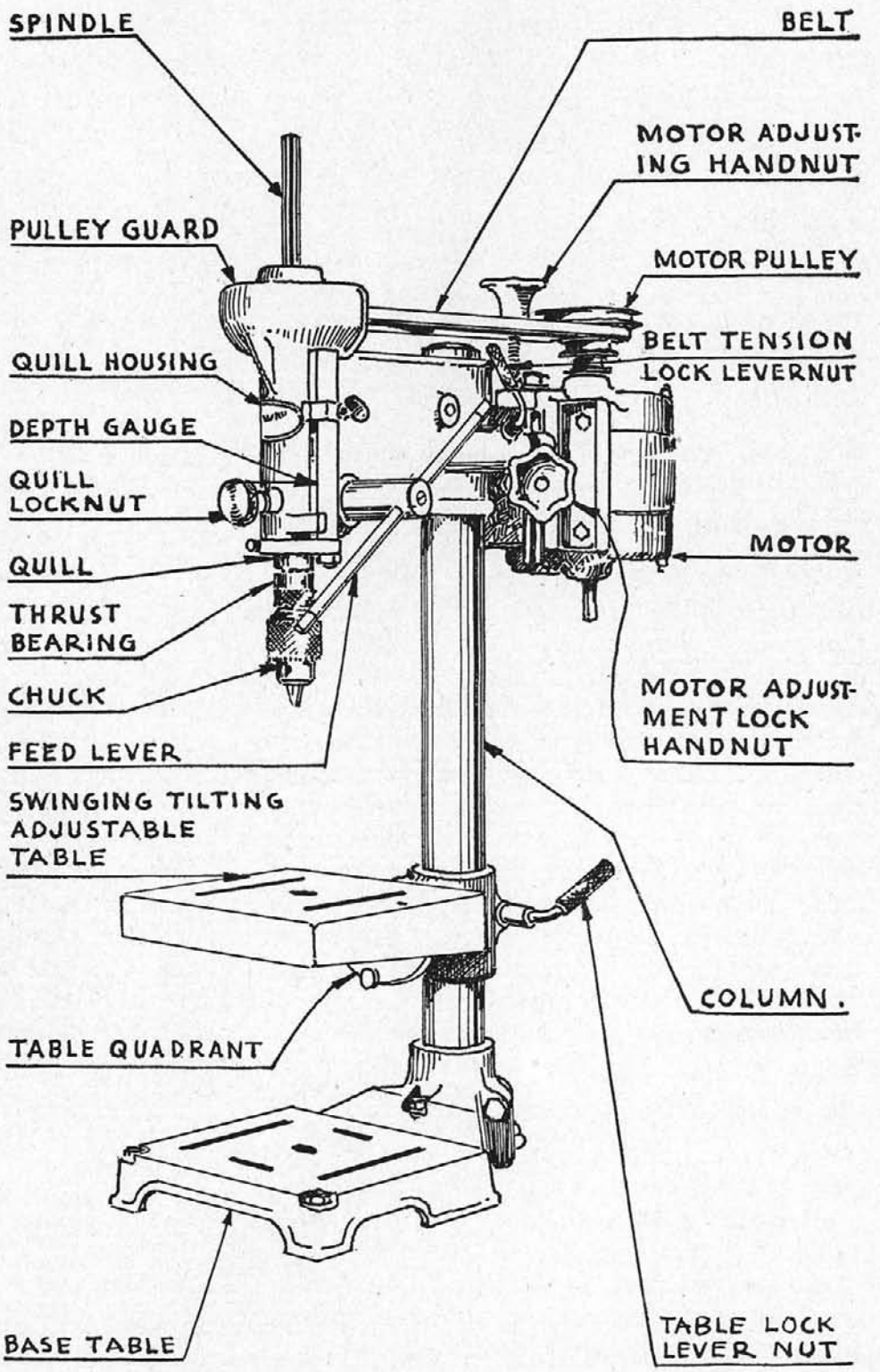

SPINDLE
BELT
MOTOR ADJUST-
ING HANDNUT
PULLEY GUARD
MOTOR PULLEY
BELT TENSION
LOCK LEVERNUT
QUILL HOUSING
DEPTH GAUGE
QUILL
LOCKNUT
MOTOR
QUILL
THRUST
BEARING
MOTOR ADJUST-
MENT LOCK
HANDNUT
CHUCK
FEED LEVER
SWINGING TILTING
ADJUSTABLE
TABLE
COLUMN.
TABLE QUADRANT
BASE TABLE
TABLE LOCK
LEVER NUT

The Drill Press

OT so many years back the lathe was considered the most versatile machine in the shop, but now the drill press, with its large line of available accessories has become extremely versatile and is constantly becoming more popular in a great many ways. The drill press used to be a one-purpose machine—for drilling holes. And until it was redesigned and many of its inherent advantages applied as a basis for using the machine for other purposes, no one thought of the drill press as being a machine of a great variety of uses. Now, the drill press may be used for boring, surface grinding, milling, sanding, shaping, routing, carving, mortising, tenoning, dovetailing, die sinking, as an arbor press and for several other purposes. With the exception of the light, sensitive machines, the drill press is made to withstand the abuse and hard use that it will receive through this variety of applications.

Only a few years ago, in order to obtain a good substantial drill press, that would withstand hard usage and maintain accuracy through a considerable period of time, it was necessary to pay anywhere from $100 to $200 for a machine of the bench type; that is, the type with the short column and motor mounted on the head of the drill press incorporating a straight line drive to the spindle. It was only in the extremely light machines whose capacity was not over ¼" that one could hope to secure a fairly good machine for less than $50. Now, however, it is possible to obtain a sturdy machine with the finest of bearings and full equipment of levers and adjustments which enable the operator to use the machine for the great variety of operations above named, at prices ranging from about $20 up, with a maximum of about $50 for the finest type of machine in this class. In addition to substantial construction and fine materials, the machines are so designed as to be easily converted into other types of machines, notably the shaper which often precludes the purchase of that machine. The advent of this type of convertible machine was a great contribution to the interests of amateur and professional craftsmen alike, since it enables them to include in their list of operations the making of mouldings, carvings, etc., without any additional investment, excepting a small outlay for the necessary accessories.

THE DRILL PRESS

Characteristics of Drill Presses

Let us examine the construction of one of these modern drill presses. There is a small drill press on the market which has a capacity of ½" and sells for less than $15. The bearings in the head are of the oilless bronze type, with a substantial steel quill operated by a steel pinion to feed the drill into the work. The spindle and quill are held in a very rigid, cast iron head on which is mounted an adjustable motor bracket. With this mounting the motor and head may be raised and lowered as a unit to allow for shifting the belt from one pulley groove to another. This enables the operator to obtain eight speeds through the medium of a four-groove pulley on the motor and a two-groove pulley on the spindle. This unit, head and motor, are movable up and down the column.

The table is adjustable to various heights for different sizes of stock to be drilled and may be tilted to 45°.

In a higher price range one may purchase a drill press in which large heavy oilless bronze bearings are incorporated with a larger and heavier quill and greater capacity. These machines are so designed as to allow for speeds up to 5000 R.P.M. without any fear of damage to the bearings. Continued operation as a shaper at a speed of 5000 R.P.M. has no serious effect on the bearings, and after several years of use, if the bearings do show any appreciable amount of wear, they are very easily and inexpensively replaced with new ones, so that the operating cost of one of these machines is very low. Most of the drill presses of this price range are equipped with a straight line drive; that is, the motor is mounted on the head of the drill press so that the entire head and motor as a unit may be inverted on the spindle and the machine used for shaper work, where it is necessary to have the spindle in an upright position. Here again, an adjustable bracket for the motor permits shifting of the motor pulley to utilize the eight speeds available through a four-step pulley on the motor and a two-step pulley on the spindle.

On this type of a machine a depth gauge is provided to indicate the depth of cut being made, and a locking hand nut is furnished for holding the spindle at a certain height for such operations as routing, carving, surface grinding, etc. Large heavy castings form the base and also the adjustable tilting table.

When one gets into the next price range, he is able to purchase a machine that is, in all respects, the equivalent of machines that sold for upwards of $200 several years ago. Here again modern production methods and intelligent planning have enabled manu-

facturers to produce a machine for a surprisingly low figure when the value of the material and workmanship on the machine are taken into consideration. Large ball bearings of the finest type carry the spindle inside a very heavy steel quill, with the rack for the feed machined directly on this quill and operated by a large steel pinion. Provision is made for clamping the spindle at any desired height, very accurate and convenient stop gauges are provided, a most convenient and substantial feeding mechanism is incorporated, and the entire machine is designed with consideration for the multitude of operations that it will go through and the intensive service that will be required of it. The ball bearings are all of the pre-loaded thrust type and are packed in grease and dust-sealed at the factory, so that a long and continued period of service may be expected without any attention whatever being given to the bearings.

Various Chucks Supplied

With the drill presses in the lower price range, chucks of the knurled sleeve spring jaw type may be had at a very nominal sum, but these chucks cannot be expected to equal the key type chuck either in accuracy or efficiency. For that reason, most drill press manufacturers supply, at extra cost, the key type chuck, the most popular make being the Jacobs. If accurate drilling is to be expected, and this accuracy maintained over a long period of time, the Jacob's Key Chuck is strongly recommended.

Direct Drive or Jack Shaft?

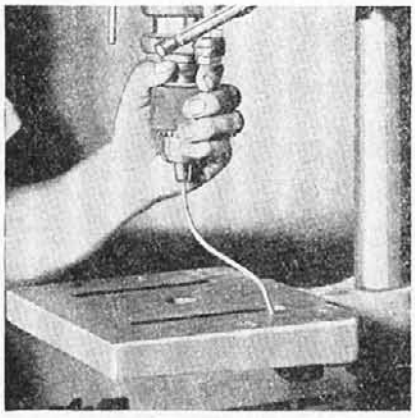
While most of the modern drill presses are designed with the motor mounted directly on the head of the drill press, a bracket with idler pulleys (Jack Shaft) is usually available which may be substituted for the motor. With the jack shaft, the drill press may be operated from a countershaft or motor mounted on the bench, which motor or countershaft also drives other machines as well as the drill press. It is therefore simply a matter of choice, or the question of investment that governs the choice of the type of drill press purchased. Naturally with one motor driving several machines through a counter-shaft a smaller investment is required in motors. Either arrangement will give satisfactory service, although an individual motor is advisable for sustaining high speed work.

Good Bearings are Vital

The accuracy of a drill press depends almost entirely on the spindle, the bearings of the spindle, and on the precision with which the chuck is made, and the prospective purchaser of a drill press is cautioned to examine these particular features with great care. If the manufacturer of a drill press supplies a series of attachments such as special chucks for holding routers or dovetailing cutters, or carving cutters, or a mortising attachment or similar attachment, you can be sure that the design of the machine incorporates sufficient strength and rigidity to withstand the strains that are occasioned by these operations so that no cause for worry need be entertained as to whether the machine will stand up under such service. If high speeds of 8000 or 10,000 R.P.M. are recommended by the manufacturer for certain operations, you may be sure that provision has been made in the machine to withstand the friction, heat and strain involved by these operations. There is no doubt but that the ball bearing equipped type of machine will outlast, in length of service, the other types of machines wherein the bearings are of the sleeve bronze type. For this reason if one intends to use the machine extensively for these operations it is wise to purchase the ball bearing type.

Testing Alignment of Table

Regardless of the type or price of machine that is purchased there is one test that should be made before the machine is accepted. This test is for alignment of table with the spindle. The test is very simple and requires only a piece of wire about one foot long, and about 1/8" in diameter. This is bent roughly to a shape (see photo) and one end inserted in the chuck. The table is then adjusted with the wire projecting towards the column side of the table, the lower end of the wire just barely touching the table. The spindle of the drill press is then turned slowly by hand so that the end of the wire describes a circle on the surface of the drill press table. If the table is accurately level in respect to the spindle,



Check the table level with a piece of bent wire.

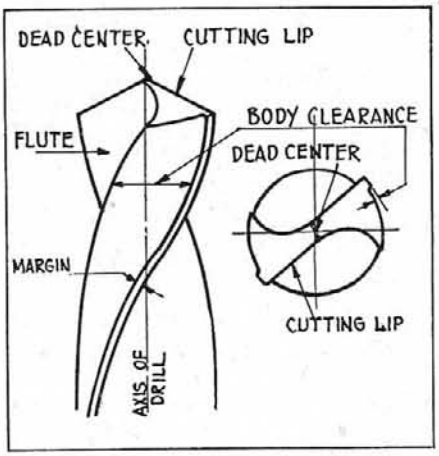
the end of the wire should touch the table with the same degree of pressure throughout the entire circle. If there is any variation in the degree of pressure it will show up in a bending of the wire at certain points, and if this happens, the table needs to be adjusted for alignment. While such alignment cannot be made with drill presses which have the table rigidly mounted on the column with no provision for adjustments either latitudinally or longitudinally, most of the present day drill presses are so arranged that the table may be tilted to the right or left. Correct table alignment is a very important point because without it precision work will never be possible.

Drilling

While the life of a drill press depends on its bearings, and the accuracy of the machine depends on the accuracy of the spindle and of the chuck, the real service that one will get from a drill press depends to a great degree on the type of drill that is used and how that particular drill is ground and sharpened. Many different materials that are being drilled require different speeds for drilling, and in some cases require a certain type of lubricant to enable the drill to cut clean and at the same time prevent it from heating. The lubricant also provides a smooth and lubricated channel, for the elimination of the chips. The experienced drill press operator knows by the color and shape of the chips that are being thrown off by the drill, whether or not the machine is operating at its greatest efficiency. This knowledge comes only from long continued experience, and can only be acquired through continued operation of the machine.

Sharpening Twist Drills

To understand the sharpening and grinding of a twist drill, it is well first to consider the various parts of the drill itself The sketch as illustrated on the following page shows a side and end elevation or point of a modern drill. On this sketch all the different parts that go to make up the design of the drill are marked. In the description to follow these terms and names of parts will be referred to from time to time, so the reader is urged to study this sketch carefully, and become familiar with the different parts and



names. The twist drill is a cutting tool made from a special type of tool steel. It is usually formed from a round piece of steel into which are milled a series of spiral grooves, or by forging and twisting flat strips of steel to produce the grooves. Whether they are milled or twisted these drills are accurately ground to their specified diameter, and are very carefully ground for body clearance as well. The dimensions of the different parts of a body of a drill are the results of long exhaustive research along these lines, and are maintained for a definite purpose.

