GETTING THE MOST OUT OF YOUR LATHE

- WOOD TURNING
- METAL TURNING
- METAL SPINNING

Published by
DELTA

GETTING THE MOST OUT OF YOUR LATHE

WOOD TURNING — METAL TURNING — METAL SPINNING

Edited by
SAM BROWN

A Complete Handbook Describing all Branches of Lathe Operation in the Home Workshop with Over Two Hundred Photographic Illustrations and Line Drawings.

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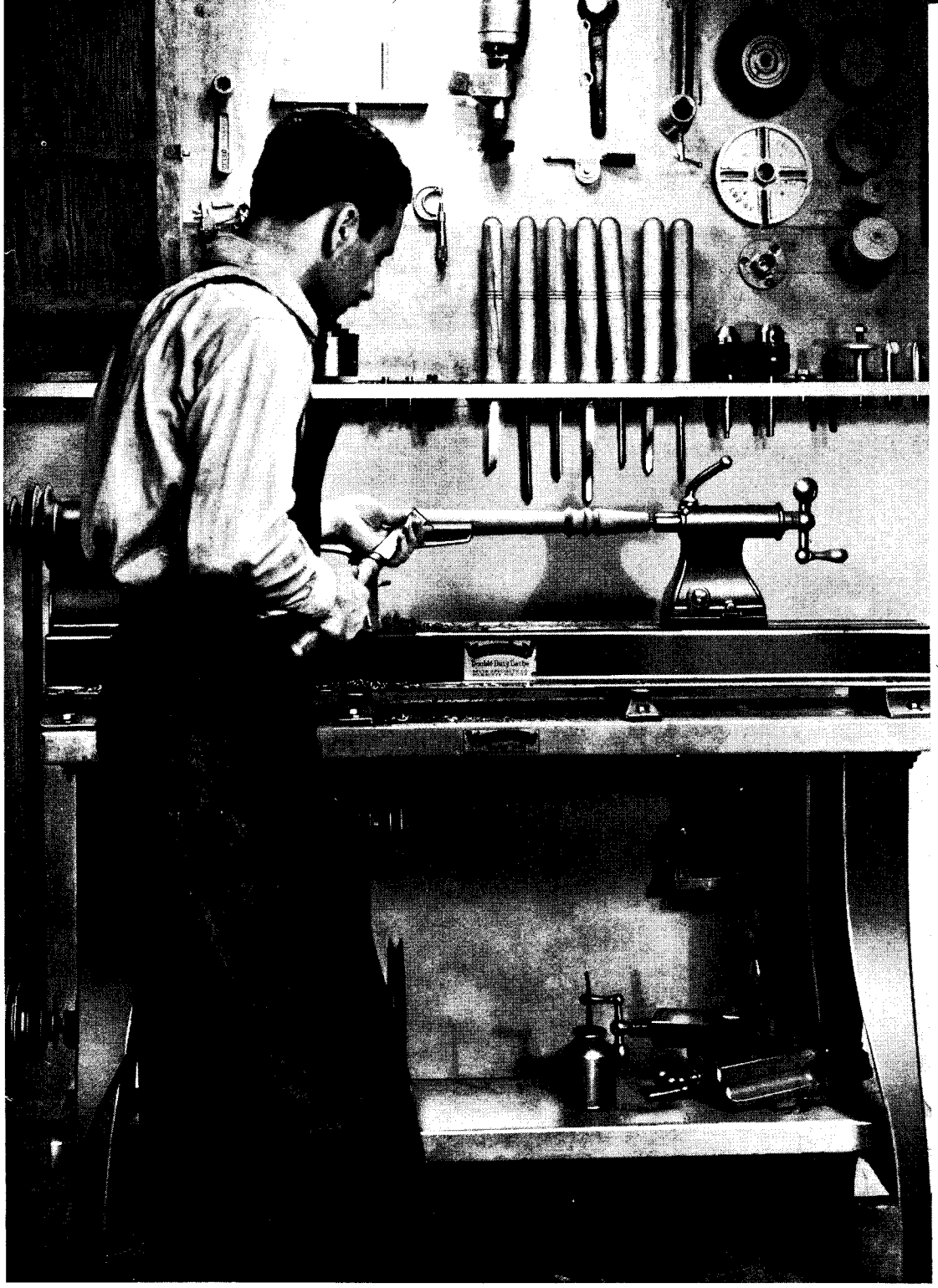
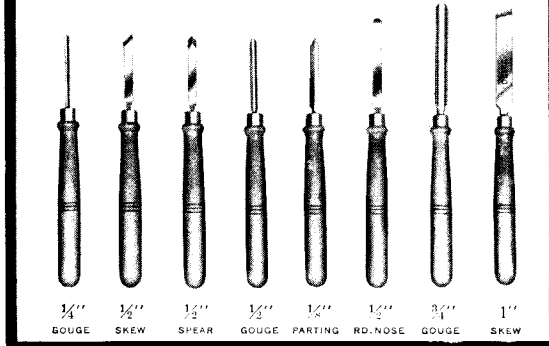
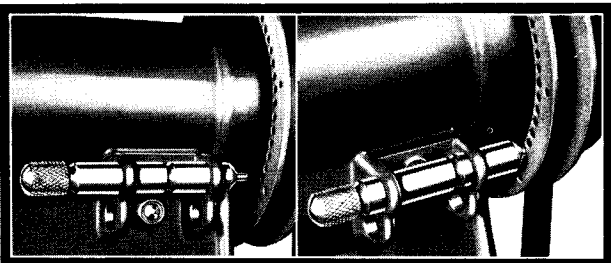


An Important Corner in the Home Shop . . . The Photo Shows the General Working Position of the Operator. Lighting Should Be Overhead. Tools Should be Arranged on a Convenient Panel or Shelves So That Each Piece Is Easily Located as Required



WOOD-TURNING TOOLS



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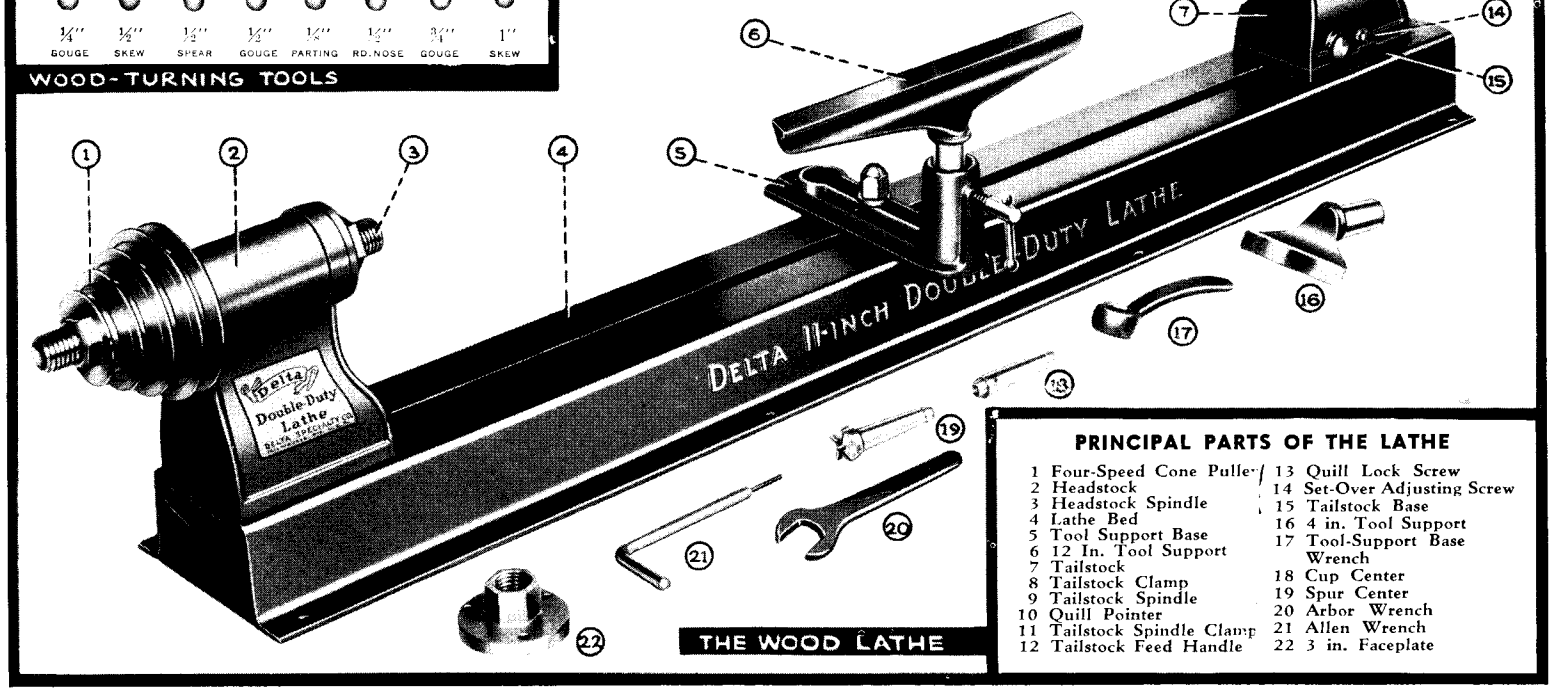


THE WOOD LATHE

PRINCIPAL PARTS OF THE LATHE

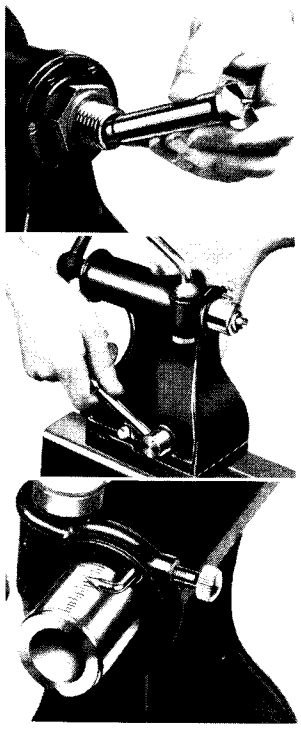
1 Four-Speed Cone Pulley
2 Headstock
3 Headstock Spindle
4 Lathe Bed
5 Tool Support Base
6 12 In. Tool Support
7 Tailstock
8 Tailstock Clamp
9 Tailstock Spindle
10 Quill Pointer
11 Tailstock Spindle Clamp
12 Tailstock Feed Handle
13 Quill Lock Screw
14 Set-Over Adjusting Screw
15 Tailstock Base
16 4 in. Tool Support
17 Tool-Support Base Wrench
18 Cup Center
19 Spur Center
20 Arbor Wrench
21 Allen Wrench
22 3 in. Faceplate

BOOK ONE
WOOD TURNING

CHAPTER ONE
THE LATHE and its EQUIPMENT

WOOD TURNING is a fascinating art, and the lathe, more than any other tool in the shop, is in itself a complete unit capable of producing finished work. The operation of the machine is not difficult, indeed, any beginner can make a creditable turning on the very first try by using scraping methods. True wood turning, however, is a cutting operation, and the acquisition of the necessary skill to fashion turnings quickly and well in this manner demands some knowledge of methods and considerable practice in their application.

The Wood Lathe.—A typical wood-turning lathe with its principal parts named is shown in the photograph on the opposite page. The essential major parts comprise the *lathe bed*, the *headstock*, the *tailstock*, and the *tool rest*. The headstock carries the live or power-driven spindle, and is firmly fixed to the left end of the lathe bed. The tailstock carries the dead or fixed spindle, and this unit is arranged so that it can be clamped anywhere along the bed of the lathe to suit different-length turnings. The tool rest consists of two major parts—the base and the tool rest itself. Different types of rests are interchangeable in the same base, and the whole unit is readily clamped at any position along the lathe bed.



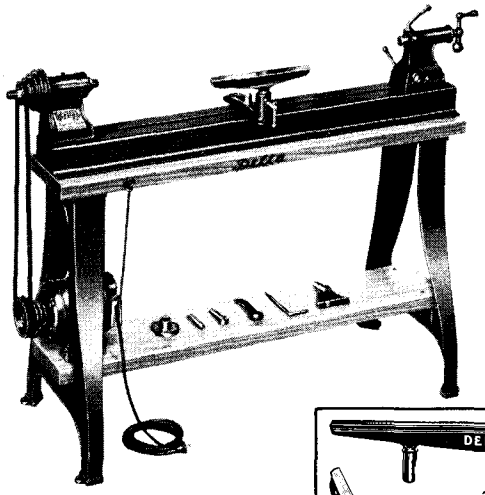
Top, inserting the spur center in the hollow headstock spindle. Center, releasing the tailstock clamp. Bottom, the tailstock spindle is graduated as an aid in taking dimensions.

There are two general types of lathe spindles. The one shown in the illustration has a hollow spindle in both headstock and tailstock. The second type has a suitable-diameter arbor on which are clamped or threaded the various lathe attachments. All operations in this book are shown on the hollow spindle lathe, yet it must be understood that these operations can be done just as well on the solid arbor spindle. Both headstock and tailstock spindles have a No. 2 Morse taper hole to take attachments with tapered shanks of the same size. The two main attachments of this nature are the *spur center*, No. 19, which fits the headstock spindle, and is consequently known as the live center, and the *cup center*, No. 18, which fits the tailstock spindle, and is known as the dead center. In operation, the work is mounted between these two centers for turning, the spurs of the live center serving as the driving member.

The headstock spindle is also threaded at either end for mounting faceplates, a right-hand thread being used on the inner end of the spindle and a left-hand thread on the outer end. The most common type of faceplate is about 3 in. in diameter, and has a center hole and three outer holes for use in screw-fastening the work to the faceplate.

The tailstock of the lathe has three different adjustments. First of all, it can be moved bodily along the lathe bed and can be clamped at any position by means of the *tailstock clamp* (No. 8). Secondly, it can be moved within slight limits across the bed of the lathe by means of the *set-over screws* (No. 14). Thirdly, the spindle can be projected or retracted inside the body of the tailstock by manipulating the *feed handle* (12). Any desired position can be fixed by clamping the spindle with the *tailstock spindle clamp* (No. 11).

Indexing Mechanism. — The indexing mechanism consists of two rows of holes, accurately spaced around the rim of the drive pulley. There are 60 holes in the inside row, spaced 6 degrees apart, and 8 holes in the outer row, spaced 45 degrees apart. The sliding pin on the side of the headstock has two positions so that the point can engage any hole in either inner or outer row. The indexing mechanism is used for dividing faceplate work, and for spacing cuts in fluting, reeding or any similar work de-



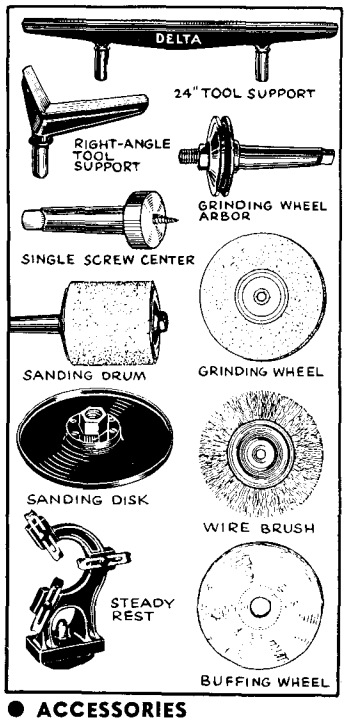
● **INSTALLATION**

manding equal divisions of space around the turning.

Tools. — The standard set of tools used in wood turning comprises five different shapes. Most important of these is the *gouge,* a round-nose, hollow chisel which is used for roughing cuts, cove cutting and other operations. Next in important is the *skew chisel,* a double-ground, flat chisel, with the end ground to an angle instead of being square across. This tool is used for smoothing cylinders, for cutting shoulders, beads, vee-grooves, etc. The *spear* or *diamond-point chisel* and the *round-nose chisel* are scraping tools which are used where their shape fits the contour of the work. The *parting* tool is a double-ground tool, and is used for cutting-off and for make straight incisions to any required diameter.

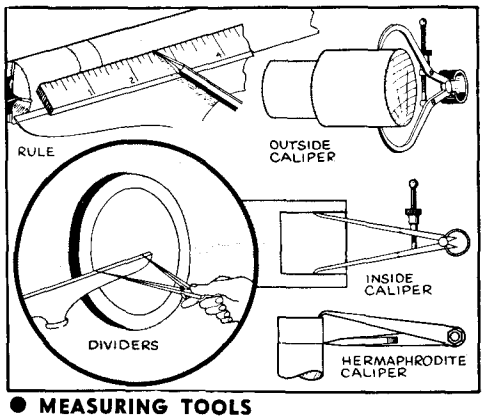
Installation.—The lathe can be mounted on any work bench or on a special bench with steel legs, as shown in the upper photo. The motor can be mounted below or to the rear of the lathe, depending on the method of installation. The motor should be ⅓ H.P., 1750 R.P.M., and should be fitted with a 4-speed cone pulley to match the pulley on tthe headstock spindle. Substantial fastenings are essential. The lathe should be securely fastened by bolts or lag screws to the bench, and the bench itself should be anchored to the floor wherever possible. Raising blocks are often used between the lathe bed and the bench top so that shavings can be easily cleared away.

Accessories.—The drawing in the center of the page pictures various accessories which are frequently used in wood turning. The *24 in. tool support* is invaluable when doing turnings which cannot be covered from end to end with the shorter tool rest. The *right-angle support* is used for faceplate work, and permits operations on both the rim and face of the turning. The *screw center* furnishes a quick and satisfactory method of mounting small faceplate turnings. The *grinding wheel arbor* is valuable as a means of mounting a *grinding wheel, wire brush* or *buffing wheel* in the lathe. Sanding accessories are worthwhile aids, the two most common types being the *sanding drum* and the *sanding disk.* The drum is fitted with a tapered shank to fit inside the headstock spindle, while the disk is threaded to fit the threaded nose of the spindle. The *steady rest* is used as a support for long, slender turnings, or as an end support for shorter work.

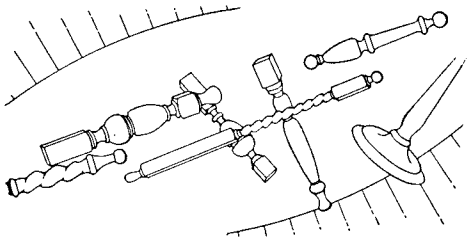


● **ACCESSORIES**

Measuring Tools. — Lathe work demands certain measuring tools, namely, the *rule* and *calipers.* The rule is used for taking dimensions along the turning, while the various calipers are used in measuring diameters. Calipers are best of the spring type since they are often applied directly to the revolving stock, and must be depended upon to hold a set dimension when in this position. The dividers are used mainly in faceplate work where they are useful in setting off diameters.



● **MEASURING TOOLS**



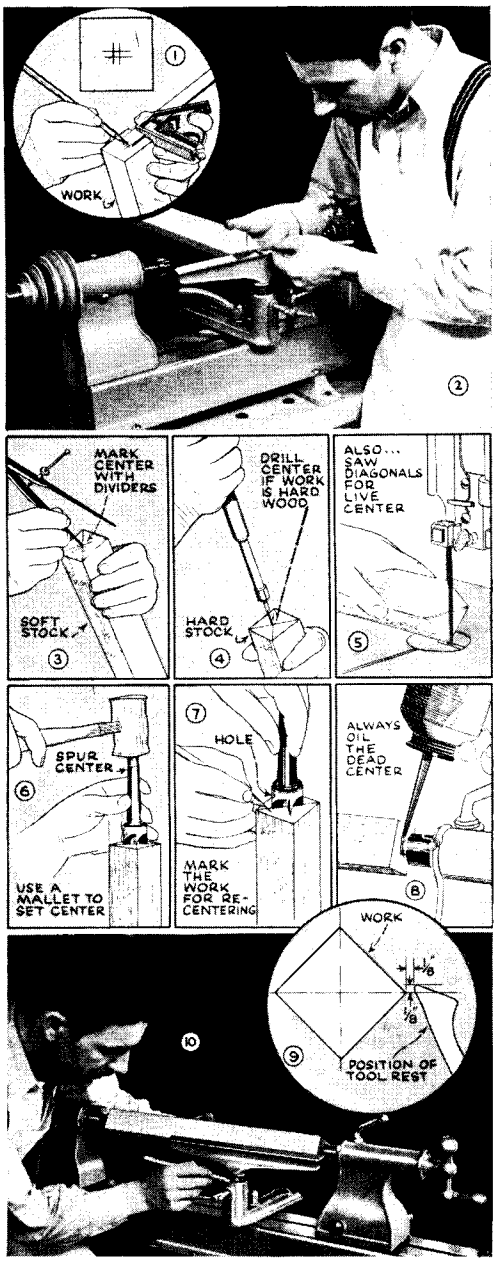
CHAPTER TWO

SPINDLE TURNING

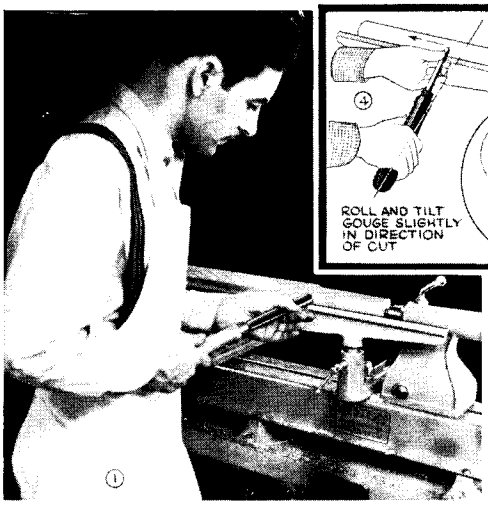
Centering the Work.—Wood stock for any turning which is to be worked between centers must be properly marked before it can be placed in the lathe. The stock should be approximately square, and the ends should be square with the sides. Two common methods of determining the center are shown in Figs. 1 and 2. In the first of these, a distance a little more or a little less than one-half the width of the stock is set off from each of the four sides. The small square thus set off in the center can then be accurately used in marking the true center. The diagonal method, as shown in Fig. 2, consists of drawing lines from corner to corner, the intersection marking the center of the work. The top of the tool rest or any other straight edge can be used in running in the marks.

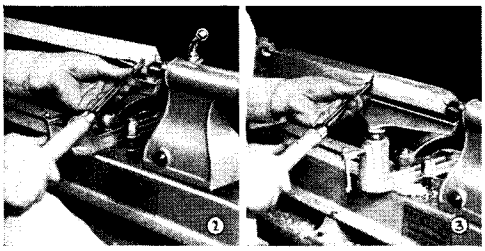
After marking each end, the true center should be definitely marked with a punch awl or with dividers, as shown in Fig. 3. If the stock is hardwood, the centers should be drilled to a depth of about ⅛ in. The spur or live center is then placed against one end of the work and seated by striking with a mallet, as shown in Fig. 6. In hardwood, it is necessary to make a starting seat for the spur center, this being done by sawing on the diagonal lines, as in Fig. 5, and drilling a small hole at the intersection of the cuts. After setting the center, a mark should be made on one of the diagonals in line with the adjusting screw centerhole, as shown in Fig. 7. This permits perfect re-centering of the work at any time. The end of the work which is to take the tailstock center should be oiled, placing the lubricant on the wood either before or after it is put in the lathe, Fig. 8.

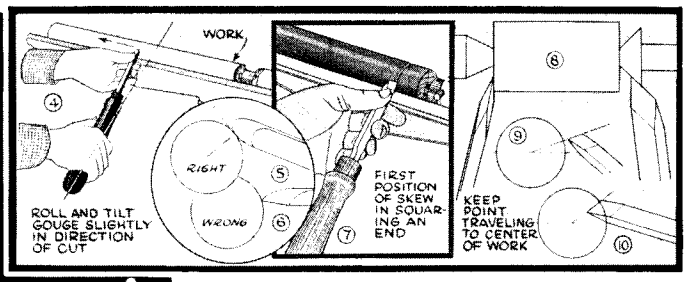
After marking each end of the stock, the work can be mounted in the lathe. The stock is first pressed against the live center so that the spurs enter the grooves previously marked. Next, move the tailstock up to a position about 1 or 1½-in. from the end of the stock, and lock it in this position. Advance the tailstock center by turning the feed handle until the center makes contact with the work. Continue to advance the center while slowly rotating the work by hand. After it becomes difficult to turn the work, slack off on the feed about one-quarter turn and lock the quill spindle. The work is now ready for turning.



Photographs and Diagrams Above Show Various Operations in Centering Lathe Work.







Left, Photos Show Right and Wrong Methods of Making Roughing Cut. The Diagram Shows Points in Handling the Gouge and Skew Chisels.

Tool Rest Position.—The tool rest is now mounted in place, about 1/8 in. away from the work and 1/8 in. above the work centerline, as shown in Fig. 9. This position may be varied to suit the work and the operator, but the rest should never be below the center of the work. A guide mark to show the most suitable working position can be placed on the tool rest shank, as shown in Fig. 10 on the previous page, as an aid to quick and accurate re-setting. Once some experience has been obtained in turning, the proper setting of the tool rest will become almost second-nature.

The Roughing-Off Cut.—The large gouge is used in the first turning operation of roughing-off the sharp corners of the work. Run the lathe at low speed, and hold the gouge in the manner shown in Fig. 1. The cut starts about 2 inches from the tailstock end, and continues from this point towards and off the tailstock end. A second bite is then taken about 2 or 3-in. to the left of the first cut, advancing again towards the tailstock to merge with the cut previously made. This procedure continues until a point about 2 in. from the live center is reached where the gouge is rolled in the opposite direction to carry the final cut off the live center end of the work. The roughing cut should not be carried out with one continuous movement, as shown in Fig 3, as this tends to tear long slivers from the corners of the work; neither should the cut be started directly at the end of the stock, Fig. 2, for the same reason. The cut can be safely carried from the center of the stock towards and off either end once the first roughing cut has been made in the manner previously described.