There are three principal parts to a drill, the point or end which does the cutting, the body or drill itself which is the spiral section, and the shank or the end that is held in the chuck. In the larger type of drills the shank is usually made in one of the standard tapers such as Morse or Brown and Sharp, and are so made to fit spindles of the larger production drill presses. Since this type is not used in the popular bench type drill press this article will not deal with tapered shank drills, but will adhere to the straight shank type.

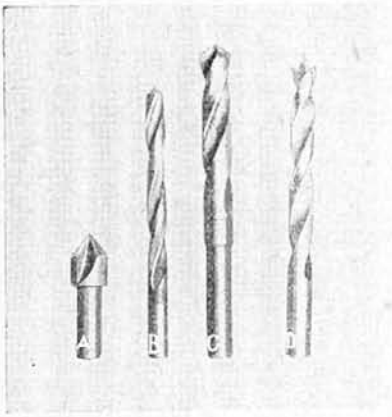
The point of the drill is the result of grinding the end of the drill to a definite angle, and this angle in conjunction with the specially shaped flute of the body of the drill form the proper cutting edge. You will find by close examination that the curvature of the flute is so arranged as to curl the chips in a very tight spiral so that it will occupy a minimum amount of space as it climbs through the flute up to the surface of the material being drilled, and be thrown off by the drill itself. Still another very important use for the flute is to allow any lubricant that is being used to reach the cutting point of the drill itself. The exact center of the point; that is, the junction of the two angled surfaces at the end of the drill, is known as the dead center of the drill, and this should be exactly on the center of the body of the drill. The remaining portion of the point of the drill is known as the heel, and is that portion of the point which is behind the cutting edge or the lip of the point. When we consider the point as being ground at an angle with the longitudinal axis or theoretical center of the drill, we also find that there is an additional angle or relief angle as compared

with that of the cutting lip. We find that the point of the drill slopes away and drops back on this cutting lip. This is known as the lip clearance of a drill. Now, examining the body of the drill, we find that along the edge of the flute, there is a slightly raised portion following along the edge of the lip, and this narrow strip or raised portion is known as the margin. The margin extends practically from the point of the drill back to the body or the unfluted portion of the shank, and the difference in diameter between this lip and the ground away portion of the drill is known as body clearance. This reduces the friction between the walls of the hole being drilled and the body of the drill, and it also insures the accuracy of the hole. Another point is that considerably more power would be required to turn a drill where no body clearance has been provided than would be with a drill having body clearance.

The Web and Its Function

Looking at the end of a broken drill, one sees a sort of X-shaped section, being thinnest at the exact center of the drill. This thin section is known as the web and runs the entire length of the drill between the flutes. Due to the shape and nature of the flute this web gets considerably bigger as it reaches the outer diameter of the drill, and on this shape and thickness of the web depend the strength and rigidity of the drill. You will find on close examination of several broken drills, that as the flutes approach the shanks of the drill, this web becomes considerably thicker than it was at the point of the drill. This thickening is done for the purpose of strengthening the drill at its point of greatest strain, but this strengthening also has the disadvantage of causing the size of the flute to become smaller, and unless some means for taking care of this is provided, serious difficulties might arise through the throwing off of the chips. For this purpose you will find also that the flute of the drill has become wider near the shank than it was at the point of the drill. Computation will show that the cross sectional area of the flute, therefore, is approximately the same at the shank end of the drill as it is at the point end of the drill.

Due to the form of the flute and the fact that the web gets thicker as it nears the shank of the drill, it is necessary when the drill becomes short from grinding or breakage, to thin down the web, in order to reduce the area of the end of the lips of the drill. This thinning is illustrated on page 25.



A—*Countersink* C—*Blacksmith Drill*
B—*Twist Drill* D—*Spur Bit*

Drills are made in various forms for many different types of work. Of these the photograph shows the most popular and most widely used types of drills. The names and component parts are shown on the photograph, and their uses will be described throughout the balance of this treatise.

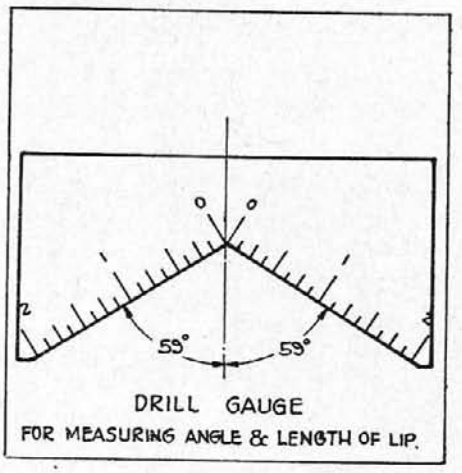
Just a word about quality. The use of inferior drills seldom, if ever, proves an economy. A good drill requires less resharpening and does more accurate work.

Grinding of Drills

Authorities on drilling seem to agree that between 90 and 95 per cent of the difficulties encountered in drilling arise from the improper grinding of either the point of the drill or the lip clearance of the drill. In order to properly grind a drill, certain facts must be known, and three things must be considered. First, the length and angle of the lip; second, the clearance on this lip, and third, the location of the dead center, in relation to the longitudinal axis of the drill. First, let us consider the length and angle of the lip of the drill. Since the dead center of this point should be at all times exactly on the axis of the drill, it follows that the length of the two cutting lips should be exactly equal at all times where accuracy is required.

One may grind an inaccurate angle and clearance on the end of a drill and with tremendous pressure on the feed mechanism, force a hole through a piece of material, but this throws considerable strain on the machine, which is unwise, and at the same time allows for considerable breakage of drills, which is unnecessary. For these reasons and for the additional reason that there is greater satisfaction in using a properly ground drill, the operator is urged to study carefully the grinding of his drills for perfect results.

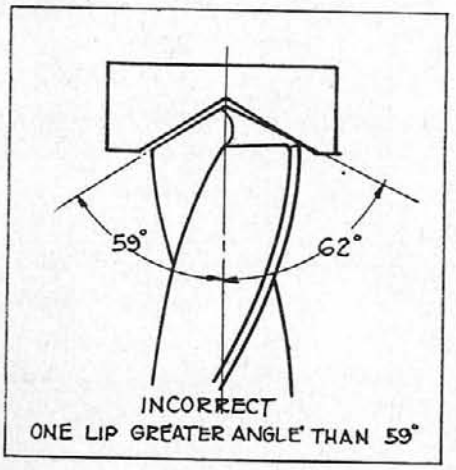
As a result of years of research and considerable expense the drill manufacturers have determined the figure of 59° as being the most effective angle of grinding, and have found that this degree requires the least amount of power to operate, and permits fastest cutting with a minimum amount of feed and power. Since the



DRILL GAUGE
FOR MEASURING ANGLE & LENGTH OF LIP.

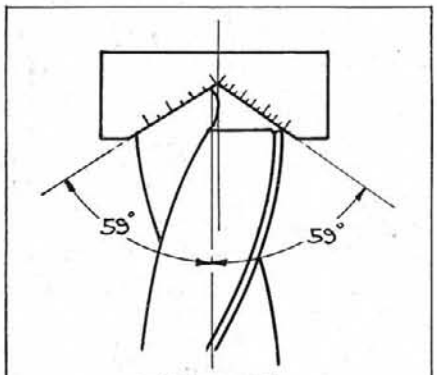
experience and research of drill manufacturers have arrived at this particular angle, it is unwise for the amateur or the experienced operator to depart from this, unless for a specified reason and for a particular type of drilling, where a different angle is recommended. While steel gauges may be purchased which will properly measure and gauge the angle of a drill, such a gauge is shown in full size form in the sketch and the operator is urged to make one for himself. The making of such a gauge is a simple task and requires only careful filing and marking in order to turn out a creditable pieces of work. It is necessary only to trace off carefully the lines and angles and the marks as shown on a piece of paper and glue this piece of paper to a piece of steel and then carefully file to the line as given. In order to mark the graduation, the simple expedient of scratching through the paper into the steel with a scriber will be found satisfactory.

Now, we know that if the lips of the drill are exactly the same length, and ground at the proper angle of 59°, that the drill will cut accurately, clean and fast. Let us find, however, what will happen if a drill is incorrectly ground. As a first consideration let us assume that the drill has been ground so that the dead center is exactly centered on the axis as the illustration shows, but that one lip has been ground at an angle of, we will say 62°, while the other lip has been ground at the proper angle of 59°. What happens? You will find that the drill will not center itself properly and due to the fact that only one of the cutting lips will do all the work, a considerable binding of the drill in the hole will result. This will cause a ragged hole and the hole itself will be off center. In addition to this you will find that the hole probably is larger than the body of the drill. This



INCORRECT
ONE LIP GREATER ANGLE THAN 59°

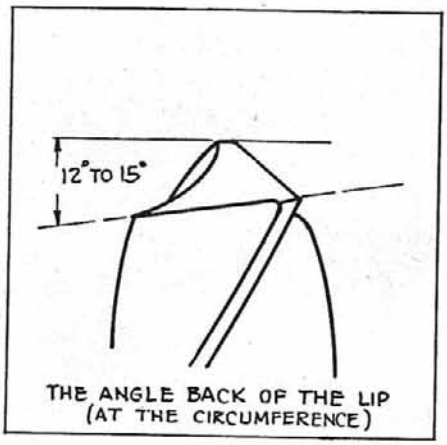
particular phenomena of drilling a hole larger than the size of the drill is sometimes taken advantage of when one wishes to drill a hole that is slightly larger than a drill he has on hand, but the method is not accurate and should only be used in emergency. Now suppose that the drill has been ground and we find that while both cutting lips have been ground to the proper angle of 59°, they are of different lengths; that is, the dead center of the drill is not on the axis of the drill. What happens? We find that the drill will cut all right but that the hole will be larger than the drill. This again throws unequal strain on the drill press. If we combine both of the above faults; that is, having angles that are not uniform and lips that are of different lengths, we have unnecessary abuse that a drill will impose on the drill press, and the strain resulting is terrific and inevitably may cause side play to develop in the spindle of the drill press. This will mean the replacing of bearings and a probable springing of the spindle, causing the drill to run untrue from then on. You will see, therefore, that it is extremely important that a drill be properly ground, not only from the standpoint of accurate work and ease of cutting, but also in consideration of the machine itself.



INCORRECT
ONE LIP LONGER THAN THE OTHER.

The second important point in the grinding of a drill was mentioned as being the lip clearance. This is the relief or the backing off at an angle of the surface of the point behind the cutting lip. Let us assume as a matter of comparison, a drill where the proper angles have been cut on the lip but where no lip clearance behind the cutting lip has been provided. You will see that this entire surface behind the cutting lip will be at all times in contact with the metal being drilled, and naturally will prevent the lip of the drill from cutting into the metal. It is necessary, therefore, to provide a clearance behind the lips, in order to allow the lips to cut into the metal. In addition to this there must be a rake angle which is the angle of the flute at its junction with the cutting lip. On a drill where the lip clearance is properly ground but where the angle of flute or the rake angle is too great, the resulting thin lip which is provided will not stand up under the strain of cutting and con-

tinued breakage will result. On the other hand if the proper rake angle of the flute in conjunction with the lip is provided and too great a clearance angle is ground on the lip, another unsatisfactory result is obtained and the lip will break down under cutting strain. Thus again we see that it is important that both the rake angle and the lip clearance angle should be pretty nearly accurate. The manufacturer of the drill has taken care of the proper angle of rake so that the operator need only be concerned with the proper grinding of the lip clearance. As shown in the sketch this lip clearance should be from 12° to 15° as recommended by the most prominent drill manufacturers. This angle is, of course, taken at the center of the drill, as compared to its circumference, in other words, in the center of the end of the drill. Now, if you will look at the sketch you will note that the heel, or the back end of the lip clearance is considerably lower than the point of the lip which is another way of checking up on the proper lip clearance. This difference in height between the point and the heel will, of course, be greater in a larger drill than it will in a smaller drill.



THE ANGLE BACK OF THE LIP (AT THE CIRCUMFERENCE)

Still another way to check this angle of lip clearance is to look directly at the end of the drill. The angle formed by the line of the dead center with the edge of the lip should be from 120° to 125°. Now if the angle of lip clearance is greater than 15° there is a resultant thinning down of the material behind the lip with a consequent chipping off of the lip, particularly near the outside or the circumference of the drill. This is, of course, more noticeable in drilling the harder materials such as wrought iron, wrought steel, and similar metals, while on softer materials, such as copper, brass, aluminum, etc., the angle of lip clearance may be increased to the full 15° and even one or two degrees beyond that where a greater speed of cutting is desired. But one will notice that if this angle is increased beyond 16° that there is a tendency under fast speed and cutting for the point of the drill to become blue from the heat. This is caused by excessive friction and too much feed pressure. The operator is therefore safe and, in fact, sure of himself when he follows the recommendations of the leading manufacturers and

sticks to the 12° to 15° angle. There are, of course, certain phases of drilling where it is advisable to reduce the cutting lip clearance to less than 12° and also to reduce the rake angle to less than the prescribed amount, but these are specialized cases and will be taken up later on.

The third point; that is, the location of the dead center in relation to the axis of the drill, depends entirely upon the proper grinding of the lip angle of the drill and also of the angle of the cutting lips themselves. If both the lip angle and the lip clearance angle are accurate, the dead center of the drill will automatically be in the proper place. Thus, an effective means of checking up the accuracy of your grinding is to measure the location of the dead center, and its angle in relation with the cutting lip and the axis of the drill.

Drill Speeds and Feed

When we speak of the speed of a drill, we mean the speed at the circumference; that is, the outside surface of the drill. This speed is called the peripheral speed. More specifically this means the distance a drill would travel if it were rolled across a flat surface, for a certain number of revolutions in a given length of time. That is, a drill running at 30 feet per minute, could roll 30 feet in one minute if given this operation.

The feed of a drill, however, is the distance the drill will travel in cutting into the material; that is, the distance of penetration from the surface of the work, in a given length of time. A steady pressure known as the feed pressure, must be maintained in order to feed the drill into the work, since the drill will not carry itself in. The closer one can maintain this constant pressure the more uniform and accurate will be the hole produced.

There are as many different opinions regarding the correct feed and speeds of a drill, as there are drill presses and drills, so that no hard and fast rule may be given for feed and speeds. However, an average range of speeds and feeds is available for different types of work, and in the charts on pages 61 to 70 you will see a range of speeds for different sizes and types of drills.

Working in soft tool steel or machinery steel with carbon steel drills, it is fairly safe to start a drill at about 30 feet per minute, and this may be increased to from 35 to 65 feet per minute for cast iron, while a speed of 65 to 120 feet per minute, may be used for brass. Now, since a ¼″ drill is considerably smaller in circum-

ference than a ½" drill, it will readily be seen that the smaller drill must travel at a greater number of revolutions per minute in order to equal the peripheral speed of the ½" drill. The table, therefore, is so arranged that under a given peripheral speed the various speeds in revolutions per minute for different size drills used, are given.