The position of the gouge in relation to the work involves two or three important angles. First of all, the tool may be advanced along the work either from right to left or from left to right. From left to right or from headstock towards tailstock is preferable, since this throws the chips clear of the operator. The gouge is rolled slightly in the direction in which it is advancing; also, the cutting point should be a trifle in advance of the handle, as shown in Fig. 4. The tool is held well up on the work, with the bevel or grind tangent to the revolving surface, as shown in Fig. 5. It should not be pushed squarely into the work, as at 6, since this position will cause the tool to scrape instead of cut. Once a cylinder has been formed, the proper location of the gouge can be determined by placing the tool with its bevel rubbing the wood, then gently lifting the right or handle hand until the edge begins to cut. The roughing cut is carried out until the work approaches 1/8 in. of its required diameter, stepping up to second low speed once a barely cylindrical form has been attained. The position and handling of the gouge, as described, applies to finish surface cuts as well as roughing-off.

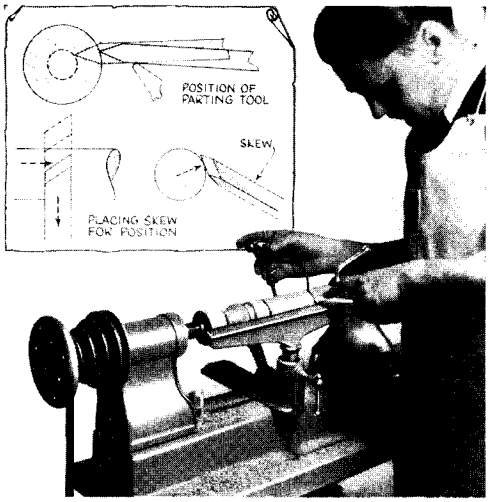
Squaring the Ends.—After the work has been reduced to a cylinder, the ends may be set off or squared to mark the length of the turning. This can be done by using the parting tool, as shown in the sketch at the top of the opposite page; it can also be done entirely with the skew chisel. In the skew method, a light nicking cut is made with the toe of the chisel, as shown in Fig. 7, above, pushing the point directly into the work a trifle outside the required dimension. This cut cannot be made very deeply without danger of burning the chisel, so it becomes necessary to make a "clearance" cut by inclining the skew away from the first cut and again pushing the tool into the stock. This procedure of side cut and clearance cut is continued until as much of the stock is removed as is desired.

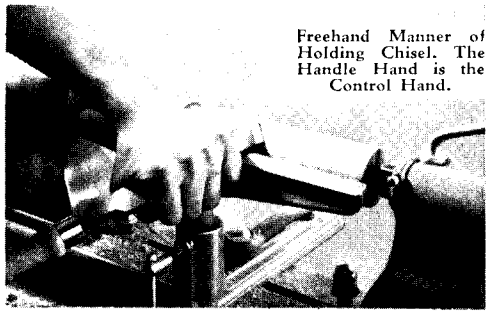
At the left end of Fig. 8 on the opposite page is shown the proper position when making the side cut in squaring an end. The essential point is that the grind of the skew adjacent to the end being cut must be nearly parallel with the end surface of the work. There should be just a fractional variation from this plane—enough to allow the toe only to cut while the heel of the grind serves as a fulcrum. The right end of Fig. 8 shows the tool being advanced for the clearance cut. Here, the tool is inclined so that the grind farthest away from the end surface being cut will parallel the intended surface of the V-cut. Here, again, the toe does the cutting, the grind or bevel being parallel with the cut surface but with enough variation to prevent the heel from catching. The heel of the grind again serves as a fulcrum. In both cuts, the cutting edge of the chisel should be advanced in a line towards the center of the work, as shown in Figs. 9 and 10.

Smoothing a Cylinder.—This operation is done with the large skew chisel. The manner of placing the tool is shown in the sketch above, the chisel being placed well above the work and then brought down until the center portion of the cutting edge makes contact with the work. The handle is then gently raised to enter the cutting edge to the proper depth, after which the tool is advanced evenly along the work. As with the gouge, the skew can be advanced in either direction; also, the cutting point should be slightly in advance of the handle. The heel of the grind serves as a fulcrum, and the handle hand controls the depth of cut by rocking the chisel on this pivot point. The point of contact with the work should be in the approximate center of the cutting edge, although some workers prefer a point a little closer to the heel of the chisel. The two center photographs on this page show the skew chisel in the proper working position, the cut being made from headstock to tailstock. For cutting in the opposite direction, the chisel is simply turned over, as can be seen in the upper diagram.

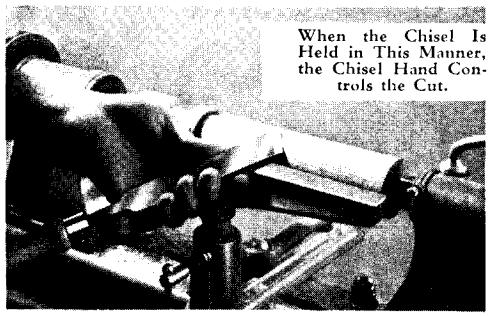
Using the Parting Tool.—The parting tool is perhaps the easiest turning tool to handle. In use, it is simply placed with its narrow edge against the tool rest and pushed into the work, keeping the lower bevel approximately tangent with the surface of the cylinder being cut, as can be seen in the upper diagram and also in the lower photo. The tool is frequently used with one hand, as pictured in the upper photo, the cut progressing until the calipers slip over the work to indicate the completion of the cut.

Position of Hands.—In all tool handling, the handle hand takes a natural position, being nearer or farther from the end depending on the amount of leverage required. The position of the tool rest hand is more a matter of individual liking rather than any set or "proper" position. The hand may be held palm down, fingers encircling the tool, and with the wrist dropped so that the heel of the hand below

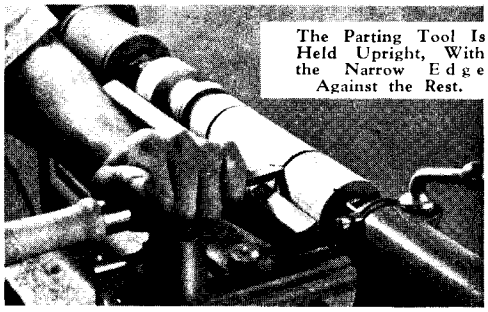




Freehand Manner of Holding Chisel. The Handle Hand is the Control Hand.



When the Chisel Is Held in This Manner, the Chisel Hand Controls the Cut.



The Parting Tool Is Held Upright, With the Narrow Edge Against the Rest.

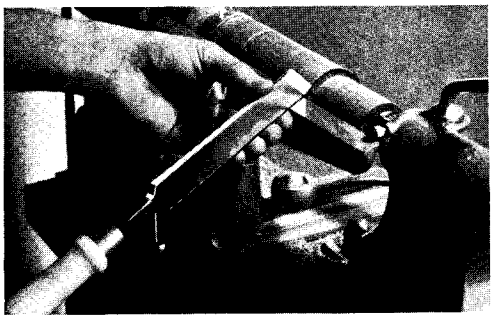
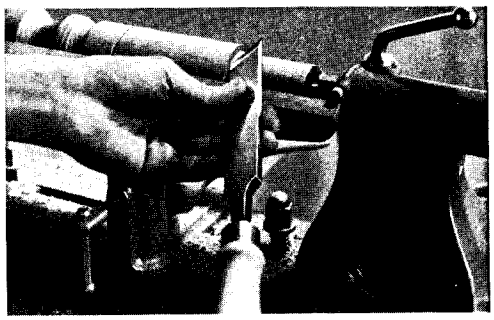


Photo Above Shows How the Skew Chisel Is Held when Making the Side Cut in Squaring a Shoulder.



The Heel of the Skew Chisel Is Used in Making the Horizontal Cut Where It Joins With the Side Cut.

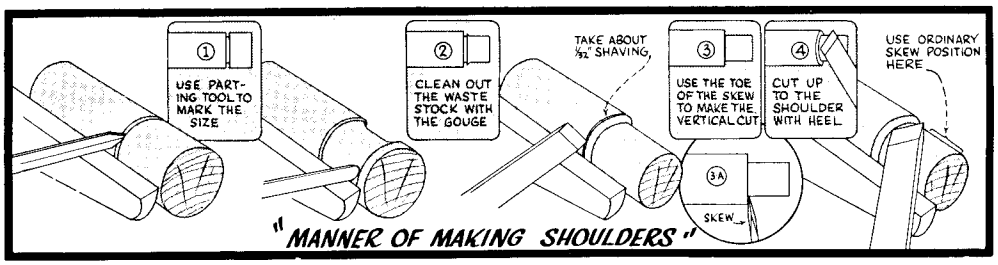
the little fingers acts as a sliding guide along the rest. Again, the hand may be held palm up, in which position the side of the index finger supplies the guide along the rest. In still another position, the wrist is not dropped, but held quite high, the small finger serving as the guide. All of these positions are shown in the various photographs; and the proper one to use is the one which you find most to your liking. Generally speaking: Palm down and a heel guide for heavy roughing; palm up and a finger guide for control and accuracy.

Cutting Shoulders. — This cut is quite similar to squaring an end. The parting tool is first used to reduce the wood to within about one-sixteenth inch of the required shoulder and finished diameter, as shown in Fig. 1. The waste stock is then cleaned out with the gouge, as shown in Fig. 2. You are now ready to actually cut the shoulder. Ordinarily, the small skew is used, holding it in the manner shown in the photograph to the left above. The most important thing here is that the bevel of the chisel next to the cut should be very nearly parallel to the cut, as shown in Fig. 3-A. There should be just a little inclination away from this plane—enough to allow the toe of the chisel to cut and the heel of the grind to pivot on the surface of the cylinder. The exact position demands a careful study with the work directly in hand. The cut taken is about $\frac{1}{32}$ in., and the handle of the skew is gradually raised as the cut deepens to keep the toe towards the center of the cylinder.

The horizontal cut is also made with the skew, but in a little different manner from that used in doing plain cylinder work. If the shoulder is long, the ordinary skew position can be used for the outer portion of the cut, but at the angle between the horizontal and vertical cuts, the heel of the chisel moves into a position tangent between the skew and the cylinder, as shown in the photo to the right and in Fig. 4. In this position, the handle of the chisel is raised slightly to allow it to cut as the tool moves along the rest. A very light cut should be taken in order to produce smooth work. The heel of the skew can be used for making the entire cut, if desired, but the cut, whether in this position or any other position, should not be picked up directly at the end of the stock. It is quite evident that any horizontal cut started directly from the end of the work will have a tendency to bite into the wood, often ruining the entire piece. Always run *off* the end and not *into* it. Where special occasions arise making this procedure impossible, make certain that the chisel is securely held and set for a light cut before touching the tool to the end grain.

If you are simply squaring the ends of a cylinder, you would use the first operation—the vertical cut—until the diameter of the cylinder is reduced to a little less than the size of a lead pencil, as described on page 8. The work can then be removed and completed with saw or knife. Experienced lathe men insert the chisel with the left hand while holding the cylinder loosely with the right, and cut away the work at the live end while the lathe

Diagram Below Pictures Successive Operations in Roughing-out and Finishing a Shoulder.

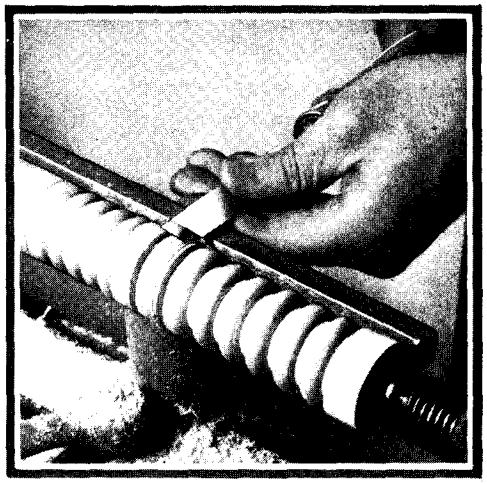


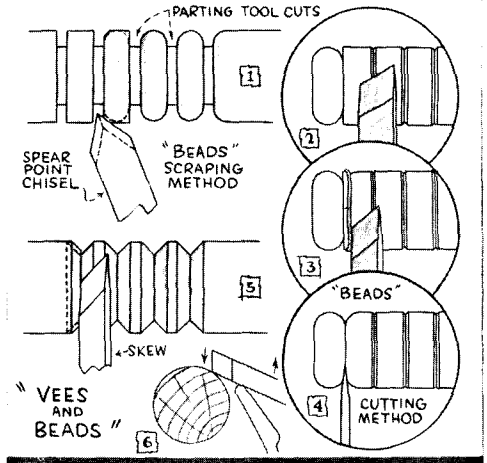
is running. Beginners should simply reduce the work to small diameter and then remove for finishing.