And since most drill presses are so arranged as to have a range of six or eight speeds, these different speed figures are arranged in groups so that it is only necessary to ascertain into what group of speeds your particular drill press will fall, in order to determine what pulley or pair of pulleys on motor and spindle are necessary for certain size drills. While the ideal speed as recommended by a drill manufacturer should be used if possible, it is sometimes impractical due to the nature and design of the drill press to reach these speeds with any degree of accuracy, so that the operator is obliged to use what speeds he has available on the machine approaching the recommended speed as closely as possible. You will find that if your press causes you to use a lower speed than recommended by the table, you will also have to decrease the amount of feed in order to compensate for the difference in peripheral speed.

In the case of high speed drills, the feed as recommended in the table for carbon drills should be used, but the speed of the drill may be increased considerably. For instance, in drilling soft machine steel or tool steel, a speed of 70 to 100 feet per minute may be used, while a speed of 70 to 150 feet per minute will be satisfactory for cast iron. For brass a speed of up to 300 feet per minute may be used.

Feed and Chip Forms

There are certain things which happen in drilling which are an indication of certain faults either in the feed or the speed, or the grinding of the drill itself. For instance, if the chips fly out from the cutting edge, it is a sure indication that the feed is either too heavy or the clearance of the lip is too great. The remedy, of course, is to lighten the feed or reduce the clearance of the lip. Then again, if a drill has split up through the center of the web, this is an indication that you are feeding too fast for the amount of lip clearance. The remedy is obvious. If the cutting edges of the drill turn blue, and become dull, it is an indication that the material being drilled is too hard for the type of drill being used. The remedy is to use a high speed drill, or to anneal the material before drilling.

Then again, if the cutting edges, particularly at the point of the intersection of the cutting lip with the margin on the edge of the flute break down and wear rapidly, it is a sure indication that you are running the drill too fast. High speeds when used with carbon drills particularly, in cast iron, have a tendency to wear away the margin on the body of the drill and, of course, the remedy is to slow the drill speed down.

It is generally recommended that a high speed and a light feed be used rather than a slow speed and a heavy feed, since this throws less strain on the drill press and promotes faster and cleaner cutting. There is, however, a certain limit to the amount a drill may be speeded up with safety to the life of a drill.

Helpful Hints on Grinding a Drill

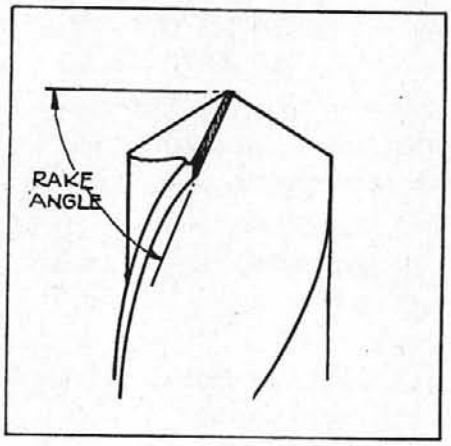
If you have a carborundum or emery wheel mounted on your bench for the grinding of drills, there are several points of importance in the maintenance of the stone itself, that are helpful in the proper grinding of a drill. The first requisite is that the face of the stone be kept absolutely flat. It is impossible to grind a straight cutting lip on a stone that is either rounded off or hollowed out from grinding some other material. In order to maintain this flat surface it is necessary to have some sort of grinding wheel dresser.

Experience has proved that it is of considerable help to have a gauge line or two, filed on the upper surface of the tool rest which is usually supplied on a grindstone or similar machine. These lines are filed using the center of the face of the wheel as a gauge, and a bevel protractor set at 59°, used to mark the lines for filing. The filed lines may be simply deep scratches and are used as a sight line in order to hold the drill at the proper angle in contact with the face of the wheel. By continued practice a reasonably accurate angle can be maintained through the medium of these guide lines.

The grinding of the lip clearance is entirely different, and one must experiment with the approximate height above the tool rest that the drill should come in contact with the face of the stone, in order to start the lip clearance at the proper angle. This is, of course, assuming that the drill is held level with the bench to start. Then as the drill is fed upward at the point over the surface of the wheel, the back end or shank of the drill, is dropped down simultaneously. This sort of roll effect to the feed provides not only a proper lip clearance but has the tendency to follow around to the heel clearance.

Special Grinding of Drills

All of the foregoing data on the grinding of drills pertains to the regular run of drilling, but there are some special cases where a little rearrangement or a little different grinding of the drill point is of great benefit. Of course, the cutting properties of the drill are helped to a great extent by the use of a proper lubricant, but this particular phase of drilling will be taken up a little further on. What we have in mind now is particularly the special grinding which not only helps the drill to cut better in some cases but also saves to a great extent the breakage of a large number of drills, particularly of the small diameters.



For instance, in drilling very hard materials, it is often advantageous to reduce the angle of the lips; that is, the rake angle, which is formed by the point of the drill, with the inside surface of the flute. By grinding off some of this flute, to make the angle between the point and the flute less acute, it prevents the drill from cutting in quite as fast as usual and reduces the size and thickness of the chips, thereby reducing the strain on the drill. A heavy feed pressure is permissible with this type of drill, but not so with the regular grinding, since the drill would have a tendency to chip at the lip. Particular care must be used in reducing this angle or grinding off the flute side of the lip, or the entire drill must be reground. Of course, there are obtainable specially tempered drills, for very hard materials, but these must usually be bought to order, and are quite expensive. Use of such special drills can usually be avoided if the proper feed and lubricant are used.

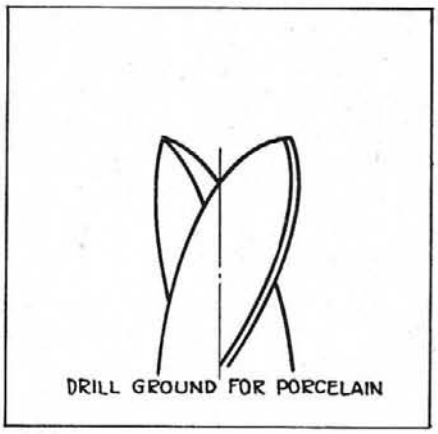
One safe rule to follow in drilling hard materials is—the harder the metal being drilled, the slower the speed of the drill should be and the feed much lighter.

It is a well known fact that in many establishments where a considerable amount of drilling is done there is usually an error in the speed used, especially in the drilling of small holes. The speed is often far too slow for the size of the drill. In fact, it is very rare to find a drilling machine running at more than half of its proper

speed for drills under 1/16″ in diameter. With drills of this size it is really much better to make a mistake on the side of too much speed rather than not enough providing the feed is kept light. This pertains particularly to the softer ferrous materials, such as iron, soft machine steel, cold rolled steel and the like.

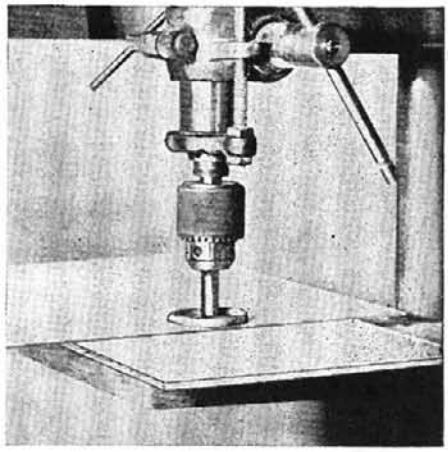
In the drilling of brass, copper and similar soft, non-ferrous materials a slight departure from the accepted angle of the cutting lip is permissible. Some operators advocate angles as great as 75°, others maintain that angles of 65° to 75°, and still others maintain that angles of 65° to 68° are proper. This is a basis of controversy and it is beyond the province of this book to attempt to settle the controversy by establishing any definite angle. On the average, however, any angle from about 60° to 70° helps materially in the drilling of brass, particularly at the time when the drill breaks through on the under surface. The particular reason for making the cutting lip longer is that it produces or establishes a greater bearing surface for the point of the drill, thus preventing it from digging in too fast, even under a very heavy feed. Some operators advocate keeping the angle of the point at 59° and using a relief angle of about 5°, as a means of preventing the drill from catching as it breaks through. Obviously, it is necessary to lighten the feed to a great extent, and this, of course, makes the drill cut much slower.

Grinding a Drill for Cutting Glass or Porcelain



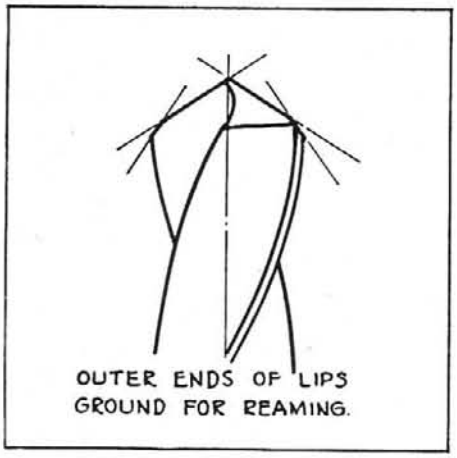
Another special grinding of the point of the drill, is that for the drilling of porcelain and glass. The form of the grinding for this particular type of drilling is shown in the sketch to the left. It is necessary when using this type of point to first cut through the glazing on the surface of the glass with a glass cutter on the circle on which the drill will cut. Another method

of drilling glass and similar substances is through the medium of a three-cornered file from which the end has been broken. In this particular case a small dam of putty or sealing wax should be built up around the hole to form a wall about ¼" high and this dam kept filled with turpentine. The file will, of course, cut a rather ragged hole, but this may be ground out by means of a carborundum or similar type of grinding pencil. Another method is to use a brass tube and valve grinding compound.



Cutting holes in glass using a brass tube, emery dust, light oil or turpentine and a "dam" made of putty.

If the novice finds it almost impossible to grind a drill to the proper angle on lip and pitch, he can make use of the trick of first drilling a hole, smaller in diameter than the required hole is to be. The difference should be about 1/16". The full size drill, or the drill of the size of the hole selected should then have the outer end of the cutting edge slightly ground away at an angle of about 45° so as to show a flat of about 1/16". This drill is then used as a reamer to enlarge the hole to the proper size, and due to the fact that its cutting lip has been ground away slightly, it will ream the hole accurately to its finished size, almost as neatly as a standard reamer. The reamer will, of course, leave a far smoother surface in the hole and should be used if on hand, since the use of a drill as a reamer is only in the nature of a substitute.



When drilling soft substances such as copper, brass, aluminum and the like, it is desirable to produce a smooth hole without the customary burr on the under side.

To do this, clamp the metal between two pieces of hardwood or scrap metal. Then when the drill breaks through, "burring" will be prevented by the wood or metal below the work.

Reduced Rake for Drilling Lead

On extremely soft metal such as lead it is sometimes advantageous to reduce the rake angle at the cutting lip of the drill; that is, the angle formed by the cutting lip and the flute of the drill. In order to do this the lip of the drill is ground away and the flute filed at an angle of from 75° to 90° with the end or axis of the drill. This prevents the drill from digging in too fast and times the cutting action of the drill into more of a scraping action. The reason for doing this is for the same reason that in turning brass or other soft metal on a lathe the rake angle, or the angle on the top of the cutter lip, is ground off and placed so that it is exactly on the center of the piece being turned and at the end parallel to the bed of the lathe.

Use of Lubricants

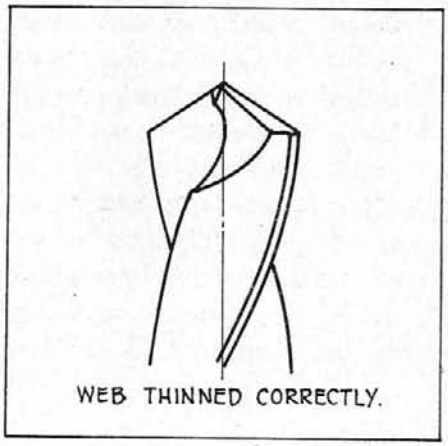
For the cutting of different metals the drill manufacturers recommend the following lubricants. For hard steel, use turpentine, kerosene or soda water. For brass ordinarily no lubricant is required but if one is desired use a flood of paraffin oil. For aluminum and soft alloys of different types the use of kerosene or soda water is recommended. Cast iron should always be drilled dry, and if trouble is experienced in getting the chips out of the hole, a strong jet of compressed air is recommended. This jet of air should be directed down into the hole alongside the drill, where it will not only remove the chips, but also tend to keep the drill point cool.

Getting Rid of Chips

The operator sometimes finds that as the hole gets deeper it is more difficult to get the chips to free themselves from the hole. One way to overcome this is the use a little slower speed and a heavier feed, in order to make larger and heavier chips, which will be lifted out with greater ease. On tough materials such as machine steel, and cold rolled steel, the operator is strongly urged to experiment with his drill so as to obtain a very tightly curled chip such as would come from a lathe tool, while turning these materials. One will find that such a chip in a long tight spiral will automatically push itself out of the hole. This type of chip never causes any concern. It is the fine dust-like chip which packs itself into the flute

of the drill, and causes considerable friction on the walls of the hole, that cause trouble through undue heating and packing.

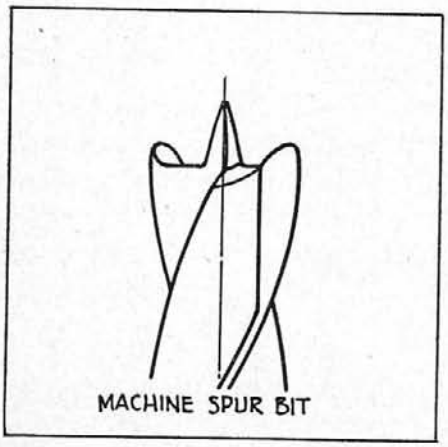
In grinding or sharpening short portions of broken drills, it is necessary, due to the increased thickness of the web to grind away a portion at the back of the heel of the point. The method of doing this is shown in the sketch. It is rather a delicate operation, but since it involves a drill which is almost ready to be thrown away, it affords a good opportunity for the amateur to practice his grinding dexterity. Care should be used in the grinding to try to get the width of the heel behind the cutting lip the same thickness or width on both sides of the dead center. This thinning of the web is particularly desirable on the larger sizes of drills, but not so extremely important on the small sizes.



WEB THINNED CORRECTLY.

Drilling Wood, Fiber, etc.