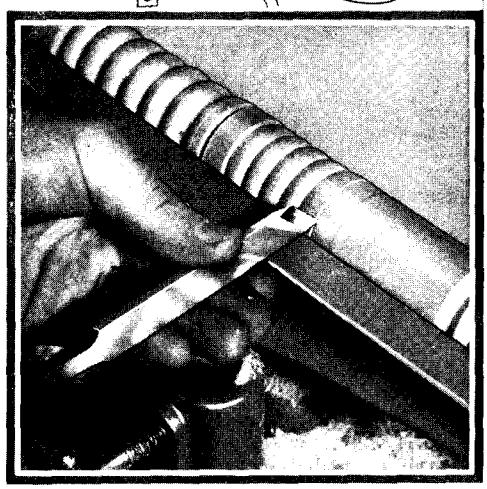
Vees and Beads.—Two methods are used in making beads—scraping and cutting. The scraping method uses the spear or diamond-point chisel, and works to best advantage on beads which are separated by a parting tool cut. This manner of forming beads is very simple—it demands only a scooping action to properly round off the corner, as shown in Fig. 1. This method is also useful in working in tight corners, where the use of the skew chisel might result in a run or bite. Scraping, as a whole, is slower, harder on chisels, and less productive of smooth, clean work than cutting methods.

Cutting beads quickly and accurately is one of the most difficult lathe operations, and craftsmen differ largely on what is proper technique. The usual method is as follows: A deep vertical cut is made at the point where the two curved surfaces will eventually come together. This cut can be made with either the heel or the toe of the skew chisel, the lower photo showing the toe being used. Care must be exercised in making this cut not to burn the chisel by too continuous a pressure. Now, place the small skew at right angles to the work and well up on the cylinder. The chisel is flat on its side at the start, and is evenly rotated through the successive stages of the cut, as shown in Figs. 2, 3 and 4. At the same time, the chisel is drawn slightly backwards so that it will be at all times tangent to the curve. The upper photo shows the cut at the halfway stage. The cut is entirely with the heel of the chisel. The opposite side of the bead is then cut in the same manner.

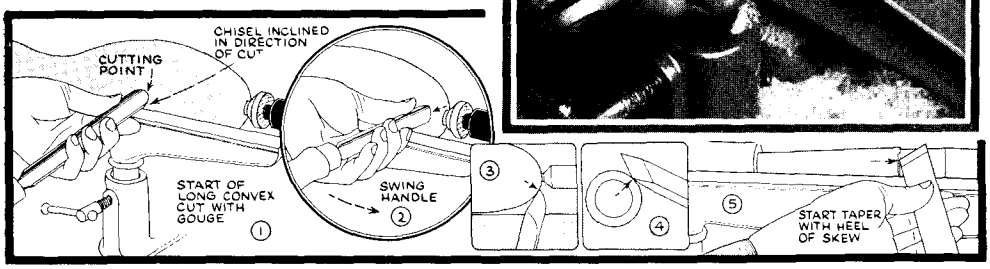
Cutting full V-grooves demands much the same technique as the cutting of beads. Here, again, a deep vertical cut is made to indicate the proposed bottom of the depression. The chisel is started well up on the work, and the handle is raised to enter the heel of the chisel to the required depth. Only one-half of the V should be cut at a time, then the chisel is reversed to cut the other half. As in all cutting with the skew, the bevel next to the cut must be used as a fulcrum, without, at the same time, allowing the full edge of the

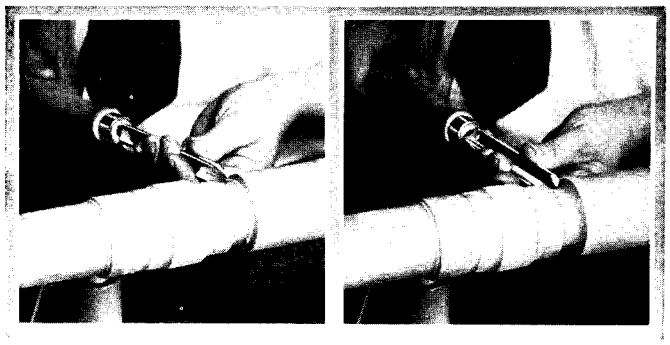






Photos Above Show Cutting of Vees and Beads. The Diagram Below Shows Manner of Making Long Cuts.





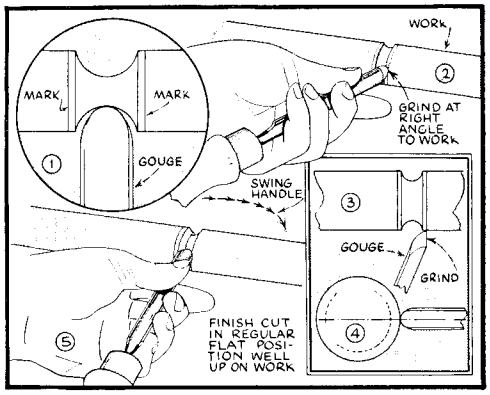
Above, Left, Shows the Start of the Cove Cut. The Photo at Right Shows How Chisel Is Rolled. Various Steps in Cove Cutting Are Shown in the Diagram.

chisel to catch and cause a run. V-grooves can also be made with the toe of the skew, the method being the same as used in making the clearance cut when squaring an end. This manner of working is particularly good for deep, narrow cuts.

Long Cuts.—Long cuts are usually either convex or straight-tapered surfaces. The work is first worked down to the approximate size, using the parting tool to determine the diameters. With a convex surface, the method used in making the finishing cut is shown in Figs. 1 and 2, page 11. The gouge is turned on the tool rest so that it will be inclined considerably in the direction in which it is about to move. The grind is tangent to the work, and the center point of the cutting edge is the contact point with the wood. As the cut progresses towards and around the end of the curve, the handle is gradually raised and swung to the right, as shown in Fig. 2, in order to maintain the tangency between the grind and the surface being cut. See Fig. 3. The large skew can also be used for this operation, the tool handling being much the same as for cutting a bead.

Figs. 4 and 5, page 11, show the cutting of a long taper. The skew is used, and the operation differs from smoothing a cylinder only as regards the start of the cut. The starting cut should be made with the heel, as shown in Fig. 5, to prevent the tool from digging into the work. As the tool runs down the work, the chisel can be pulled back to allow the center point of the cutting edge to cut. However, the full taper can be made with the heel. There will be a tendency to cut too deeply at the center of the taper which should be guarded against. The direction of cutting is always downhill.

Cove Cuts.—Second to forming a perfect bead, the cove or concave cut is the most difficult to master. This cut is made with the gouge, the size of the tool depending upon the size of the cut. The size of the intended cove is first laid out, and the gouge is pushed directly into the work to remove the surplus stock slightly within the lines showing the limits of the cut, as pictured in Fig. 1. The cove cut can now be made. The gouge is placed on edge on the tool rest in such a position that the grind of the chisel forms an approximate right angle with the work, as shown in Figs. 2 and 3. The chisel contacts the work at the center of the cutting edge, the tool being held so that the centerline of the gouge is pointing directly towards the center of the



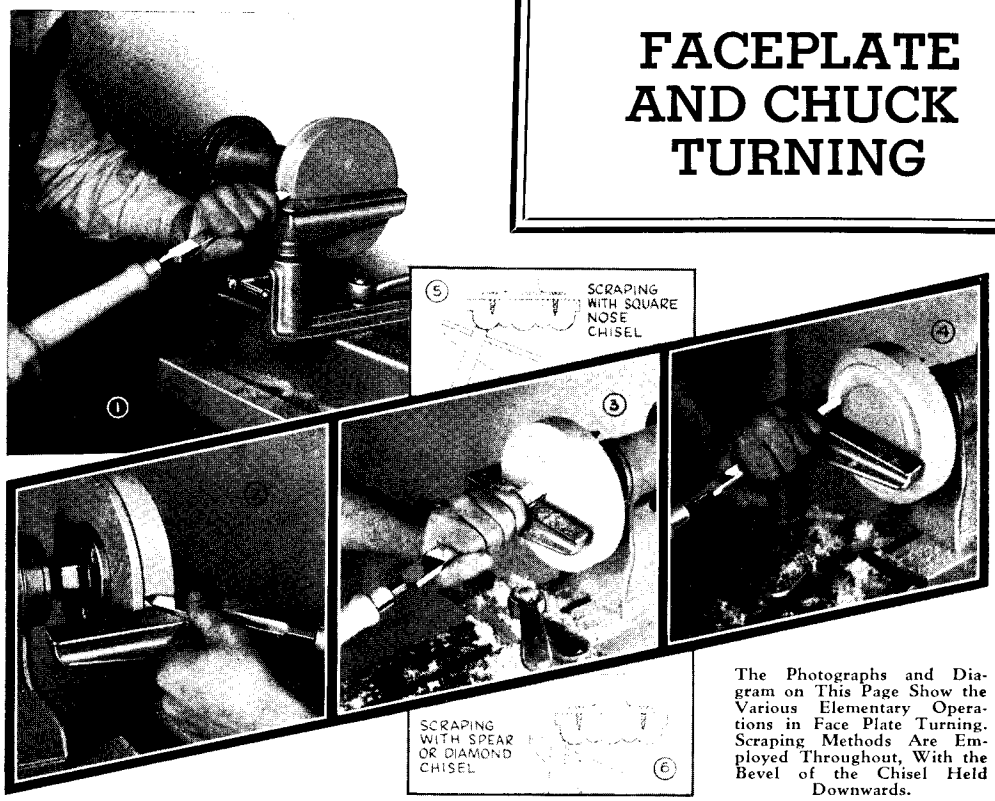
revolving stock, as shown in Fig. 4. The chisel could be held higher on the work, if desired, but the centerline of the tool should still point towards the center of the stock. This starting position is important; otherwise the gouge will have a tendency to run along the surface of the work.

From the starting position, the gouge is pushed into the revolving stock, and the tool is rolled on the rest. A triple action takes place here: First, the chisel is rolled to follow the shape of the cut; second, the handle is dropped slightly so that the portion already cut will force the lip of the chisel sidewise; third, the chisel is pushed forward so that at the end of the cut, Fig. 5, it will be well up on the work and tangent with the cut surface.

Only one-half of the cut is made at one time, then the position of the chisel is reversed to cut the other half. The corners of the chisel should be well-rounded, and the cut should always stop at the bottom of the cove in order that the tool edge will not catch in the wood on the other side of the cut. Because of the possibility of a run when starting the cut, many workers grip the tool *onto* the rest. Solidly held in this manner, any tendency towards running is avoided. If the exact center of the chisel contacts the wood, Fig. 4, a run is impossible, but since this position cannot be seen exactly in actual work, a solid gripping of the tool onto the rest is sometimes advisable.

CHAPTER THREE

FACEPLATE AND CHUCK TURNING



The Photographs and Diagram on This Page Show the Various Elementary Operations in Face Plate Turning. Scraping Methods Are Employed Throughout, With the Bevel of the Chisel Held Downwards.

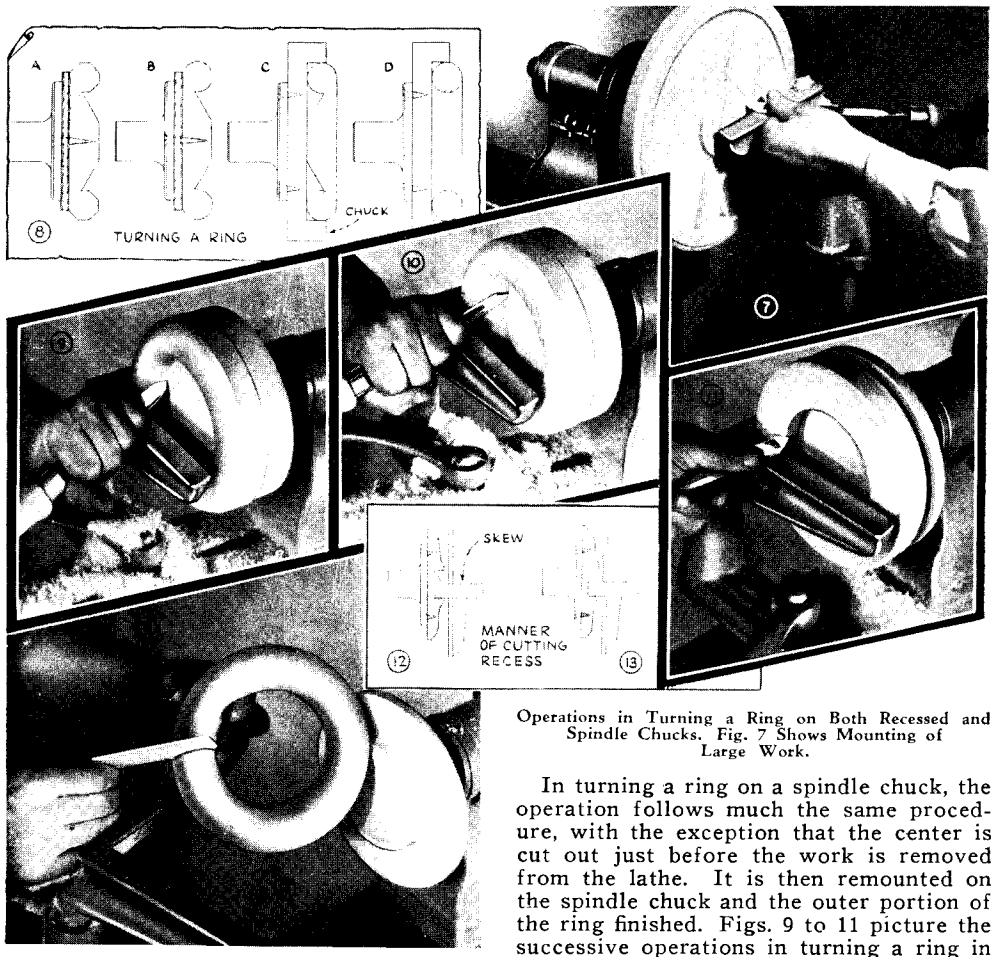
Mounting the Work.—Turnings which cannot be worked between centers are generally classified as faceplate or chuck turnings. The faceplate to which the work is attached can be of several types, the most common being the single screw center, the 3-in. plate with center hole and three outer holes, and the 6-in. faceplate with four slots through which screws may be inserted into the wood. In operation, the work to be turned is simply screw-fastened to any of the face plates mentioned. On work where screws are impossible or objectionable, a piece of scrap stock is first screw-fastened to the faceplate, and to this is glued the turning stock. A piece of paper is usually placed between the glued surfaces so that they can be later separated. The paper is not necessary with some of the fast-drying adhesives now on the market.

Elementary Operations. — The turning is largely scraping, using the round nose or mortising chisels. The bevel side of the chisel should always be the underside, and the point of contact should be horizontal on a line passing through the center of the work.

The first operation on any faceplate turning is generally cutting to diameter. This can be done with the square nose chisel by simply holding the tool against the work, as shown in Fig. 1. The chisel may be moved from side to side if a single cut does not cover the width of the stock. The turning should be previously cut to within ⅛ in. of the required diameter on the band saw. In another method of turning to diameter, the spear point chisel is used, holding this so that one of the cutting edges parallels the surface being scraped, as shown in Fig. 2. The skew and parting tool are also used in cutting to diameter, making the cut from the face to the rear of the stock.

Very often the face of the disk is surfaced as the initial operation, using the square nose chisel, as shown in Fig. 3. The cut should be started at the center and worked towards the rest. After the cut is completed, the new wood surface should be tested with a straight edge or with the side of the chisel to determine whether or not it is perfectly square.

Some workers prefer to use the large skew for facing. The tool is placed flat on the rest and square with the lathe bed, the toe edge of the chisel being next to and parallel with the face of the work. A light bite is then taken and the chisel advanced to the center of the work in the same manner employed when using the parting tool. The point of the spear chisel and the bevel on the left side can also be used in the same fashion. Do not use any tool on the far side of the disk, as this will only throw the tool upwards.



Operations in Turning a Ring on Both Recessed and Spindle Chucks. Fig. 7 Shows Mounting of Large Work.

Other elementary operations in face plate turning are shown in Figs. 4, 5 and 6. The round nose chisel is used for all concave cuts, while convex surfaces are worked with the spear point chisel or the square nose chisel in the manner shown. Larger turnings are worked in the same manner, but are mounted on the outer end of the lathe, as shown in Fig. 7.

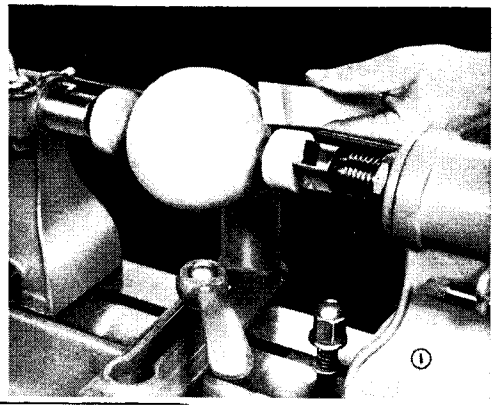
Turning a Ring. — Some work must be turned on both sides, prohibiting the use of screw fastenings. The turning of a ring is a typical example. In order to hold work of this nature, chucks must be used. Chucks are of two kinds—recessed and spindle—and are made up as needed. The manner of turning a ring on a recessed chuck is shown in Fig. 8. The work is mounted on a backing block while the outer surface is shaped to the required contour, as shown at A and B. The work is then removed from the lathe, and a recessed chuck is made which will just take the half-finished ring with a "press-fit." The center portion of the turning is then cut away and the ring completed, as shown at C and D.

In turning a ring on a spindle chuck, the operation follows much the same procedure, with the exception that the center is cut out just before the work is removed from the lathe. It is then remounted on the spindle chuck and the outer portion of the ring finished. Figs. 9 to 11 picture the successive operations in turning a ring in this manner. The spindle chuck on which the work is mounted in Fig. 11 can be easily seen in Fig. 14. Variations in the exact use of chucks are quite numerous—the essential points being merely that the chuck will hold the work while permitting the turning of the surface. Constant use should be made of templates to guard against over or under-cutting the work.

Internal boring, as required in cutting out the center of a ring and in many other operations, can be done in a number of different ways, the most common being as shown in Figs. 12 and 13. If a disk only is to be cut from the center of a larger piece, the parting tool is used to cut in at the required diameter. Internal boring is also done with the gouge, holding this vertical and a little above center. Special tools can be made up for deep cutting. The use of an expansive bit with the lead screw filed smooth is sometimes useful, as is also the boring tool held in the slide rest.

Turning a Sphere.—Wooden balls of any size are first rough-turned between centers,

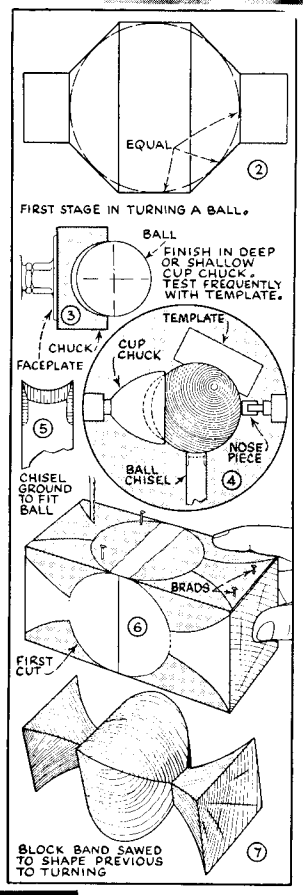
as shown in Figs. 1 and 2. The stock should be of sufficient length to permit cutting-off. Care must be exercised in the initial turning to avoid any deep cut which would make the later forming of a perfect sphere impossible. The work is then removed from the lathe and the surplus end stock cut off. A chuck similar to the one shown in Fig. 3 is made up to hold the partly finished ball. The recess should preferably be in end grain. With a snug-fitting chuck of this kind, no other support for the work should be necessary. The tailstock can be brought up, however, after first removing or setting back the point. The cup itself will not mar the work if a piece of leather is placed between it and the end of the turning.



Above, Rough-Turning a Ball Previous to Chucking, as Shown at Left.

A shallower type of chuck is shown in Fig. 4. This may be recessed in a solid block for attaching to the faceplate as before, or it can be made of hardwood with a taper shank to exactly fit the headstock spindle. The shallow chuck requires end support for the work, a good method being to use an adapter center in the tailstock, slipping a nosepiece of wood over this, as shown. The nosepiece should be lubricated on the inside so that it will revolve freely on the adapter, turning with the work. In a similar manner, a button can be made up for a 60-degree plain center, or a spinning center and small follow block as used in metal spinning can be used. Whatever the method, care should be used to avoid burning the work.

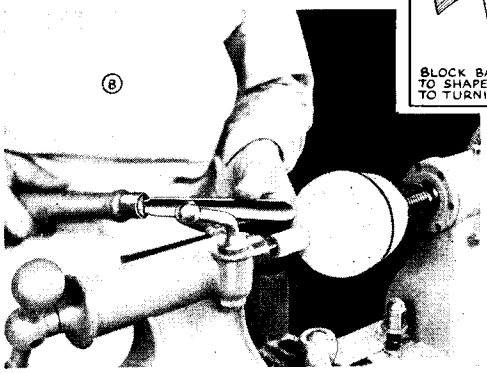
The actual turning of the ball in any kind of chuck is a scraping operation. The essential point is a frequent and systematic rotation of the work inside the chuck. That is, a light scraping cut is taken in one position, then the lathe is stopped and the work turned slightly within the chuck, this being followed by another scraping cut in the new position. The shallow cup chuck will readily accommodate the ball as it grows smaller, but the deep chuck will need refacing and deepening as the work progresses.

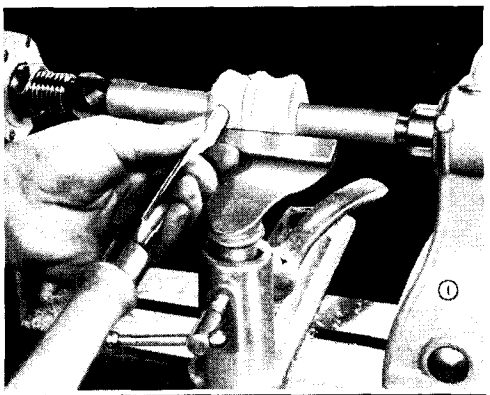


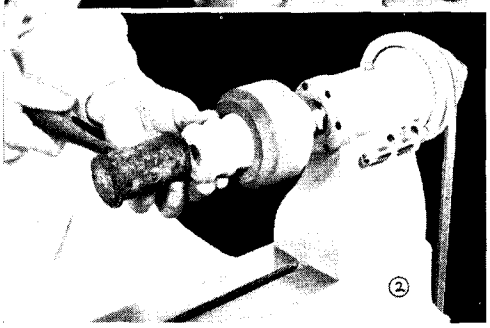
Figs. 4 and 5 show a special ball chisel which is ground to the same radius as is intended for the finished ball. Working with this chisel, the first cut sets the diameter and furnishes a positive guide for each succeeding cut as the ball is rotated in the chuck. Another method which affords a positive ridge line to work to is shown in Figs. 6 and 7. In this method the diameter of the ball, with a slight allowance for trimming, is set off on adjacent sides of the square stock and cut on the band saw. Pieces from the first cut are bradded back in position to allow the second cut to be made, as shown. The band-sawed work, as shown in Fig. 7, is then centered in the usual manner and mounted in the lathe where turning to remove the sharp corners will give a perfect spherical section which needs only trueing of the ends in a cup chuck. If the initial turning is done at low speed, the ball-shape can be easily seen.

Whatever the method used, frequent use should be made of templates and calipers.

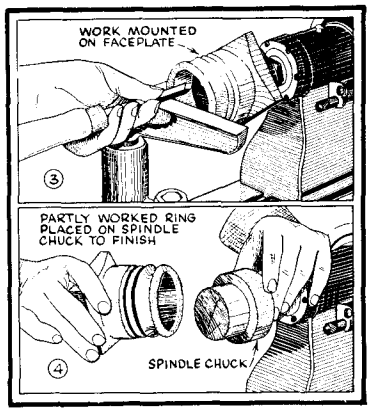
Below, Trueing the Surface of a Ball Held in a Shallow Cup Chuck With Nosepiece End Support.







Above, Use of Arbor in Turning Napkin Ring. Sketch at Right Shows Turning of Ring on Spindle Chuck.



Templates may be rubbed with black lead so that they will naturally mark the high spots of the work. Final testing for accuracy should be made by boring the proper diameter hole through metal or thin wood, and dropping the ball through the opening several times in various positions.

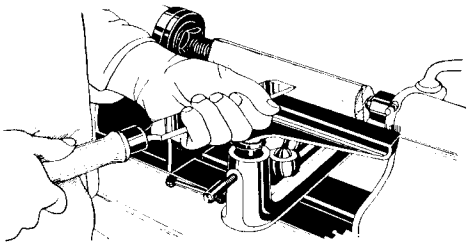
One point which may not have been sufficiently stressed in the preceding paragraphs is the position of the chisel while the ball is being turned in the cup chuck. One or two light cuts may first be taken from the largest diameter of the work towards the tailstock, as shown in Fig. 8 on the preceding page. Finishing cuts, however, are always taken on the diameter of the ball, turning the work in the chuck to bring any high spots to this line. The best chisel to use, lacking the special ball tool, is a flat nose scraping chisel of generous size.

Napkin Rings.—Napkin rings afford another example of chucking, with many different methods at the disposal of the turner. The work somewhat parallels the technique as used in making rings and boxes, with some changes to suit the nature of the work. Fig. 1 pictures the turning of a napkin ring on an arbor. In this method, a hole is drilled completely through the blank wood stock. A separate piece of wood is then turned between centers to fit this hole snugly, having a *very slight* taper from headstock to tailstock. The work is forced over this arbor, and the outer contour of the work shaped to exact dimensions. A chuck is then made to fit the outside dimension of the napkin ring very tightly. The partly-turned ring is pressed or gently hammered into the chuck, as shown in Fig. 2, and one end of the work and then the other is turned out to the proper dimension.