For the drilling of wood, fiber, and similar materials, a special drill or machine spur bit, as it is called, is sometimes used. The particular shape of this type of drill is shown in the sketch. While it may be ground by hand by a fairly proficient operator, the novice is urged to purchase this type of drill, first to ascertain its exact nature before attempting to grind it. Makeshift bits may be made by the novice from regular bits ordinarily used with a brace and bit set, by grinding off the threads on the screw center of the bit, retaining a plain tapered center. In this case, however, it is necessary to reduce the rake angle of the cutting lip, since for machine work this type of bit would cut in or dig in entirely too fast and cause considerable trouble. The machine spur type of bit cuts a very clean



MACHINE SPUR BIT

and accurate hole, and may be operated at higher speeds, than would be the case using ordinary drills for the cutting of wood. It also has the advantage of being able to accurately center itself on a center punch mark. This is of untold advantage when drilling holes for dowel pins, which have to be accurately located. The advantage is still further magnified when one takes into consideration the fact that stock wooden dowel pins as purchased from a local hardware dealer are usually anywhere from 1/64″ to 1/32″ under their stated size, and since the machine spur bit cuts an accurate hole to its actual size, there is not quite the discrepancy that there would be using the ordinary drill. The regular type of machine drill has a tendency in drilling wood to cut a larger size hole than the nominal size of the drill. Not only this but the regular machine drill often has a tendency to cut a hole which is somewhat oval rather than being perfectly round. This is due to the fact that the drill cuts more easily parallel with the grain than it does across the grain. The owner of a drill press is therefore urged, if he intends to do considerable drilling in wood, to invest in a set of these machine spur bits.

The Center Drill

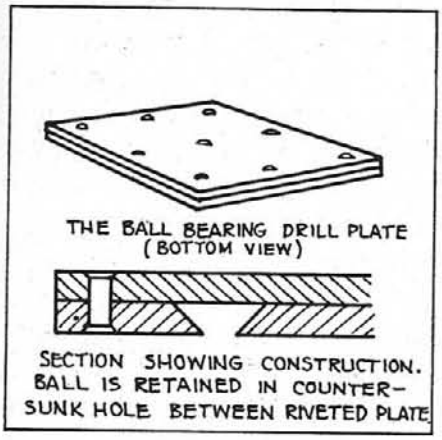
CENTER DRILL OR
COMBINED DRILL & COUNTERSINK

Another type of drill which is necessary around the drill press is one known as a center drill. This is in the nature of a small drill end with a countersink shape shoulder just behind the drill. This is for the purpose of centering or accurately locating holes to center punch marks, and for centering work for a lathe.

The Countersink

Still another item which is necessary is a good countersink. This may be of the milled or multiple lip type, or may be of the solid type with two lips milled out of the bar. Either type will do good work, but the first type has a tendency to chatter, particularly on the

softer types of material. Where the use of a countersink does raise a series of ripples, a convenient way of removing them is through the medium of a small grinding stone, the end of which has been formed to an 82° angle. A piece of dowel stick which has been shaped to an 82° angle may be used by inserting a piece of coarse emery cloth between the end of the wooden pin and the countersunk hole. If a considerable amount of drilling is being done where accuracy is of great importance, the operator is urged to construct for himself a ball bearing type of centering bed. The construction of this is clearly shown in the sketch.

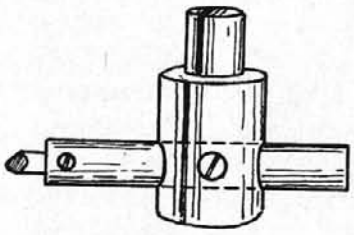


Hints on Laying Out Work for Drilling

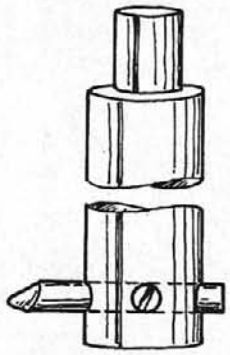
When laying out your work, particularly holes of rather large diameters such as 5/8" or over, it is a great help to scribe a circle of this diameter on the surface of the work and draw two center lines at right angles to each other intersecting at the center of the circle. At the points where these two center lines intersect the circumference of the circle, put four small center punch marks. These will help considerably in ascertaining whether the drill is entering the material perfectly centered or not. Before a drill has entered the metal to a point where its lips are below the surface it is not too late to use some substitute in order to force the drill to recenter itself accurately on the laid out work. One of the methods of doing this is to gouge a small "v" or round bottomed mark on the side of the conical shaped depression formed by the drill on the side where the drill has crept away from the center line. Some operators in drawing the circle for the drilling operation scribe two or more circles one inside the other. This is very convenient in that the operator is enabled to check the accuracy of the centering almost immediately the drill starts cutting through the smaller or inner circle. While the center punch marks at the intersections of the circumference with the center line are not absolutely essential, they are always there even though the scribed line may be cut away during the drilling operation and even after the hole is finished.

Use of Boring Bar

Several boring bars are available to the machine owner, but if the skill of the operator permits it, one may advantageously be made by himself. One of the simplest types of boring bars is composed of a piece of shafting, one end of which has been turned down to ½" to allow it to be gripped by the chuck of the drill press. Through the other end of this piece of stock a ½" hole has been drilled at right angles to the axis. In the end of this piece of ½" stock, a hole has been bored to accommodate a piece of ¼" drill rod. In the 1" piece of stock, a set screw may be mounted with which to clamp the cross bar at any predetermined position. Another set screw is installed in the end of the ½" bar with which to clamp the ¼" drill rod.



BORING BARS



By grinding the projecting end of the drill rod to the shape of a lathe tool, it becomes a very efficient boring bar. Several different sizes of these boring bars may be made up by the operator and they preclude the necessity of purchasing large drills of ¾" or over 1" size, these drills being rather expensive and worst of all it is difficult to obtain a drill of this size with a ½" shank. It might be well to point out that on drills of the larger sizes, a rather heavy drill press is necessary to handle them. Not only the size of the drill press enters into the picture, but also the size of the motor necessary to run one of them, and in addition, the fact that drills made to fit these large drill presses, ordinarily have tapered shanks, which will not fit the smaller types of drill presses.

Center-Drilling Short Rods

The owner of a small bench lathe which is not equipped with a hollow spindle larger than ½", is sometimes at a loss to determine how the end of a rather large piece of shafting can be properly and accurately centered on both ends. This size bar cannot, of course, be chucked up in the lathe for the center drilling operation. One of the easiest and most accurate methods is to run the drill press spindle down until the center drill makes a slight indentation in

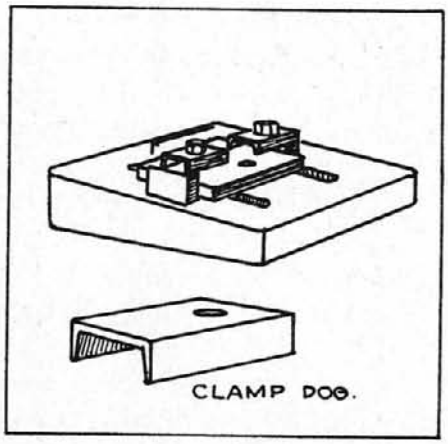
the table of the drill press. In this indentation a small steel ball is placed. One end of the bar stock to be center-drilled is drilled only slightly and then is turned end for end and this indentation in the end of the bar is rested on the steel ball, while the other end is being completely drilled and countersunk by the center drill. It is then reversed end for end and the former end is completed as to centering and countersinking by the center drill. This is an absolutely accurate method of center-drilling short lengths of bar stock.

Shank "Adapter" for Small Drills

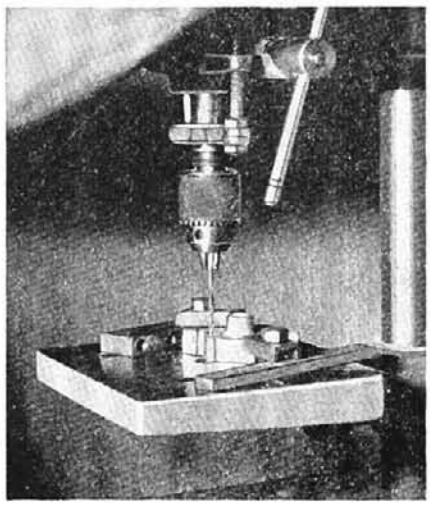
One of the little tricks that is well worth knowing about the drill press is the method of adapting very small drills for use in a chuck that will only grip drills of a comparatively small diameter. For instance the average chuck will not grip a drill smaller than about No. 50 of the number sized drills. It so happens that quite frequently an operator wishes to drill a hole with a drill as small or smaller than No. 70 and, of course, the chuck will not hold this size drill unless some arrangement is made to adapt it. If the shank of the drill is wrapped with very fine copper or iron wire and is then heated in an alcohol flame and a drop of solder run in on the wire, this will increase the diameter of the shank sufficiently, so that it may be tightly gripped by the chuck. The wire on the shank of the drill must, of course, be evenly wound, and care must be used not to allow one turn of the wire to overlap another turn.

Use of Compound Slide Rest on Drill Press

You will notice in the photograph on page 32 illustrating milling operations, that a compound slide rest from a small popular priced lathe has been bolted to the table of the drill press. The one hole with which the compound rest is provided is used to bolt the slide rest fast and on the opposite side of the slide rest a piece of channel iron in which a hole has been bored is used to clamp it down. Since we



have mentioned the use of the length of channel iron for clamping wood to the table, it might be well at this point to mention that a quantity of different lengths of channel iron are almost a necessity around the drill press if one hopes to be able to clamp his work properly to the table. Of course, there are any number of different types of blocks with which a drill press may be equipped for this purpose. but it might be well to point out that many craftsmen have been using drill presses around the home workshop and machine shop for years and never had occasion to use any type of clamping dogs other than pieces of channel iron of different sizes. With them one may use some of the pieces as the rest on which to support one end of the clamp dog, as it is called, while the other end rests on the piece which is to be pulled down. One of the typical uses of these home-made clamp dogs is shown in the accompanying illustration which also shows the crank case of a small gasoline motor rigidly bolted to the table for accurate drilling.

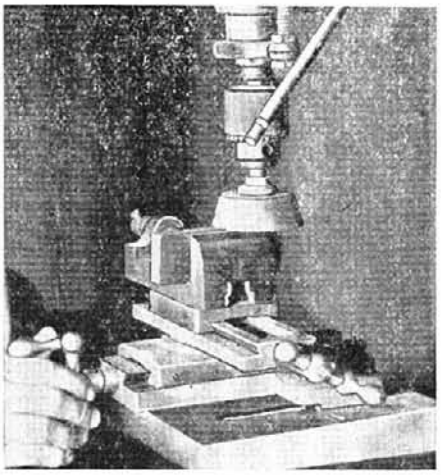


Clamping work securely to the table promotes accuracy.

Special Arrangement of Slide Rest

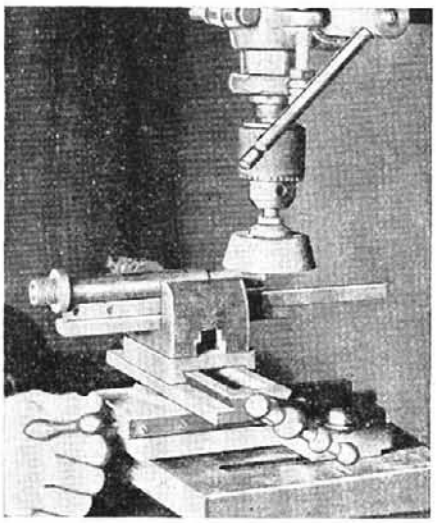
To get back to the subject of the compound slide rest and its uses around the drill press, you will notice that the tool post holder has been removed from the compound slide rest and a typical vise such as may be purchased readily has been securely fastened by means of a pair of screws to the flat surface provided on the compound rest. This is so arranged that the cross slide of the compound rest may be swiveled through an arc of 360°, making a most convenient method for swinging work at right angles or some other angle to a cut first made. It is an accurate method of surfacing off pieces of metal where it is desired to have one surface at an absolutely accurate angle with another surface. In the illustration shown on the opposite page the same set-up of compound slide rests and drill press vise has been used to hold a shaft on which a flat is being ground for the installation of a pulley with set screw. Usually this

operation is done in a milling machine, but the operator will find that a cup-shaped wheel which is usually associated with surface grinding may be used advantageously as a satisfactory substitute for a milling operation. One of the principal attributes of this set-up is in its comparative cheapness when one compares the cost of a cup-shaped grinding wheel with the cost of even the smallest of milling cutters.



Surface grinding a flat surface.

By drilling several holes in the upper surface of the compound rest on which the tool post is usually bolted one may provide himself with a surface on which to clamp flat pieces of metal for very accurate grinding. For instance, it is sometimes necessary to grind the edges of a strip of bar metal to an angle of 60° for the purpose of making a "V" slide contact. If the metal is bolted to the surface of the compound rest at an angle of 60° and a cup-shaped wheel is used, one will find that he can do very close and accurate work. Then again it is sometimes desired to surface grind a flat surface and to do this grinding we do not wish to have the concentric circles which are left by the cup-shaped wheel in the ordinary operation of surface grinding. We can then mount an ordinary 3″ or 4″ wheel of about ½″ face in the drill press spindle and so clamp our work that it is at right angles to the side of the wheel or parallel to the spindle of the drill press. It is then only necessary to run the wheel from one end to the other of the surface and then drop the spindle of the drill press a fraction of an inch and continue running the wheel back and forth to accomplish a very satisfactory surface-ground piece of work.

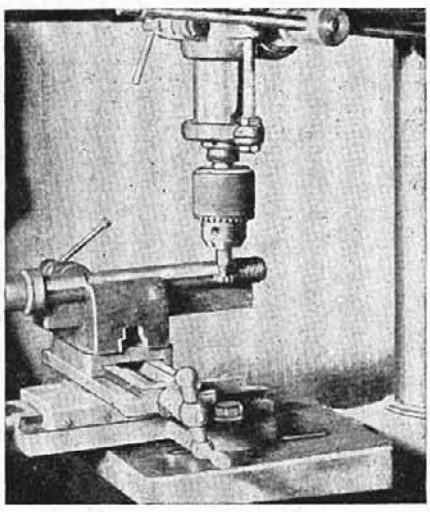


Surface grinding a flat section on a round shaft.

Using the Drill Press as a Milling Machine

In order to use the drill press as a milling machine it is necessary only to make some arrangement for reducing the number of revolutions down as low as 30 revolutions per minute. There are several ways of accomplishing this, one being through the medium of a counter-shaft mounted at some point behind the drill press and so arranged so that the height of this shaft is on a level with the lower end or the lower shaft of the motor which is on the drill press itself. On the bottom end of the motor on the drill press a 6½" diameter pulley is mounted and this pulley is belted to a 1¾" pulley on the counter-shaft just mentioned. This counter-shaft in turn is driven from a 1¾" pulley to a 5" pulley on the counter-shaft. This will give a very low range of speeds and we have utilized the shaft of the drill press motor itself as a counter-shaft with which to reduce the speed. This will in no way harm the shaft or the bearings of the drill press motor even though it be used continuously for that purpose. This applies particularly to the ball bearing type of motor.