The arbor or mandrel has many other uses in turning where it is necessary to have the inside and outside portions concentric. Toy cannons, wheels and spools, lamp pedestals, etc., are typical examples of the work involved. In most of these cases, the original drilled hole marks the finished diameter of the internal cut, leaving only the outside to be shaped to dimensions. Possible slipping on the arbor while turning can be prevented by slightly dampening the arbor to raise the grain of the wood. Chalk or rosin can also be used. These aids are seldom necessary if initial precautions are taken in tapering.

Figs. 3 and 4 picture another method used in turning napkin rings. In this method, the blank wood stock is mounted on the single screw center or on the 3-in. faceplate. Sufficient surplus stock must be left in either case to clear the screws. The free end of the work is turned to the proper dimensions, both inside and outside, as shown in Fig. 3. The work is then removed from the lathe, and a spindle chuck is made up to take the recessed portion of the ring, as shown in Fig. 4. A snug fit is essential, but the work cannot be forced excessively without possibilities of splitting the turning. The rest of the ring can now be finished, making the internal cut gradually larger to merge perfectly with the inside cut previously made in the opposite end.

In working with any kind of a made-up wood chuck, do not tolerate a poor fit. Any play between the work and the chuck will immediately make itself evident by off-centering the turning, making accurate cutting impossible. A very slight play may be taken up by wetting the wood, but an out-and-out poor fit can only be corrected by making a new chuck. One or two turnings of this nature will rapidly show any beginner why well-made and perfect-fitting chucks are essential.



CHAPTER FOUR

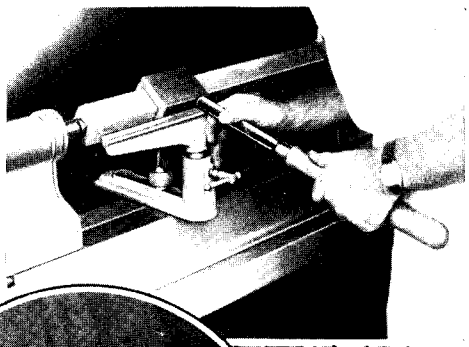
SPECIAL TURNING OPERATIONS

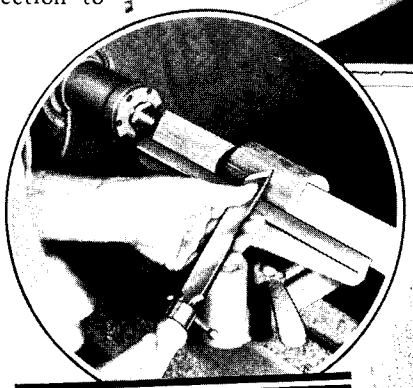
Post Blocking.—Some very attractive and useful forms of spindle turnings have square sections which are smaller in cross-section than the diameter of the largest round section. The two types shown in Fig. 1 are typical examples, and turnings of this kind are generally known as "turnings with reduced squares."

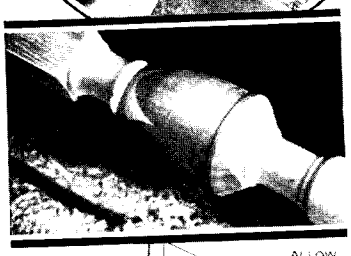
In preparing the stock for turnings with reduced squares, two distinct methods can be used. The first of these consists in using stock of sufficient cross-section to accommodate the largest diameter of the turning. The reduced squares at either end or along any part of the turning are cut to the required size on the band saw, as shown in Fig. 2, or on the jointer, as in Fig. 3. The use of the jointer gives a smooth, finished edge, but this method cannot be used where the reduction is heavy. Squares reduced by band sawing must always be finished by sanding in order to remove the saw markings.

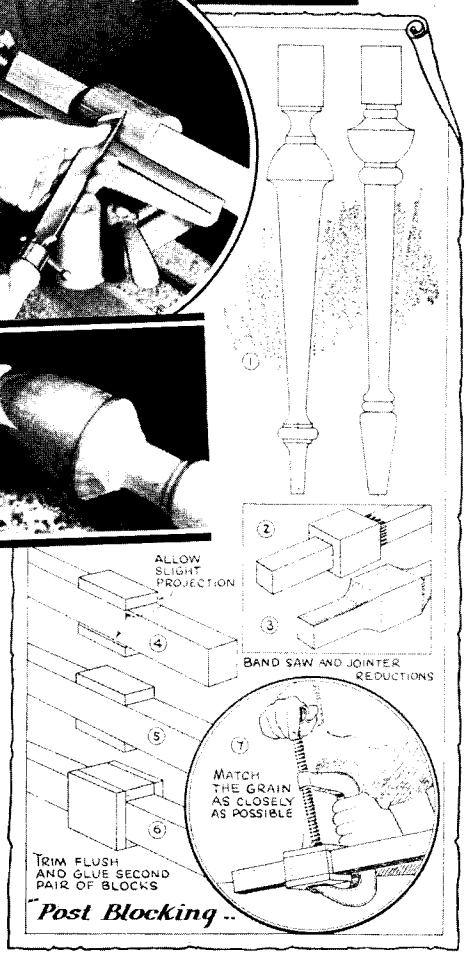
The second method of working is known as "post blocking," and with careful workmanship and good glue results in a finished product almost as good as the solid stock turning while being less expensive. The first operation in post blocking calls for the jointing of the main body of the turning to a perfectly square section. Then, blocks of the same wood of sufficient size are glued to two sides of the square stock at the proper position. Notice, Fig. 4, that a slight projection is allowed so that the wood may be sanded or jointed to a perfectly flush joint. This is important. Fig. 6 shows the two remaining blocks glued into place. Perfect joints, matched wood, good glue, and careful glueing are the essential points of good post blocking.

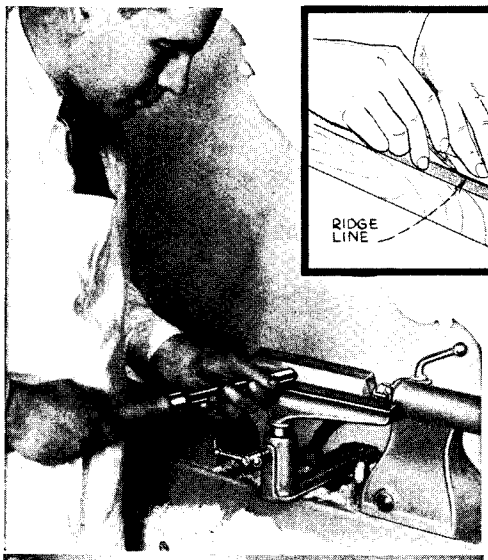
Turning the blocked post is carried on much the same as any other spindle turning. The stock must be absolutely "on center." The edges of the built-up section can be cut away on the circular saw or band saw before commencing the lathe operations. If turned directly from the square, as shown in the upper photograph, only a very slight roughing cut should be taken, as the strain on the joints during the first stages of turning is considerable.

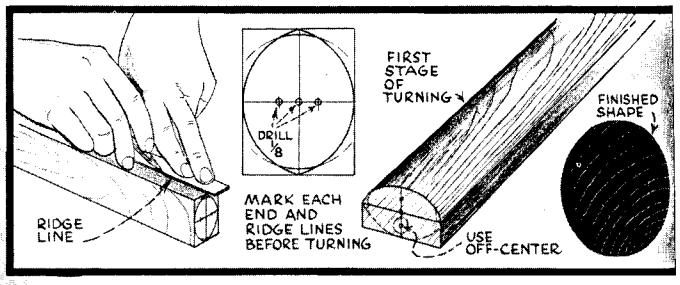


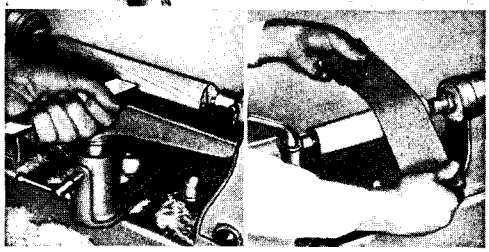












Above, Laying Out Work for Oval Turning. Photos at Left Show Operations in Turning the Work.

Oval Turnings.—This kind of turning can be made on the lathe by off-centering the piece to be turned. The stock from which the turning is to be made should be of a suitable rectangular shape. The true center of the work is located in the usual manner, after which the required off-center points can be located by experiment to obtain the shape required. A compass is used in marking the end of the stock, as shown in the diagram above, the compass curves showing exactly how the finished work will shape up. The shape should be laid out on each end of the wood stock, and the ends of the major axis of the ovals should be connected with a heavy pencil line, as shown. This line is called the ridge line, and serves as a guide when making the turning.

In making the turning, centering holes are drilled at the two off-centers and the true center at each end. The work is then placed in the lathe, using two corresponding off-centers as centers. Turn the lathe by hand to see that the revolving stock will not strike the tool rest. Use slow speed for the roughing cut and second speed to finish. The lathe should be stopped frequently to inspect the progress of the work. Cutting should continue until one side of the stock is rounded off exactly to the ridge line. This stage of the turning is shown in the upper photograph and in the diagram. The cut should not fall short nor go beyond the ridge line, and it should be straight and parallel with the work throughout its entire length.

The work is now removed from the lathe and remounted, using the opposite pair of off-centers. Duplicating the same procedure as before, the work is turned down to the ridge line. The gouge can be used for the roughing cuts, while a flat nose scraping chisel does best for the finishing. The lower left-hand photo shows the turning with both sides of the oval shaped to the ridge line. The stock is finally mounted on the true centers and the sharp points cut away. A further approximation of a true ellipse is obtained by sanding while the lathe is in operation with the stock on true centers. Final sanding should be done after stopping the lathe, working the paper with the grain of the wood.

The same procedure is followed in turning tapered ovals, such as screw driver handles. The work is first mounted on true centers and the taper is turned to approximate major axis dimensions. The work is then removed from the lathe to permit the marking of the ridge lines and the rechucking of the work on either pair of off-center points. The work proceeds as before—to the ridge line on either side, and finally on the true centers again for rounding off.

Split Turnings. — Cabinets and furniture are often decorated with pieces of half round turnings. These may be made on the lathe very easily by screwing two pieces of stock together, as shown in Fig. 1. The screws should be kept well clear of the intended turning. Heavy stock can be fastened with small screws by countersinking, as shown in Fig. 2. The use of corrugated clips is also practical as a means of holding the stock together. After fastening, the work is turned in the usual manner. Perfect centering is necessary in order that both halves of the turning will be the same size. The finished turning should not be cut off with the parting tool, but should be removed from the lathe and separated with a back saw. The terminals of the pieces can then be rounded off with sandpaper or left square, as the case may be.

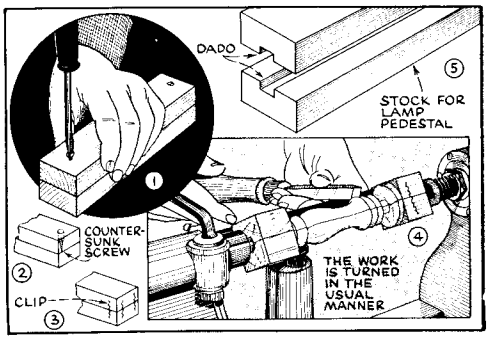
A somewhat parallel procedure is involved in the making of lamp pedestals where the turning is of such length as to make boring impossible. In this case the stock is sawed apart, and the hole for the wiring is run in with the dado head on the circular saw, as shown in Fig. 5. The stock is then jointed smooth and the two halves fastened together. In this case, of course, the assembly is with glue for a permanent joint. The ends of the stock are then plugged for centering in the lathe, the plugs being bored out with a suitable bit once the entire turning is completed.

Turned Boxes.—These are generally classified in two main divisions: (1) The grain of the wood is vertical, and, (2) the grain is horizontal, as shown in the sketch below. The classification is again carried to the lid, the usual element taken into consideration being the matter of whether the lid fits the inside or the outside of the box proper. Sketches A, B, C, and D show typical cover styles.

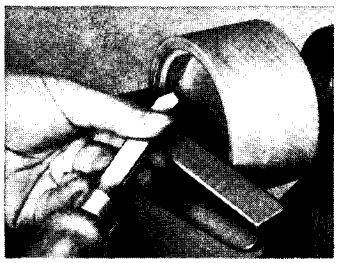
Boxes are generally faceplate turnings, and follow the same general technique. In most instances of horizontal-grained boxes, the stock must be glued to a soft wood block, with a piece of glazed paper at the joint. This block takes the screw or screws of the faceplate so that the fastenings do not pentrate to the bottom of the box. The lid of the box, being shallow, can sometimes be fastened directly to the face-plate.