Should the operator not wish to go to the trouble or expense of installing an extra counter shaft or the purchase of an extra motor to reduce the speed it may still be accomplished by a very simple method and that is the mounting of a crank handle on the lower end of the drill press motor. This may be turned by hand by some friend or other member of the household while the operator himself manipulates the tool and the work on the drill press table.



Milling a keyway into a shaft.

Of course, the main requsisite here is to obtain the services of a helper. The work or the turning of the drill press motor is very easy and although it is rather a makeshift proposition almost perfect milling operation may be accomplished by this means. In the accompanying illustration the drill press is shown rigged up for the purpose of milling a key way in the shaft which is clamped in the vise. Several different sizes of this T flat type of milling cutter may be kept on hand for the purpose of making different sized key ways. Of course,

the shaft might be turned around at 90° to the position shown and an end milling cutter used to cut the key way. The number of ways in which a drill press may be converted into a very satisfactory milling machine is limited only by the ingenuity of the drill press owner. There is no better illustration of the old adage that "necessity is the mother of invention" than around the home workshop particularly the home workshop that is not fully equipped with all manner of tools and fittings.

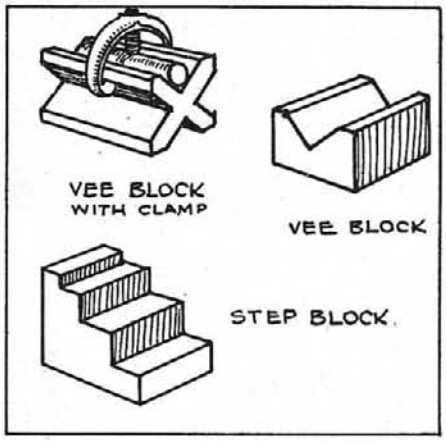
Calipers, Dividers and Other Accessories

In order to facilitate the laying out of work on the drill press and enable the owner to get the most good out of his machine it is recommended that he purchase as soon as convenient the following tools. A pair of 4" or 6" hermaphrodite calipers for marking off holes at a given distance from the edge of a piece of wood, a pair of dividers for stepping off distances on the circumferences of a circle or a straight line, a surface gauge for laying out holes and gauging height or depth, a depth scale for measuring the depth of holes and counter bores, a combination square that consists of one head with a 90° and 45° angle in combination with a steel rule and a center head which arranges the steel rule at the bisecting point of a 90° angle, that is, will give an accurate angle of 45° from the center of the 90° angle. This latter tool is one of the most convenient for locating the center of round bar stock in the absence of a bell type center punch. A small attachment may also be purchased for this combination square which will adapt it very nicely for use as a surface gauge. Most of the machinist tool manufacturers list these tools. It is rather poor policy to purchase a sensitive and accurate drill press and then use guesswork methods of laying out work and drilling holes.

Several other items which are almost necessities around the drill press are chalk or whiting which are used to whiten the surface of metal on which lines will be scribed with a scratch-awl, or a small bottle of a copper sulphate solution, with a brush or a swab permanently mounted in the cork. A coating of this liquid spread over the surface of steel deposits a very thin coating of copper on it and any lines or punch marks which are put on this copperized surface show up very plainly and clearly and facilitate accuracy in your work. Then again a solution of silver nitrate produces a

deposit on copper or brass through which lines that are scratched show very clearly. Soapstone pencils may also be used and make very satisfactory substitutes for the chalk or whiting for marking up cast iron, malleable iron and similar materials. The soapstone is also very handy in marking out lengths of rough angle iron and other similar rough work.

"V" Blocks and Vises

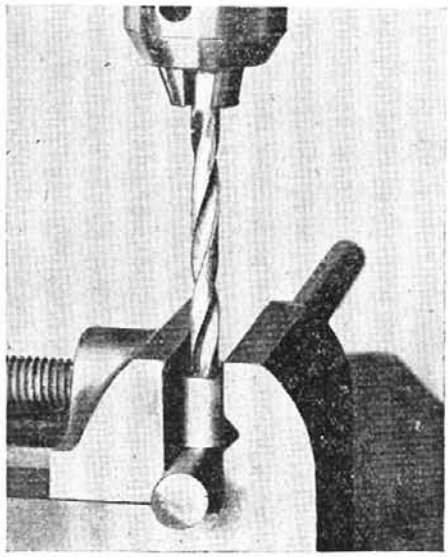


One or more "V" blocks of the type shown in the sketch are among the most useful adjuncts to the drill press. In them round bar stock may be clamped for drilling and other pieces of material other than flat stock may be rested to provide a solid foundation for drilling. Then, too, the "V" block makes a convenient tool with which to find the exact center of stock, either round or square, when used in conjunction with a surface gauge. A drill press is really not complete without at least one "V" block of some type. There are numerous types on the market and the owner of a drill press is urged to purchase one or more of these blocks.

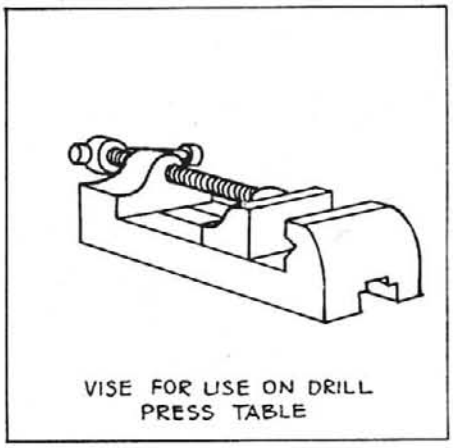
There are several methods of arranging substitute material with which to clamp materials on the drill press table. Several pieces of angle iron on which the legs are of equal length; that is, pieces of 1″ x 1″ angle or pieces of 1½″ x 1½″ angle serve admirably as a substitute for a "V" block. It must be pointed out, however, that these should be firmly clamped to the table.

Among the other adjuncts with which a drill press may be very advantageously equipped is a series of drill bushings. These may be bored and turned from bar stock as the main precaution is to make absolutely sure that the hole in the bushing is concentric with its outside circumference. One of the uses of a drill bushing is shown in the photograph on the opposite page, where, in a piece of ½″ round bar stock a 5/16″ hole is being drilled. Without the

help of a drill bushing to guide the drill it is almost an impossibility to drill a hole of this size through a ½" shaft and have the hole exactly centered in the shaft. But since the shaft and the bushing are held in absolute alignment in the vise and the vise is in turn clamped securely to the bed of the drill press, there is nothing that will prevent the drill from drilling a hole exactly where it is intended and there is no tendency for the drill to creep off to one side. The use of bushings is an advantage in drilling wood dowel pins as well as metal rods.



Using a drill bushing to accurately center a hole in a shaft.

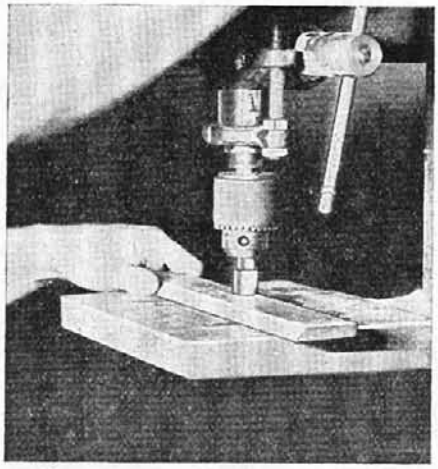


Another almost indispensable accessory is an accurately machined vise, in one jaw of which a "V" groove has been milled which is parallel with the top of the jaw. Some of these vises are fitted with a self-adjusting vise facing which adjusts itself to pieces where the two sides are not parallel. This type of vise is shown in the sketch. Provision is usually made for bolting these vises to the drill press table.

Spot Polishing

To spot polish or give an "engine turned" finish to a metal surface it is necessary only to provide a piece of dowel stick, one end of which has been turned down to ½" to fit the drill press chuck. Any diameter may be used for the polishing. On the end of this dowel glue a piece of leather belting and trim it roughly to a circle.

Moisten the surface of the metal to be polished and sprinkle on it a little fine emery dust, carborundum crystals or pumice stone. Holding the work stationary and beginning at one corner, spot a



Spot polish steel strip with leather disc and pumice.

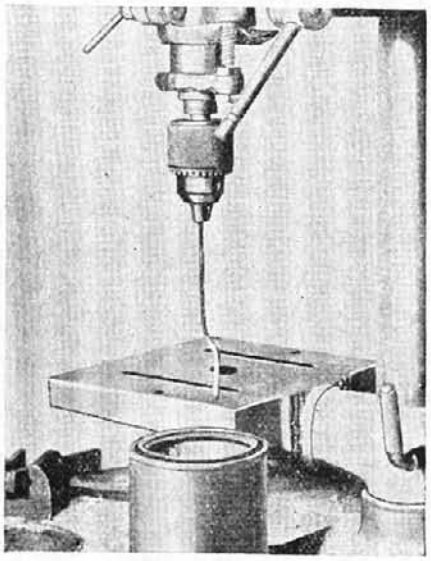
place by bringing the leather disc down in contact with the surface. Move the work a little more than half the diameter of the leather disc and repeat the spotting. Continuing along these lines gives a beautiful finish to metal surfaces.

Since the average drill press has a range of speeds of 600, 1280, 2390, and 5000 R.P.M., to use the table, find the speed in R.P.M. under the peripheral speed, opposite the size drill to be used, and then use the nearest higher speed that the drill press will give. Remember, that it is better to use a greater speed than necessary and lighter feed than the reverse.

Mixing Paint With the Drill Press

One of the many uses to which a drill press may be put is that of mixing paint. As everyone knows one of the tedious jobs around the home is that of mixing paint and all too often the job is only half done because the steady stirring with a paddle by hand is a rather tedious job. But with the aid of a drill press and a simple formed piece of wire the drill press removes practically all of the drudgery and insures a thorough mixing of almost any type of liquid. The piece of wire pictured is of the type used for mixing rather heavy material while for mixing very thin liquids a simple tool is a piece of rod on the end of which has been placed two hexagon nuts.

Operating speed should be very slow, especially if the "mixer" has a large outside diameter.

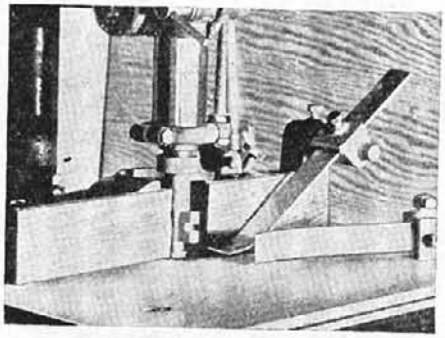


Paint mixing made easy. "Stirrer" is simply a bent wire.

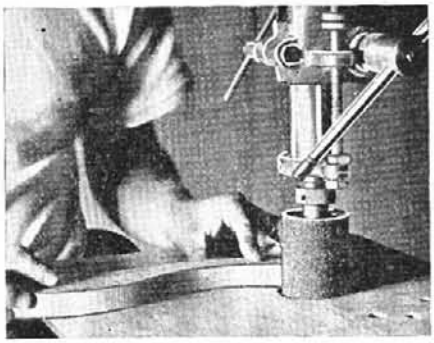
A distinct advantage of mixing paint with the drill press is afforded by the fact that the height of the spindle with "stirrer" may be varied. Thus, if the paint is very solid at the bottom of the can stirring may be begun near the top and the position of the stirrer gradually lowered until all of the solid matter has passed into solution. The same principle can be used satisfactorily with other liquids.

Shaping Work

If by installing a larger pulley on the motor, you are able to increase the speed of your drill press to 5000 R.P.M. or better, you will have a machine which undoubtedly can turn out very creditable shaper work. If the type of work you want to do is all straight work such as the edges of tables, panels, long strips of mouldings, etc., and your machine has a threaded spindle, it is unnecessary to make any further changes in the set-up of the machine. If, however, you wish to do more extensive shaping including interior work, the drill press head and motor should be inverted on the column and the column dropped down through the base and table so that working limits will not be restricted by the column. Since shaper cutters must be held on with a nut your drill press must have a threaded spindle at the chuck end or, if your machine has a tapered spindle it will be necessary to secure a special adapter, threaded at one end with a recessed taper on the other. It is a great advantage to have a larger table of wood or heavy sheet steel which may be bolted to the regular table, in order to provide a larger working surface. This auxiliary table should be fitted with an adjustable guide and guard. It is necessary to have near the center of this auxiliary table a hole large enough to allow the cutters that are to be used to project entirely through the table. This is necessary because a large amount of shaper work is cut from beneath the work. Since the spindle of the drill press is adjustable up and down and the guide and guard on the auxiliary table are adjustable laterally, you have all the attributes of a shaper.



The drill press equipped with auxiliary table, guides and guards, for shaper work.



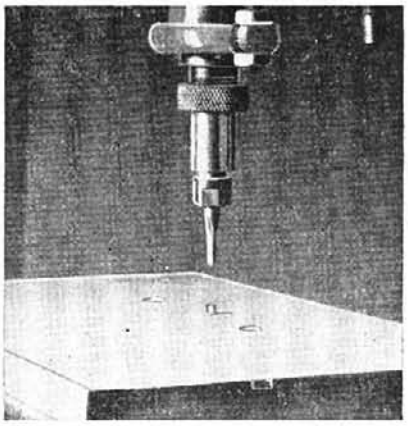
Sanding curved shapes with the drum sander.

It is also advisable to speed up the machine to 7000 or 8000 R.P.M. and in many cases this entails the purchase of a motor which runs at a speed of approximately 3500 R.P.M. If considerable shaper work is contemplated, the purchase of such a motor will prove a good investment.

For more details and information on shaper work in general, the reader is referred to the book under the title, "The Bench Saw, Jointer and Shaper," which is part of this series. This book may be purchased where the present copy was obtained.

Router Work

As in the case of shaper work, if your machine can be speeded up to 7000 R.P.M. or better, you have on hand an ideal routing machine, the uses of which are manifold. Router carving, fluting, beading, mortising, tenoning and similar operations are yours to command.



A level board with pin centered under router guides templet when carving.

In order to adapt your drill press for router work it is necessary to supply yourself with an auxiliary table which may be clamped to the regular drill press table by means of countersunk bolts. In the exact spot on this table where the drill would touch when set down, a metal pin should be inserted. The easiest and quickest way of affixing this pin is to insert a No. 14 wood screw into the wooden table, and after doing so cut off the head, leaving a 1/8" projection above the table top. This pin is intended to guide the templets used for carving and routing.