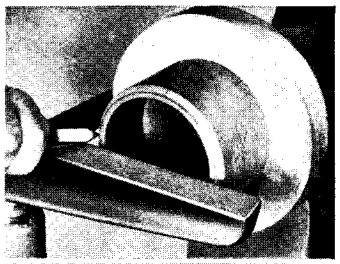
The inside of both parts of the box should be turned first. In the left-hand small photo below is shown the lid recess being cut in a typical small box. The outside is not touched beyond smoothing the rough edges which may have been left by the band or circular saw. After turning the inside, the lid can be removed from the faceplate, and the main body of the box mounted in place. Here, again, the inside only is turned, the operation being as shown in the right hand small photo. The lid should be tested for a fit at various stages of the work, taking very light cuts on the rim of the box proper to finally arrive at a perfect joint. Once the joint has been fitted, the outside of the complete box can be turned down, as shown in the lower photo. With a well-fitting lid, minor touches on the top of the lid can be done without the support of the dead center.

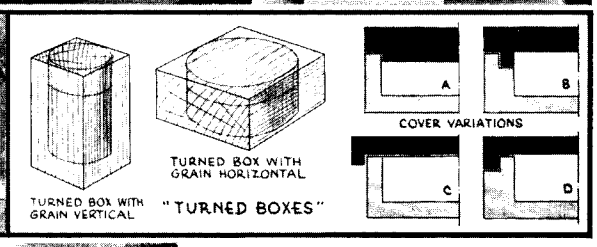
Where the grain of the wood in the box is to run perpendicular to the base, the stock can generally be left sufficiently long to take the faceplate fastenings. The turning proceeds as before. A glue

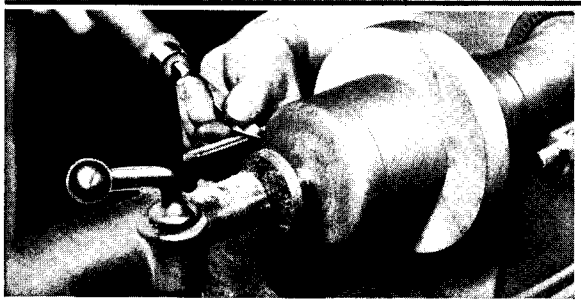


Above, Manner of Fastening Stock for Split Turnings. Fig. 5 Show Stock Dadoed for Lamp Pedestal.

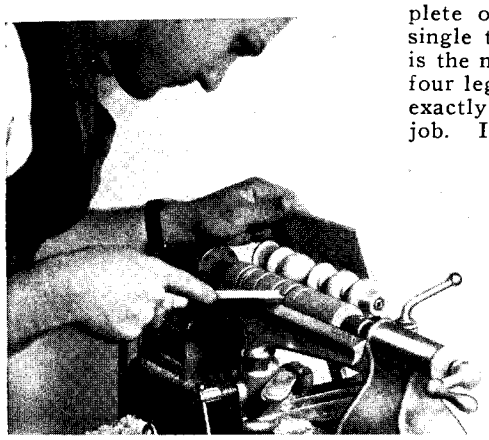


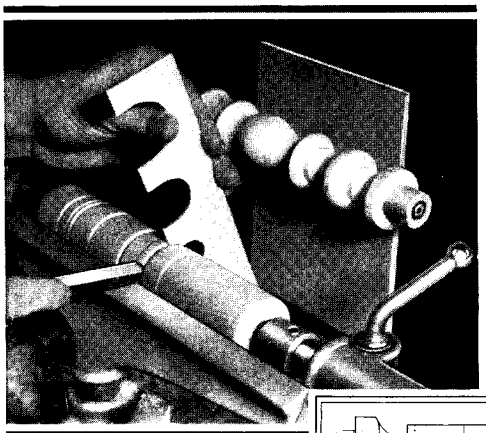


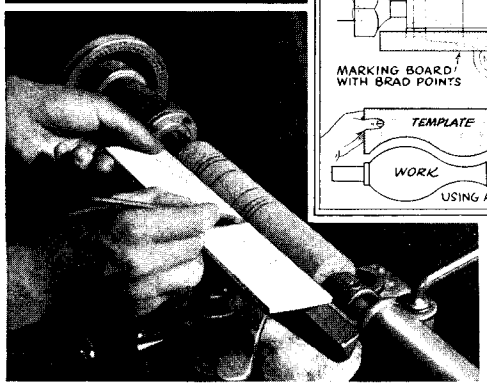


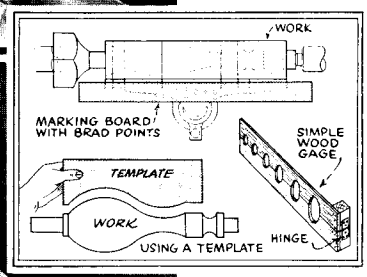


Photographs Above Show Various Operations in Making a Turned Box. The Sketch Shows Types and Variations in the Lid.









Methods of Making Duplicate Turnings, Using Patterns, Templates and Layout Board for Checking the Work.

chuck is sometimes used for this type of box. This is made by turning a ½ inch tenon at the end of the box stock, and glueing this tenon into a corresponding hole drilled in a soft wood base block which is fastened to the faceplate.

Duplicate Turning.—Under this head are classified such models as requires the making of two or more pieces alike to complete one unit of work, or the duplication of single turning on a production basis. The form is the most important, since it is apparent that tl four legs of a table must duplicate each other mo exactly than four single turnings of a productic job. In either case, however, the same gener methods apply to the work.

In making duplicate turnings, three po sibilities of inaccuracies must be tak into consideration. The first of these the matter of lengths along the turnin the second deals with diameters; the thi has to do with the curved surface itself.

There are a number of methods in co mon use for taking measurements alo the turning. A rule can be used, of cours but it is simpler and more accurate to wo from a measuring stick or layout boar This shows a half-section of the require turning, with all dimensions indicate From this board, the necessary lines c be easily transferred to the cylinder, shown in the lower photo. An approxima method which is very good for productic work is shown at the top of the page. Th set-up is simply the "master" turning fas ened to a piece of thin plywood, and s mounted that it can be swung directly int line parallel with the new work. Measurin points can thus be taken off by eye wit fairly accurate results. By penciling th division lines first, this method becomes a positive as the layout board. Another com mon form of layout board has a sma brad, which has been sharpened at bot ends, inserted at ever point where a new diam eter is indicated. All of th brads protrude the sam distance, about ⅛ inch The measuring stick thu prepared is held in plac against the turned cylinde while it is in motion.

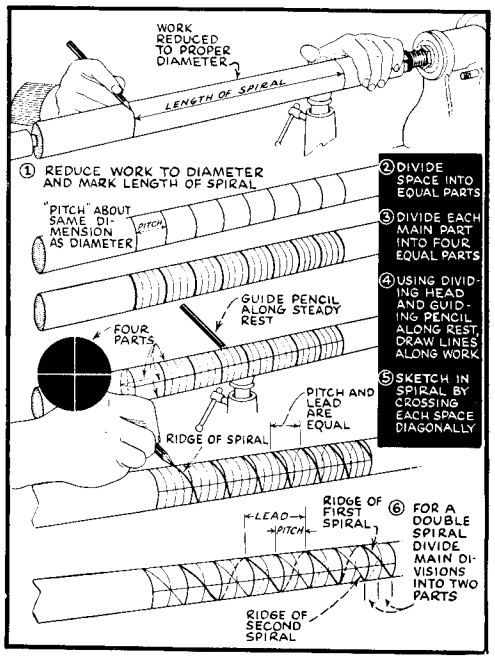
The calipers are the sin gle greatest aid in deter mining diameters, and othe methods are simply varia tions of the same prin ciple. The center photo shows the famil iar diameter board. The checking of lon curves is best accomplished by the use o templates. Templates can be made of an thin, stiff material, and must often be i two or three sections to accommodate th full length of the work.

Spiral Turnings.—These are not turned o the lathe in the true sense of the word, th lathe serving only to hold the work whil the spiral portion of the turning is worke by hand. The most common type is th single twist or single spiral. Like an screw thread, the pitch of the spiral is th distance from center to center of consecu tive ridges. The lead is the distance ad vanced in one revolution. In the singl spiral, the pitch and the lead are equal. A double spiral has two ridges advancing along the cylinder. The pitch is the same

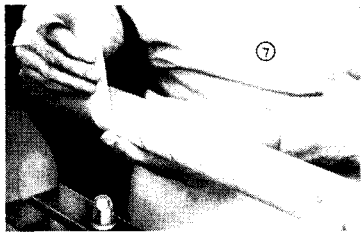
as the single spiral, but the lead or distance traveled is twice as great. In a triple spiral, three ridges wind around the cylinder and the lead is three times the pitch. Spirals with more than three ridges follow the same rule, but more than four threads are seldom practical for average work. The thread can be either right or left-hand, pairs generally being made up in opposite rotation.

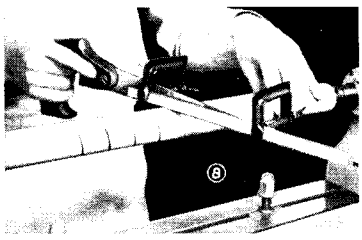
To lay out a single spiral, turn the wood stock to a cylinder of the required size, and on it mark the extremities of the intended spiral, as shown in Fig. 1. Select a suitable pitch. This is generally more pleasing if approximately the same dimension or a little less than the diameter of the work. That is, work 1½ in. in diameter would have 1¼ to 1½-in. pitch. The exact dimension is somewhat decided by the length of the spiral, since the length must be divided into a number of equal spaces, each space representing the pitch of the spiral, as shown in Fig. 2. Each of these main divisions is again divided into four smaller parts, as shown in Fig. 3. Next, the dividing head is set to quarter the stock, and four horizontal lines are drawn on the work, using the edge of the tool rest as a guide, as shown in Fig. 4. The ridge of the spiral can then be sketched in by drawing a line across each of the diagonal spaces thus laid out, as shown in Fig. 5. The distance between threads or ridges (pitch) is the same as the distance the thread or ridge advances in one revolution (lead).

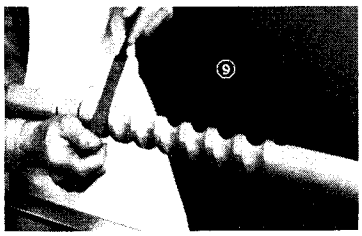
In laying out a double spiral, each main division is divided into two parts instead of four parts. A diagonal line is then drawn as before to give one ridge of the double spiral. The second spiral is started directly opposite the first, and proceeds in the same fashion along the cylinder. The distance between ridges remains the same, but the distance each ridge travels in one revolution is twice the pitch. In laying out a triple spiral in this manner, three horizontal lines instead of four are drawn on the work.

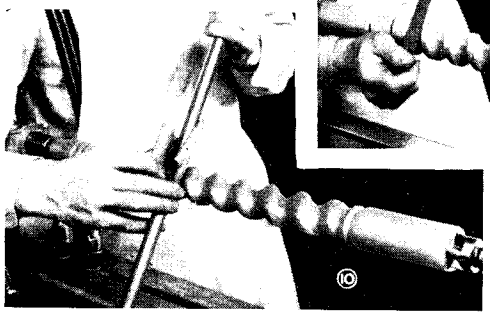


Drawing Above Shows Method of Laying Out Spiral. The Photos at Left Picture the Shaping Operations.



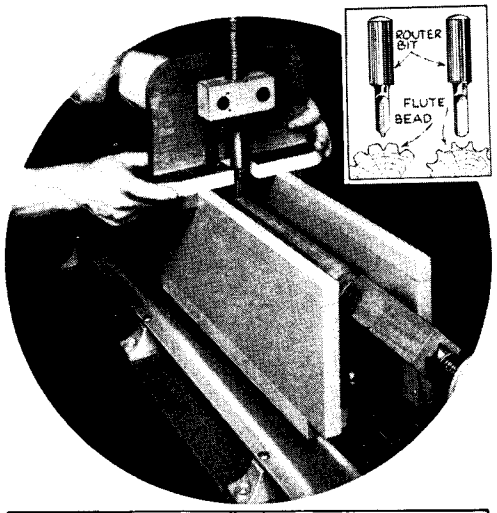


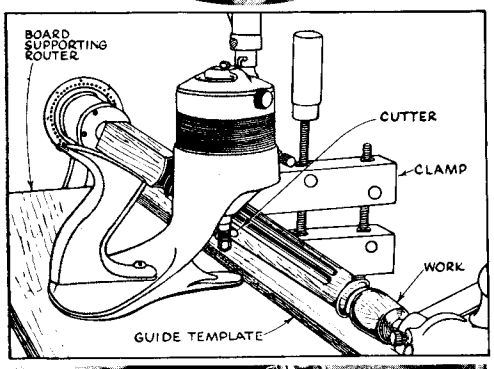


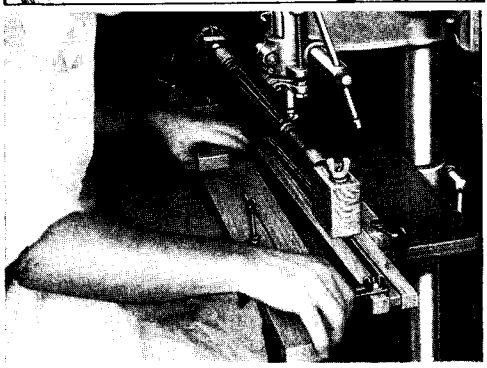


Besides the ridge line, other lines can be sketched in on the turning, preferably in colored pencil, to mark the bottom of the groove, the limits of the true groove portion, etc. The same result can be obtained in a simpler manner by wrapping a strip of paper spirally around the turning, as shown in Fig 7, marking between the edges of the strip to arrive at the ridge line. A double spiral laid out in this manner would require two strips of paper, each of the same width as before.