The pin should be filed perfectly smooth to assure even movement of the templet.

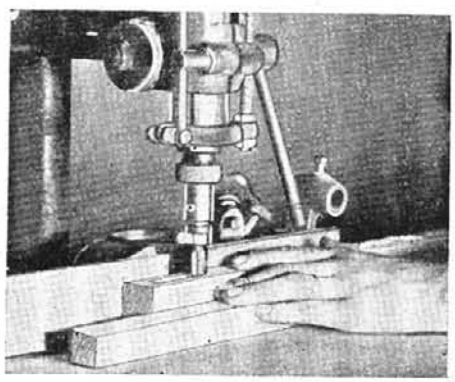
Before proceeding, just a word of caution on the use of a drill press for router or carving work at high speeds such as 7000 R.P.M. If your drill press is equipped with a Jacobs type of chuck which is fitted to a tapered spindle; that is, if the chuck is held on the spindle by means of a tapered hole only, **do not use this chuck for holding router cutters at high speeds,** since taper-fit chucks are intended only for drilling and will loosen up when used for other operations. This is particularly true when using such types of router cutters as dovetail or inlaying routers, where the cutting edge of the cutter recedes from the point; that is, the end of the cutter is larger than the body of the cutter. If your machine is equipped with a tapered spindle, it will be necessary to obtain a special adapter and collet chuck which are designed primarily for the holding of router cutters on tapered spindles. In the case of shaper work the use of a special threaded spindle is advocated because it is necessary to have this type of spindle to mount the shaper cutters.

If your drill press is of such design as to necessitate the removal of chucks and spindle as a unit and the insertion of a special spindle, the use of such a spindle is strongly advised.

It is extremely important that the spindle of the drill press should run absolutely true, if fine router or carving work is to be expected.

Mortising With a Router

In order to do mortising work with router bits it is necessary only to provide a guide with some sort of hold-down clip for the table to hold the wood rigidly in contact with the table and guide. It will be necessary to remove the metal pin from the auxiliary table so that the guide may be mounted in such a manner as to bring the router cutter in the proper position for making the mortise. Start the machine and feed the router cutter down into the wood for a distance of about ⅛", then move the wood from right to left until the length of the mortise has been reached. Return the router to its

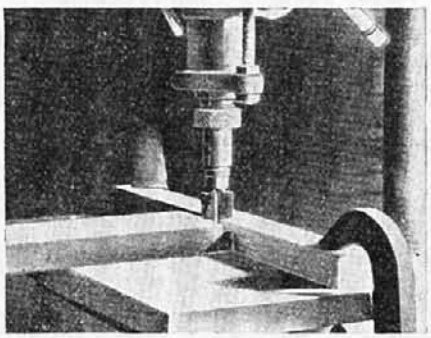


Mortising with a standard router bit.

original position by pulling the wood back and then feed down another 1/8" and repeat the movement of the wood until the mortise has been cut to the proper depth.

Tenoning With a Router

In tenoning work, the router proves itself of great advantage in the removal of the wood on the tenon end. It is necessary for absolutely true work first to run a saw cut where the shoulder of the tenon is to be, and use the router only to remove the wood on the tenon itself between the saw cut and the end of the piece. While the bench saw with a dado head is the ideal and proper tool to use for the making of tenons, this method will be found quite satisfactory and a real benefit to the shop owner who does not own a bench saw or dado.

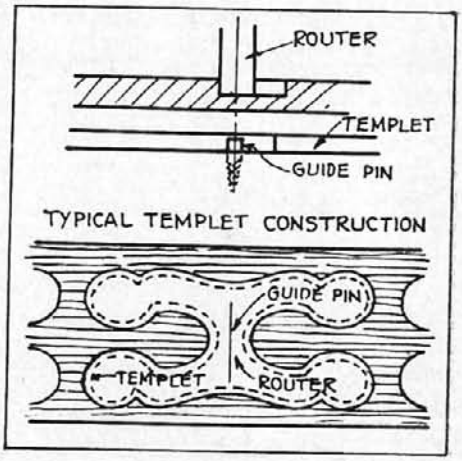


Set-up for tenoning on drill press with router bit.

Pierced Fret Work

The router cutters particularly of the diameters 1/8" and 1/4" may be used in the absence of a jig saw for cutting out fret work and other pierced panels. In order to use a router for reproducing curved shapes in panels, or for making pierced fret work, it is necessary to provide a templet. For this type of work the guide pin is placed in the auxiliary table and accurately held underneath the center of the router.

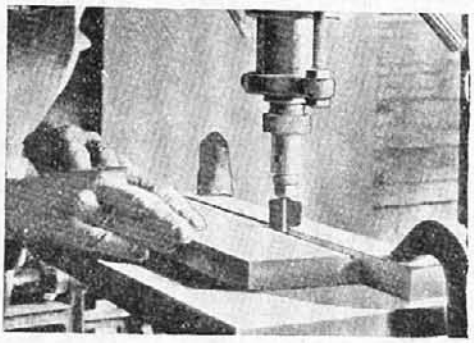
In the making of such a templet, two things must be borne in mind; that is, the size of the router bit to be used and the size of the guide pin. For instance if the router bit is 1/2" in diameter, and the size of the guide pin is 1/4", there is a difference of 1/4" or 1/8" on a side of the groove in which the guide pin will operate and guide. Where the edge of a piece of lumber is to be cut to a form, it is necessary to draw a line on half the diameter of the router bit away from the form line. Then using this as a center, draw an additional line between it and the form line. In order to make this clearer, the reader is referred to the sketch. Note that the shape of the finished



piece is shown in a solid line, while the edge of the groove in which the guide pin rides is shown in a heavy dotted line. In the sketch is shown the method for making a templet where the work is being done on the inner surface of a panel. In this case it is necessary to take into consideration the full difference in diameter between the router bit and the guide pin. This difference is shown by having the finished form indicated in solid lines, and the edges of the groove in which the guide pin rides are shown in heavy dotted lines.

Where the panel does not exceed over 3/16″ the cut may be made in one operation, and a very clean type of work turned out. In many of the present day furniture factories, the router machine has supplanted the jig saw almost entirely, and with these high powered machines, materials up to 1½″ in thickness are pierced entirely through in one operation. For the making of grills for China closets and similar work the plywood is piled up to a thickness of 1″ and a multiple of grills is cut in one operation.

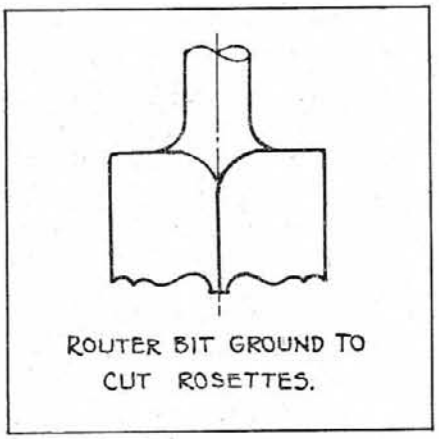
The router bits may be also used for the cutting of rabbets and dados, either in panels or in heavier lumber. It is, of course, necessary to clamp one or more guide strips on the drill press table in order to properly gauge and guide the work. Where a dado or rabbet is to start and stop inside the extremities of a piece of stock, a strip of wood with the stop block clamped or nailed to it, should be fastened to the guide piece in order to start and stop the cut properly.



Set-up for rabbeting on drill press, with router bit.

This strip may be attached to the drill press table by clamps or may be fastened to guide by means of screws. Small "C" clamps facilitate adjustment of the stop blocks, after trial cuts have been made to check the accuracy of the setting.

Spinning Rosettes and Ornamental Buttons



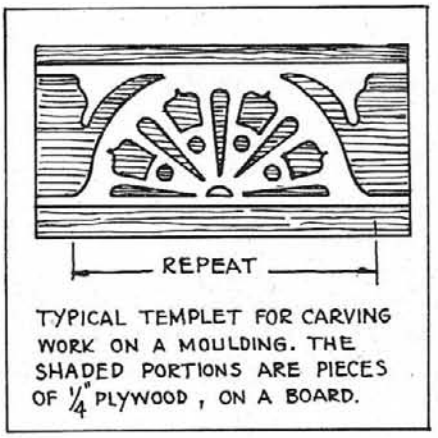
ROUTER BIT GROUND TO CUT ROSETTES.

Through the medium of specially ground facing routers it is possible to spin rosettes and ornamental buttons in one operation. An example of this type of special cutter is shown in the accompanying sketch.

In some designs it is permissible to run the cut slightly deeper to form a shoulder around the edge of the design.

Carving Work

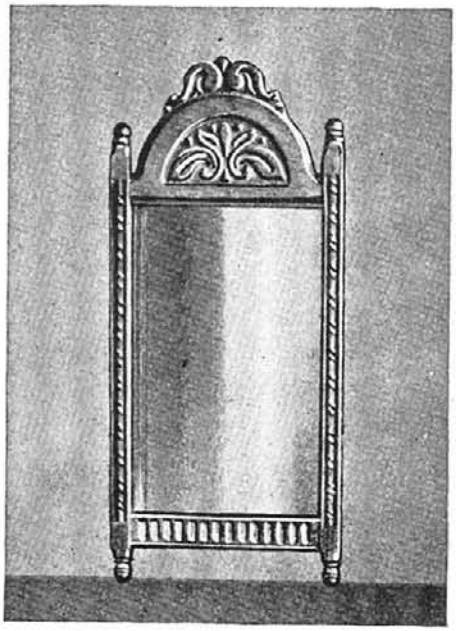
For the making of very intricate carved work, the only requisite in addition to the drill press is a specially shaped carving cutter. The actual use of this cutter is a duplication of the router method of making pierced panels, with the exception that the cutter is fed down only to a certain depth in order to make a rounded oval form. The exact shape of this type of carving router, and a depth to which it should be fed is shown in sketch.



TYPICAL TEMPLET FOR CARVING WORK ON A MOULDING. THE SHADED PORTIONS ARE PIECES OF 1/4" PLYWOOD, ON A BOARD.

The making of templets for either router work or router carving work is not a hard job, but in some instances proves rather tedious. Constant care must be exercised in making curved lines smooth and flowing, without any breaks, unless the design calls for a definite break in the line. There must remain no mark from either tool or saw after cleaning up these grooves in the templet, since any slight break in the lines will be reproduced by the router cutter in the finished work. Any slots that are cut in the templet

must be of such a size as to allow the free passage of the guiding pin, but this slot must not be so large that it is a very loose fit on the pin, otherwise there will be a tendency to prove a wavy rather than a smooth line in the finished work. This wavy line effect is particularly noticeable when cutting across grain since hard spots in the wood will cause the cutter to jump from side to side if not held rigidly to its direction by the templet.



The Italian Console Mirror as illustrated on the right was made with the special carving cutter. The pattern at the top of the mirror was made by following the templet shown below.

As shown by the photo, certain parts of a pattern may be in the form of loose pieces and in this case it is necessary to mount the templet on a base board, which may be any thickness from ¼" to ¾". These pieces should be firmly nailed and glued to the base board and particular care paid to allowing sufficient clearance between parts of the templet to allow the free passage of the guide pin.

After the templet has been made it will help the manipulation to a greater extent if the edges of the templet where the guide pin will rub is given a thin coat of paraffin wax.

After a little use this forms a glazed surface on which the guide pin will ride and allow greater freedom in moving the templet. It is very advantageous to make the templet itself from ¼" fiber.

The edges of a fiber templet will considerably outwear the edges of a wooden one, and through continued use obtain a very hard, highly glazed surface on which the guide pin rides almost like a roller.

On the upper side of the templet or the base board it is necessary to provide two or more small pointed pins on which the stock to be cut is pressed before putting it through the router or carving operation. These points prevent the stock from slipping under the action of the router or carving bit.

As in the making of mortises, both the router and carving operations should be taken in a series of steps, rather than attempt to go the full depth, in one cut. Particularly in carving this is of advantage in producing smooth and uniform work. In carving especially, you will note that you are working in a blind fashion, that is the templet from which you are working is hidden from view, since it is turned upside down on the table of the drill press. The first cut which should be about 1/16″ deep will produce a pattern on the upper surface of the stock, and from then on you have a guide which shows you in which direction to push the templet and the stock.

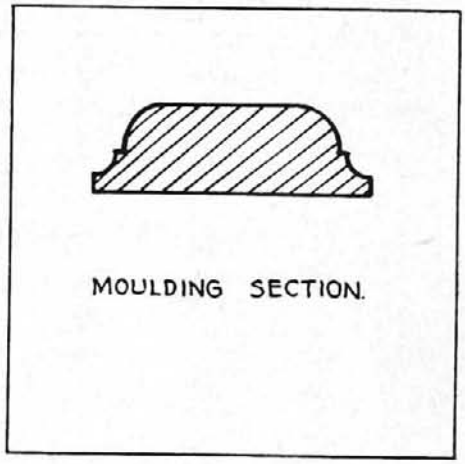
Through the medium of the regular routing bit and the shaped carver bit, also the different shapes of rosette cutters which one may grind for himself, it is possible to produce a great variety of carved mouldings, with which to ornament pieces of furniture, and other projects. In fact there is practically no limit to the different types of mouldings which may be turned out on the drill press, the range being limited almost entirely by the operator's ingenuity.

Combination Carved and Routed Mouldings

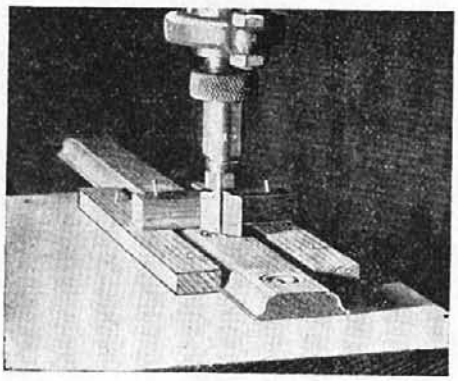
The making of carved and routed mouldings is a combination of shaper work and router work or carver work, wherein the shape of the moulding is first run on the drill press or shaper, the shape of the mouldings themselves being limited only by the variety of cutters which you have on hand, and by your ingenuity. The second part of the making of carved and routed mouldings is in slotting or cutting into this shaper moulding with the router or carver cutters as indicated by the design you have in mind.

There is also the possibility of ornamenting turned pieces of moulding with the router bit or carver bit. In most examples of

this type of work the turnings are first made in cylindrical form and later are ripped into half rounds or quarter rounds before the ornamenting with the router or carver takes place. It is fairly obvious therefore that there is an endless combination of forms which may be utilized in the making of these ornamental mouldings. The drawing on the following page shows a series of different types of mouldings that have been made either with the router bit or the carver bit in conjunction with the moulding which was first run on the shaper. Since the different operations are plainly shown in connection with the carver or router bit, which was used in their making, considerable space need not be taken up in explaining all the different operations. In order to further clarify the making of some of these mouldings, however, we will choose one of the mouldings and describe the making in detail. Using the moulding shown as an example, we will see that the first operation is running a piece of stock through the shaper in two operations; that is, using the same cutter and cutting from two sides of a piece of wood. These two operations form a quarter cove and a quarter round with a break between them, leaving a flat surface on top of the strip on which we will perform router and carving operations. A cross section of this inlay is shown in the sketch.



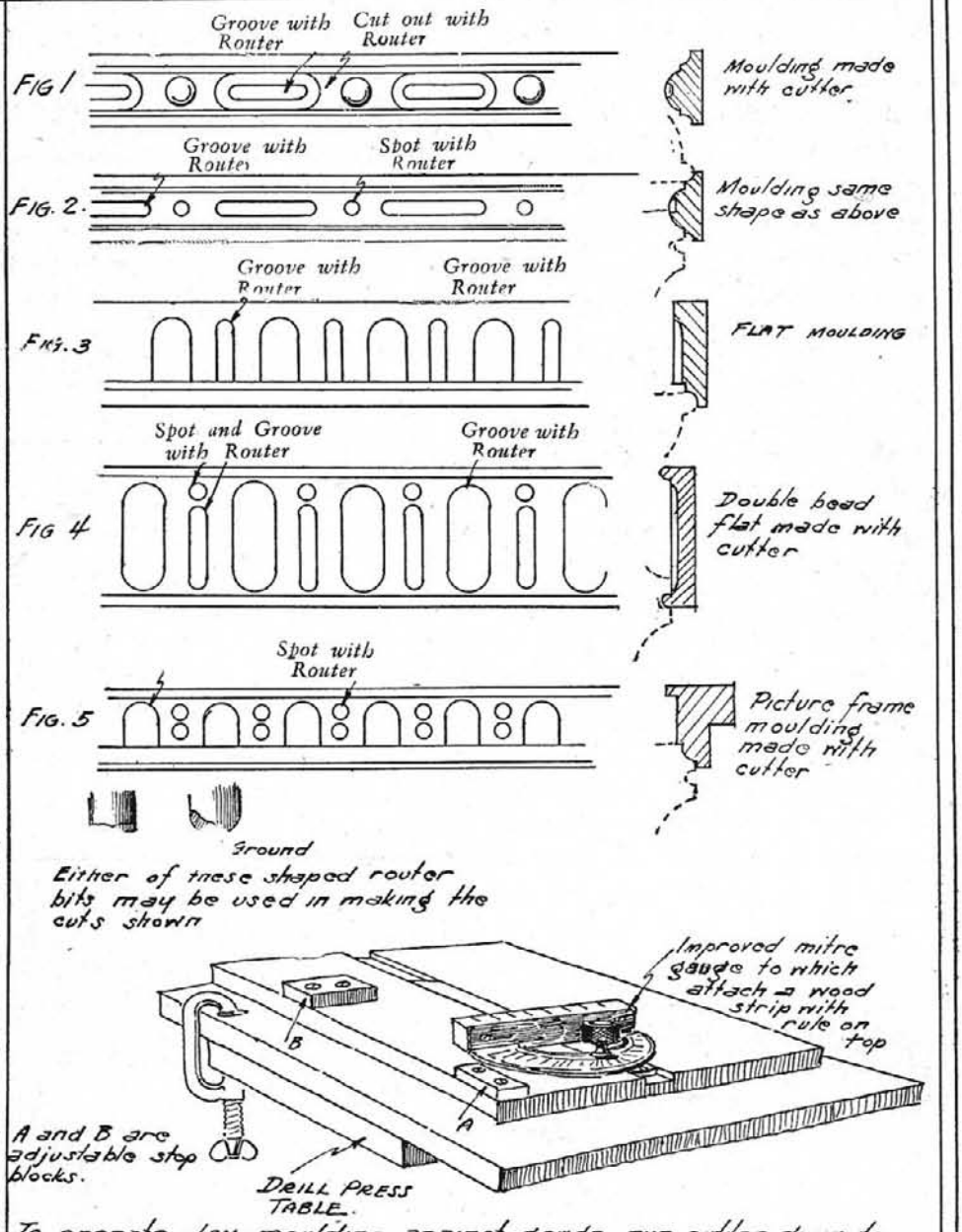
We now attach to the drill press table two strips of wood which are separated the width of the strip of moulding. This will form a guide for the strip of moulding to be fed through the drill press. It is also necessary to provide a hold-down block, or clips, as near to the router bit as possible to prevent the moulding from raising and cutting deeper than we require. The photograph shows how this is accomplished.



Spotting rosettes on a moulding.

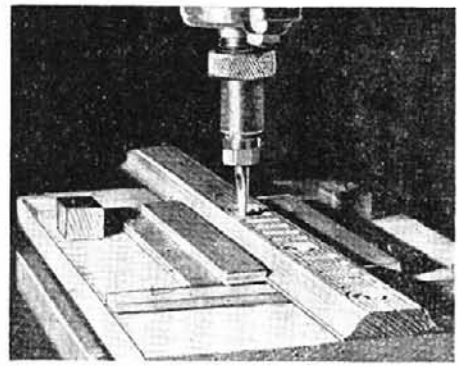
This particular moulding has a series of rosettes which are spaced

Carved Wood Mouldings



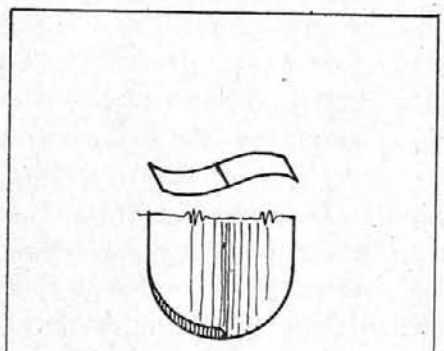
equal distances apart and our first operation in the router end of the ornamentation is the spinning or cutting of these rosettes. The shape of the cutter used is shown in the sketch on page 42 and it is necessary only to spot this on the strip of moulding. We will assume that the rosettes are to be 4" apart. On a scrap of the moulding, ascertain just how deep it is necessary to feed the rosette cutter in order to produce a finished rosette form, and at this point adjust the stop of the drill press so that the cutter may not be fed beyond this point. After careful adjustment has been made for depth of the cutter, it is then necessary only to spot the rosette cutter at each of the marked points on the strip of moulding, feeding it through between the guide strips after each successive spotting.

Before proceeding with the fluting it is necessary to make a slight change in the guiding members on the drill press table. We not only must guide the mouldings in a lateral direction but must also make provisions for straight line guiding from the front of the table towards the column of the drill press, since this will be the direction of our cut. To make this change take two pieces of ¼" plywood and nail them to the auxiliary table on the drill press, a distance of ¾" between them, with the grove thus formed running from the front of the tables toward the drill press column. On the underside of another piece of plywood, mount a strip of wood ¼" thick by ¾" wide. The length of this strip is not important. On the side of this plywood opposite the one with the strips, tack a strip of wood at right angles to the strip on the under side. This strip of plywood need be only about 4" wide. On the pieces of plywood which were nailed to the auxiliary table, tack two blocks in such a position as to allow a movement of the piece of plywood only a distance of 1" which is the length of the groove that is to be cut in the moulding. A photograph of this arrangement is shown at the right.



Routing flutes in a moulding with the "special" attachment.

After the rosettes have been cut, our next operation is the making of the series of flutes which appear between the rosettes. For the making of these flutes it is necessary to grind a ¼" router bit on the end so that it will produce a half-round groove as a cut. To



ROUNDED ROUTER BIT

do this grind away the lip of the router bit to the form as shown by the sketch. Then put this router bit in the collet chuck and adjust the depth gauge so it will feed to a depth of approximately 1/8". This will give a perfect half-round groove. It is now necessary to provide some sort of gauge to determine the distance between the grooves. For this purpose find the exact points opposite the router bit on one of the guide strips, and make a mark with a pencil at this point. We will assume that the grooves are to be a distance of 3/8" apart. At a distance of 3/8" from the mark just made on the guide strip drive in a small nail, so that it will project out over the moulding strip, at least a distance of 3/4". After running one of the flutes on the moulding, it is necessary only to shift the moulding a distance of 3/8" so that the nail will be directly over the groove just cut. This will automatically space the grooves to 3/8".

After the location of the groove has been made on the guide strip and the nails indicating spacing have been put in place, move the strips one space at a time, run a groove, then shift to the next groove, and so on, until the entire strip has been completed.

If the router bits and rosette cutters are extremely sharp and a speed of 7000 or 8000 R.P.M. is used in the cutting, very clean work may be performed and the cuts will require little if any sanding afterwards.

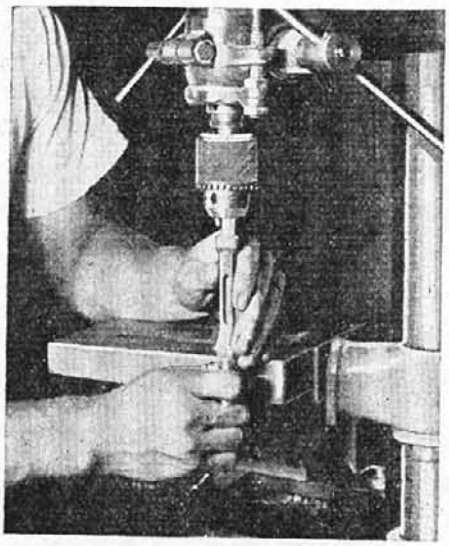
This is the typical example of the running of a flat moulding, in which rosettes and flutes perform the decorative feature. It is possible to use the same rosette cutter and the same form of router cutter in the making of other types of carved mouldings, wherein the form of the rosette or router cutter is made to intercept or cut into a form as made by the shaper, for the moulding. Several of the examples shown are of this type.

It is suggested that the operator design and make some samples of different types of mouldings using different cutters of such forms as he may work out for himself. This making of samples not only provides a means of determining what forms and shapes of mouldings it is possible to make but also gives him experience in the operation of the drill press, using it as a router or carving machine.

The Drill Press as a Mortising Machine

Most drill presses offered on the market today are equipped with or have available a special set of accessories which will allow the operator to use a drill press as a mortising machine. With an outfit of this type practically all of the hard labor of making mortises is taken care of by the drill press, and furthermore, the accuracy of the mortise is greatly increased due to the mechanical precision of the machine. Particular skill is not necessary in its operation but there are certain points which are important and must be observed, if the results obtained are to be of creditable nature. Unlike the operations of routing and shaping, mortising requires **low** spindle speed, 400 to 500 R.P.M. is fast enough for most work.

The mortising chisel is in the form of a hollow square in which a hole has been provided. Inside this the mortising bit revolves. The chisel is so ground at the point that its extreme end has four points which enter into the wood and cut out the square corners after the bulk of the material in the hole has been removed by the bit. This cutting end of the chisel must be kept sharp if one desires to cut well without undue pressure and strain on the drill press. For the purpose of sharpening these cutters, a special high speed grinding stone is usually available, and this stone should be mounted in the chuck of the drill press. The chisel is ground by holding it in an inverted position against the stone. The shape of the stone itself automatically gives the proper angle to the inside of the cutting lip of the hollow chisel. Under no circumstances should the operator do any filing or sharpening on the outside of the mortising chisel. All sharpening must be done on the inside.



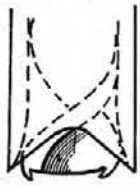
Sharpening a hollow chisel with special grinding stone.

The bit which bores the hole for the chisel has no guiding point, but the end of it has been flared out to fit fairly accurately into the tapered end of the hollow chisel. The physical requirements of the chisel itself due to the fact that a certain amount of material must be retained in the walls for strength, automatically determines the

size of the shank of the bit. It is therefore necessary that the end of the bit be flared out to remove as much of the stock as possible and the bit is usually so flared as to be of the same diameter as the width dimension of the chisel.

The chisel has a slot in the side to allow chips to come out. This must be kept open, otherwise the chips will bind and cause trouble.

Opinions vary with different manufacturers as to the correct mounting of the chisel and bit in the housing. Some state that the points of the chisel should precede the end of the bit while other manufacturers of hollow chisel outfits advocate the bit preceding the chisel by a small margin. Because of this difference it would be well to find out exactly what the manufacturer of your drill press recommends. The success of your work and the economical operation of the machine demand that the chisel and bit be set up correctly. Under all conditions, however, the bit must be tightened firmly in the collet chuck to prevent its being forced up. With all hollow chisels it is imperative that clearance be left between the end of the chisel and the "flare" of the bit end.



POSITION OF BIT IN HOLLOW CHISEL WHEN MORTISING

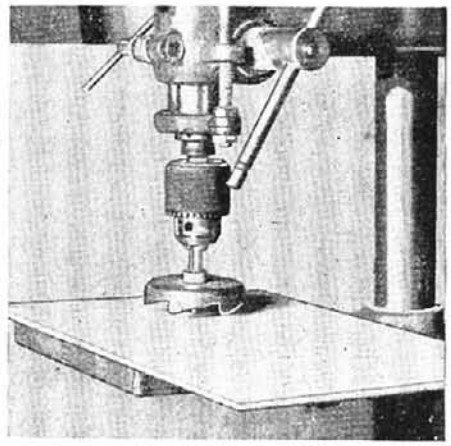
It is necessary to provide some means of guiding the work on the drill press table and at the same time make provision for holding the wood down as the chisel is withdrawn. A hold-down and guide is usually available for your drill press and is arranged so as to be adjustable for various widths and thicknesses of wood. The important point in the location and adjustment of the guide is to be sure that the surface of the guide is absolutely parallel with the flat portion of the chisel itself. If this is not true the mortise will be in the form of a series of steps rather than a hole with a smooth side.

After properly setting the guide and adjusting the hold-down so that the chisel will come exactly on the point desired the best procedure is to cut to the required depth at each end of the mortise, adjusting the depth gauge on the drill press to determine the subsequent cuts and then remove the stock in the mortise between the two end cuts as later operations.

If mortises are to be run clear through the stock make certain that bit and chisel will pass through the hole in the table, otherwise if they hit the iron table both chisel and bit may be ruined.

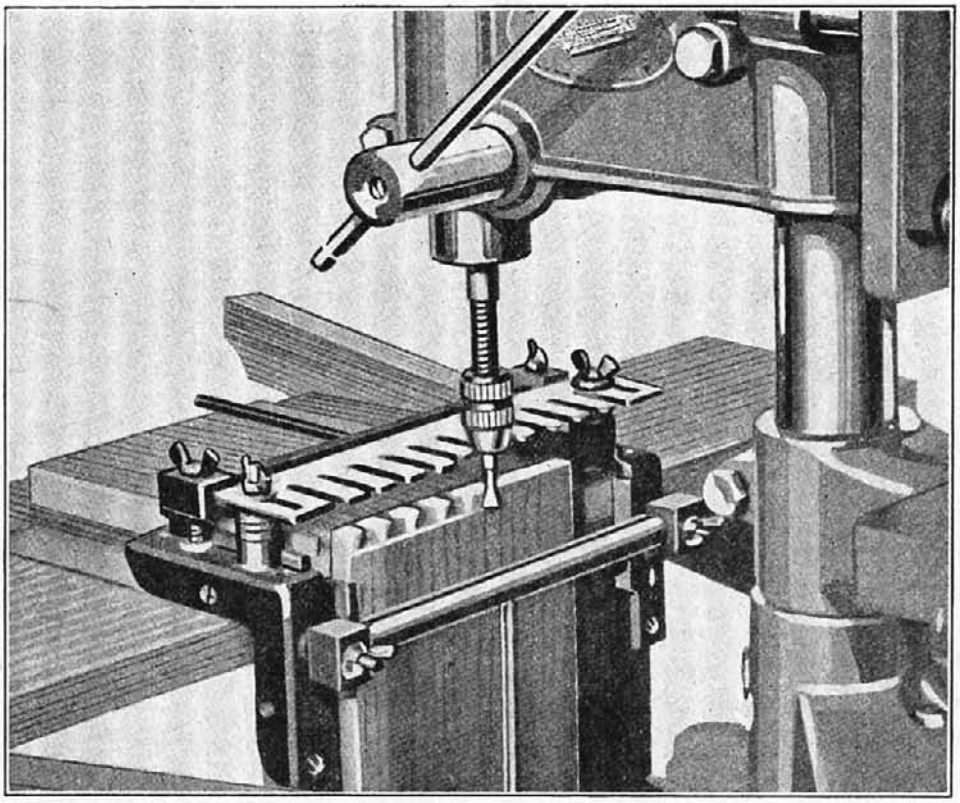
Hole Saw

Another tool which is available for use in the drill press is a disc cutting arrangement for wood on which the cutting member is in the arrangement of an ordinary saw. This may be purchased in flat disc form and the saw or piece of saw blade inserted in a groove in the disc or it may be purchased in the form of the one shown in the photograph. Either type will do very accurate and quick work, but, of course, one must realize that in working with large diameters it is necessary to run the drill press considerably slower than its normal rate of speed. Most of the drill presses which are available for the home workshop do not give speeds of less than 500 R.P.M. when using a motor of 1750 R.P.M. When it is necessary to reduce the speed of a drill press below this point the operator should install a counter shaft on the drill press to belt the motor which has been mounted on the table. Speed reduction of 5 to 1 would then give a range of speed from 100 R.P.M. up. This particular phase of speed might be pointed out as one of the disadvantages of having the motor mounted directly on the drill press, but it is usually found that the number of advantages gained by so mounting the motor far over-shadows the slight disadvantage of the loss of the lower range of speed.



A hole saw or disc cutting tool.

The mention of reduced speed brings up the subject of counter boring wherein comparatively large holes are required. The inside of a cylinder which we will assume is 1½" in diameter is one of the examples which would be necessary to class as a boring operation. While this operation would ordinarily be done on the lathe the absence of a lathe would necessitate the use of the drill press.

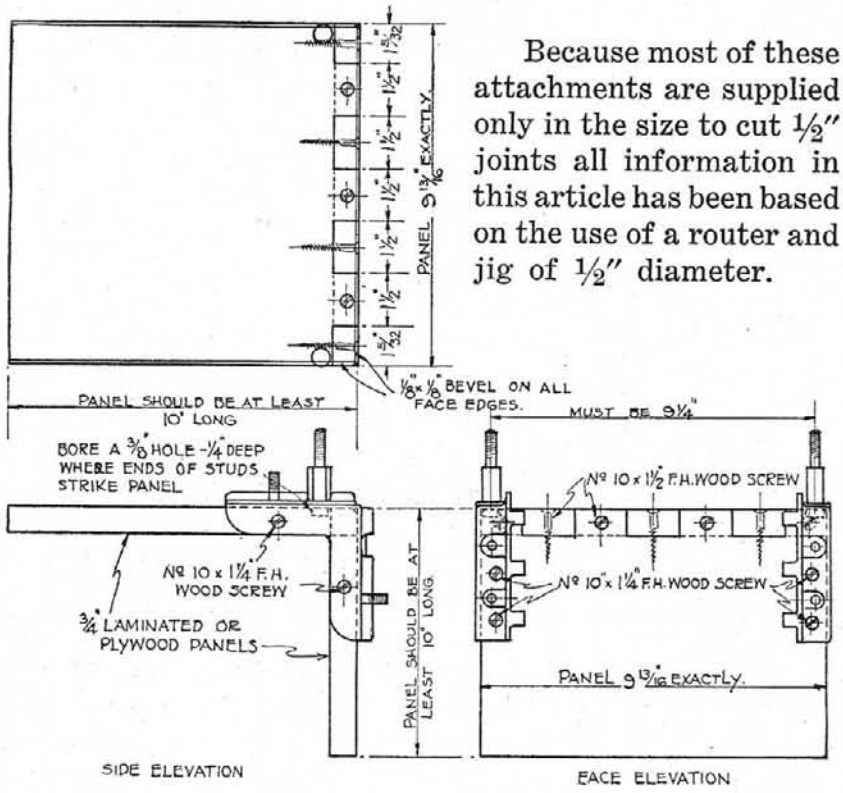


Making Dovetail Joints

The dovetail jig fills a definite need in the small shop and in the home workshop. When you consider that laying out a dovetail joint on each end of the four parts of a drawer or a box by hand invariably takes several hours, and that now you can obtain an inexpensive jig with which you can cut the dovetails on all four corners of a drawer or box in less than half an hour, you will realize the wonderful labor-saving ability of modern power tools and accessories.

The jig is used with the drill press operating at a speed of 7000 to 9000 R.P.M.

The dovetail router used with this jig is generally the ½" size. The comb or guiding element is spaced properly to give the correct distance between the dovetail cuts, and is so made that the shank of the cutter, which is ground to 5/16", is a smooth running fit in the slots.



Because most of these attachments are supplied only in the size to cut ½" joints all information in this article has been based on the use of a router and jig of ½" diameter.

Setting Up the Jig

It is necessary to procure or make two pieces of plywood panel 9 13/16" x 10" x ¾" thick and fasten the two brackets to them. The panels should be given at least two good coats of shellac or varnish and then smoothed with steel wool. (See sketch.)

These two panels are made locked-corner construction as per detail in sketch, and a No. 10 x 1½" F. H. Screw put into each tongue of each board, to prevent any possibility of warping.

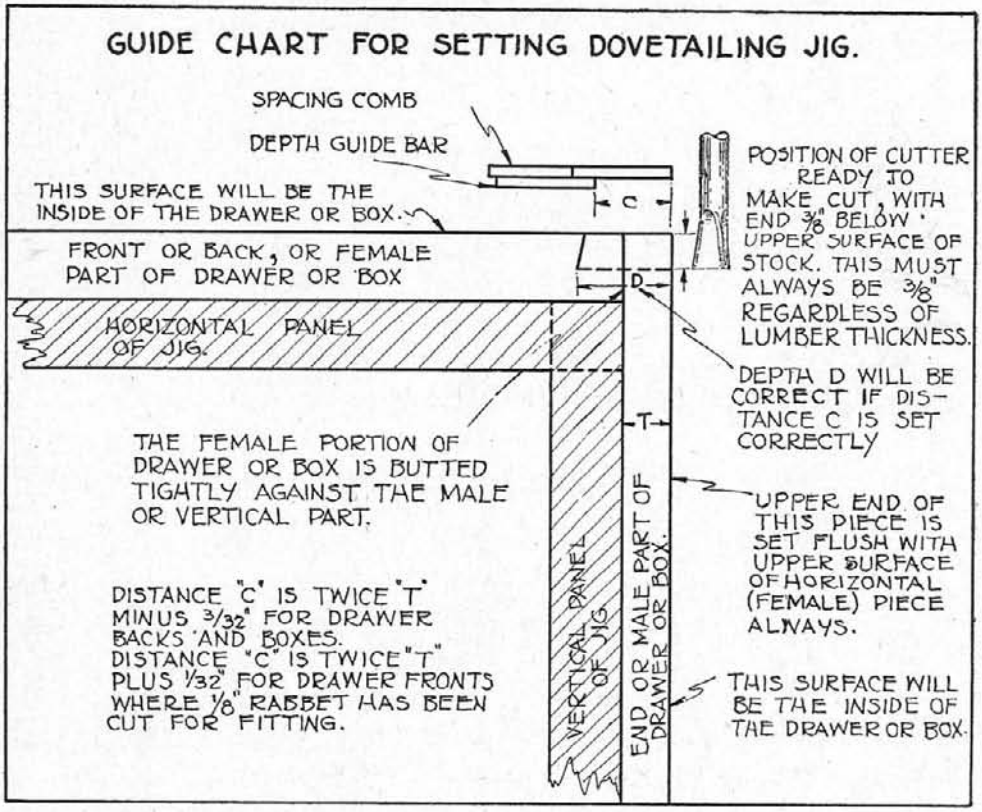
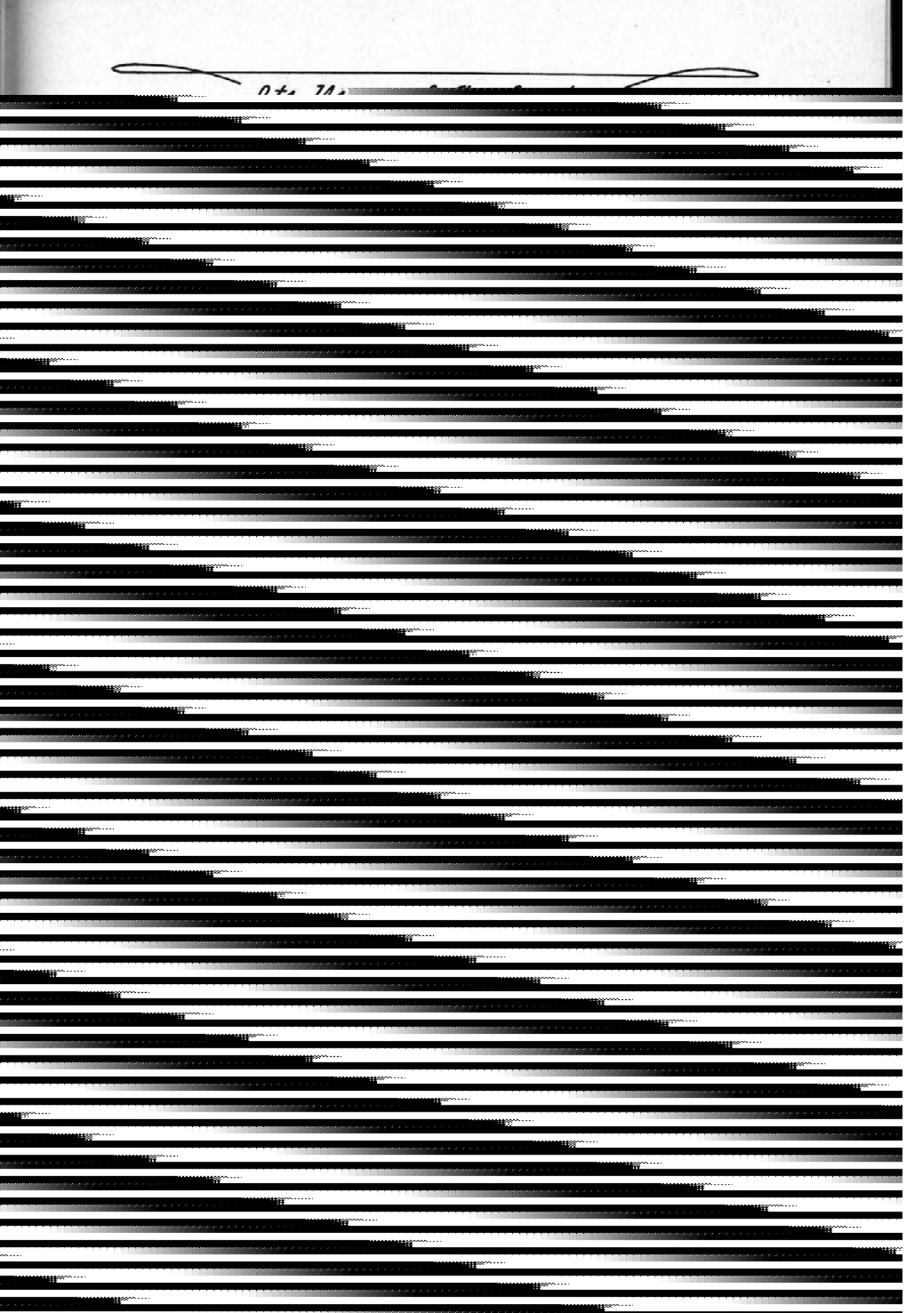
Fasten the two brackets to this "L" shaped base, one on the right side and one on the left side with the rib having the three bosses on the same panel, which will be the vertical panel when operating the jig. (See Face Elevation.)

On the hexagonal studs nearest the face, place the guide bar and comb, with a washer and wing nut on each stud. On the studs in back of this, first put a long spring, then place hexagonal blocks on each end of an eccentric hold down bar, with the handle away from the comb. Put the hexagonal blocks on the studs, and a washer and wing nut on each stud. On the face of the brackets put an

eccentric hold down bar with hexagonal blocks on two short springs over the studs, and put the washers and wing nuts on the studs. The jig is now ready for operation.

Cutting the Dovetail Joints for a Drawer

In the following description the length of the drawer is measured across the front, the depth is measured from front to back and the height is measured vertically on the front. (See sketch.)



Assume that you have the two sides, front and back of a drawer already cut to size. It is general practice to use ¾" stock for drawer fronts, ½" stock for drawer ends and backs. The front is cut to exactly the length and height of the space it is to fit; a rabbet ⅛" deep and 9/16" wide is cut across each end as is shown in sketch. The drawer back is then cut to a length equal to the distance between these rabbets or ¼" shorter than the front. It is also general practice to make the drawer ends an even number of inches long, allowing at least ½" clear between the drawer back and the