The actual work of turning is started by sawing a spiral cut accurately between the ridge lines, as shown in Fig. 8. A stop block should be clamped to the saw to determine the depth of cut. After the saw cut has been made, a wood rasp is used to rough out the hollow of the spiral, the saw cut serving as a guide and depth indicator. The





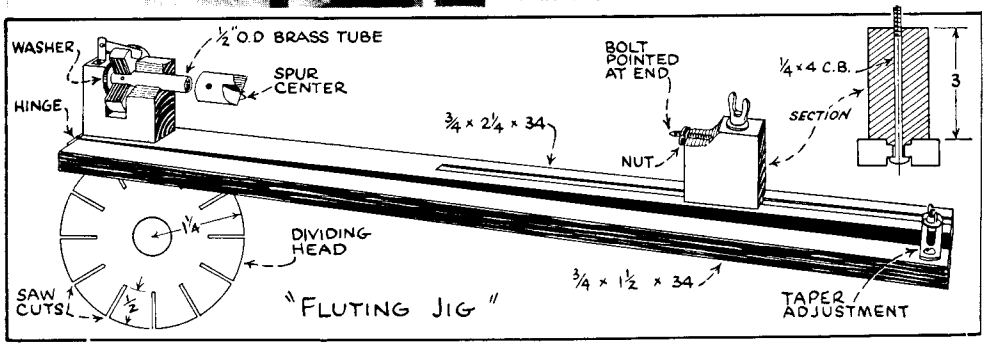


lathe, of course, is not under power, the work being turned by hand. After a uniform groove is formed, as shown in Fig. 9, the edges are rounded over carefully to the ridge line. The lathe can then be operated at low turning speed (8-speed lathe only) and the spiral chased-up with sandpaper wrapped around a dowel stick, as shown in Fig. 10. Regular turning operations can then be carried out as usual on either end of the spiral. The change from spiral to turning should not be too abrupt, but should be a gradual blend, flattening out the final spiral to blend with the true circle formed in turning.

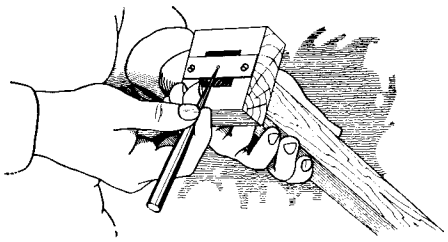
Fluting and Reeding.—Flutes and reeds add greatly to the appearance of many kinds of turnings. The required shape can be obtained by grinding router bits to suit, or by using regular shaper cutters of the proper size. One of the simplest methods of working is shown in the upper photo. Here, a flexible shaft or small electric drill carries the router bit. The wooden frame centers the bit directly over the turning and serves as a depth stop. Proper spacing of the flutes or reeds is automatically done by using the dividing head to set off the required number of divisions. Another method of working, using a portable router fitted with a shaper cutter, is shown in the center drawing. A board supports the router at the proper height, while a guide template determines the depth of cut.

The lower photo and diagram picture a simple fluting jig for use on the drill press. This takes the form of a small homemade lathe, the headstock and tailstock of which are mounted on one of two strips pivoted on a hinge at the head end. Adjustments provide a dividing head and a simple tapering device.

In using any kind of fluting or reeding jig, stop blocks should be used to determine the exact start and finish of the cut. These are simply nailed or clamped to the jig in the proper position to allow the right amount of travel. Correct spacing around the work is done automatically with the dividing head, or the placement of the flutes can be first laid out with pencil. A little figuring should be done before starting actual work in order to make certain that the last cut will come out even.



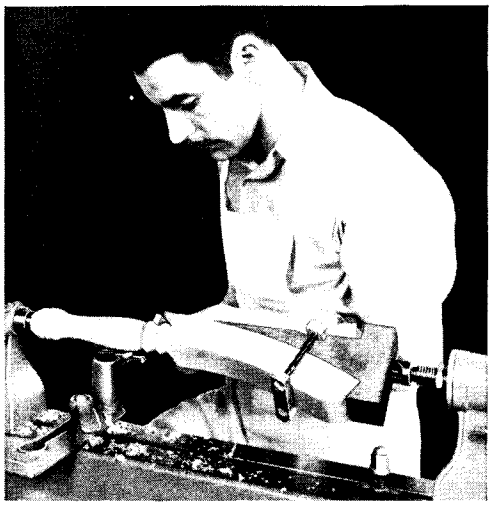
"FLUTING JIG"



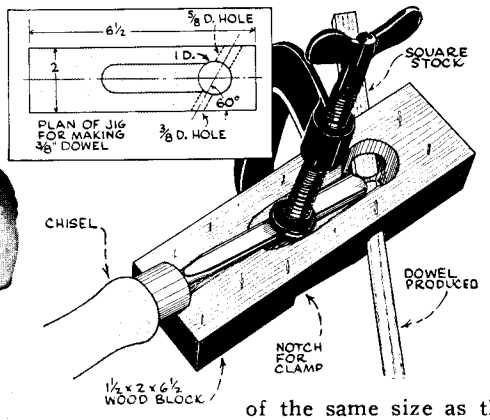
CHAPTER FIVE

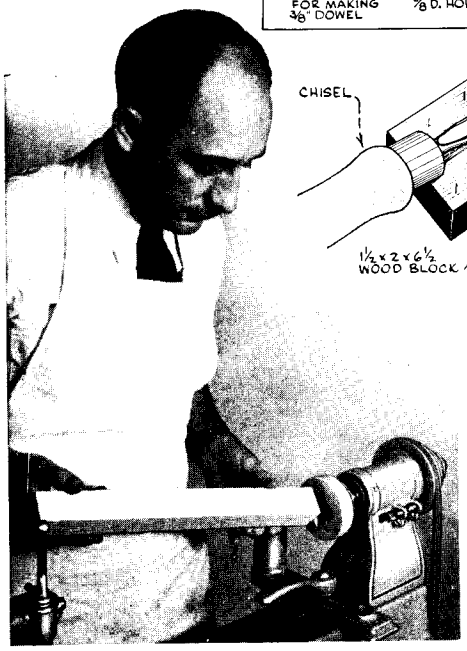
JIGS and FIXTURES

Off-Center Work.—Legs for stools, chairs and other pieces of furniture often have one end turned while the opposite end is band sawed to shape. Turnings of this kind can be readily worked in the lathe by making up a suitable jig to center the curved portion, as shown in the photo at the right. The jig makes up without waste since it can usually be made from the scrap leg cuttings. The centerline of the portion to be turned is projected to the end of the jig; then, the centers are marked in the usual manner. Work of this kind should be run at low speed. However, higher speeds can be used if the jig is properly balanced to prevent vibrations. With the type of clamp shown, balancing is easily effected by turning the bolts one way or the other and adding nuts or washers.



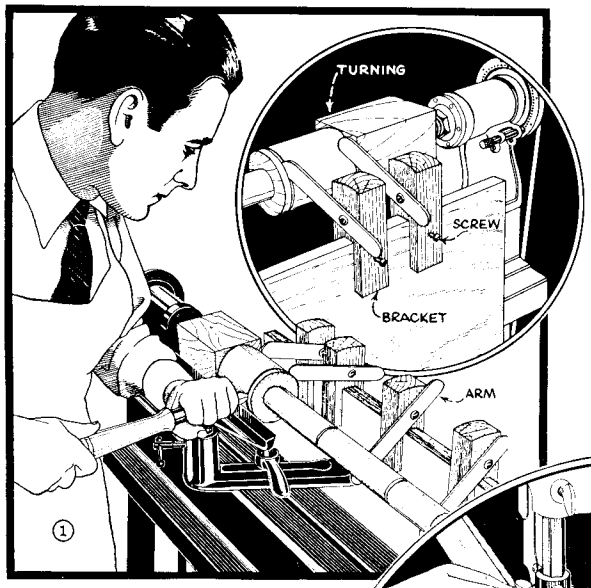
Turning Dowels.—The drawing in the center of the page shows a useful jig for making dowels on the lathe. In use, the square stock to be turned is centered in a suitable chuck. The size of the jig will depend upon the size of the dowel required, the plan view showing dimensions for making 3/8 in. dowel. With the work revolving in the lathe, the jig is simply slipped over the end of the stock and advanced towards the headstock, the chisel paring the wood down to the required diameter.





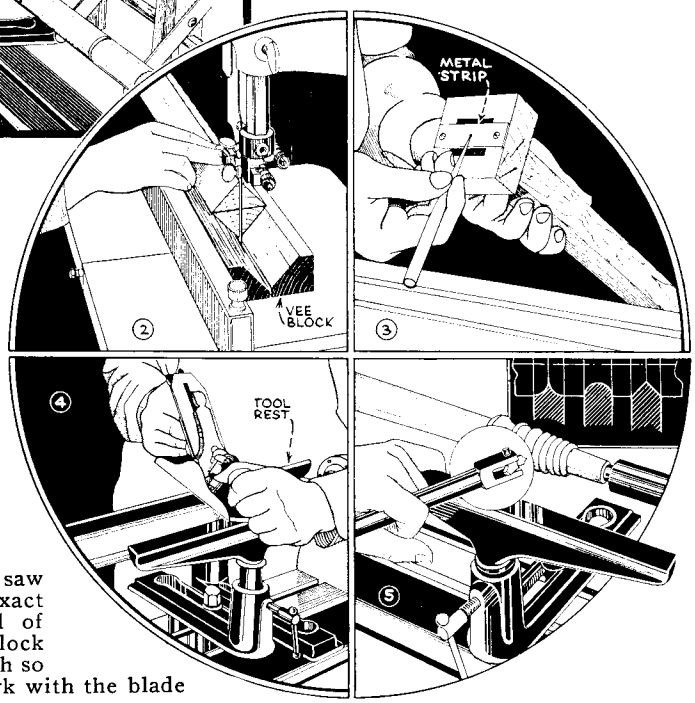
Centering. — The lower photograph shows a centering jig which is often useful in production work. A square hole of the same size as the stock to be turned is sawed in a suitable piece of wood. The block is then centered and fastened to the lathe faceplate. In use, the work is automatically centered on entering the hole, thereby eliminating the job of centering and seating the spur center generally used. The work, of course, is driven as well as centered by the jig.

Other Ideas.—Other useful ideas in connection with wood turning are shown on the following page. Fig. 1 shows a simple semaphore jig which speeds up any kind of production work. The jig consists of a board fastened to the back of the lathe, the top of the board supporting the wooden brackets which are adjustable along the



turning to take a fine shaving.

Precision turning can be done by using shaper cutter bits in a special tool holder, as shown in Fig. 5. The inset shows a few of the typical shapes which can be turned perfectly uniform in this manner. This manner of working is particularly useful where a long series of coves or beads must be cut—a difficult job with skew or gouge. The special tool holder required is made up to the approximate shape shown, the width between the shoulders being slightly greater than the width of the cutter. One shoulder is threaded to take a bolt which compresses the two jaws



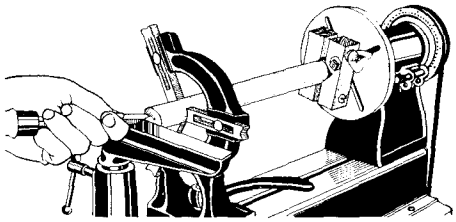
length of the board. Each bracket carries a wood or metal arm of such a length as to suit the work. In use, the arms ride the top of the turning and thereby mark distances along its length. When the parting tool cut reaches the proper depth, the arm signals the completion of that particular operation by dropping below the turning.

Fig. 2 and 3 picture two centering devices. In the first, a suitable vee-block is usd in connection with the band saw fence to aid in sawing exact diagonals across the end of the work. The vee block should be some exact width so that it will center the work with the blade when the fence is set at some even measurement—say, 2 inches. Fig. 3 shows the use of centering blocks. These are made up to fit the size of the work, and, in use, check the squareness and size of the stock as well as locating the center mark.

Frequent use can be made of a small plane on lathe work, especially in smoothing cylinders and straight tapers. Special jigs can be made up for production work. Good results can be obtained by using two tool rests to support the plane, the rests being set at a height to suit the intended diameter of the work. The wooden jigs for tapers or long curves are made up on the same order. The plane can be used alone in smoothing up straight work by simply holding it in contact with the revolving

the slight distance necessary to hold the cutter securely. In using shaper cutters for this purpose, bear in mind that the original bevel of the cutter is not particularly ideal for wood turning when handled in the conventional manner. Best results can be obtained by handling the tool somewhat as for metal spinning, hinging the cutter into the work well below center. For production work, depth collars can be used on either side of the shaper cutter.

Precision work of another nature can be done by using special cutters in the slide rest tool holder, this method of working applying more to production or very exacting work.

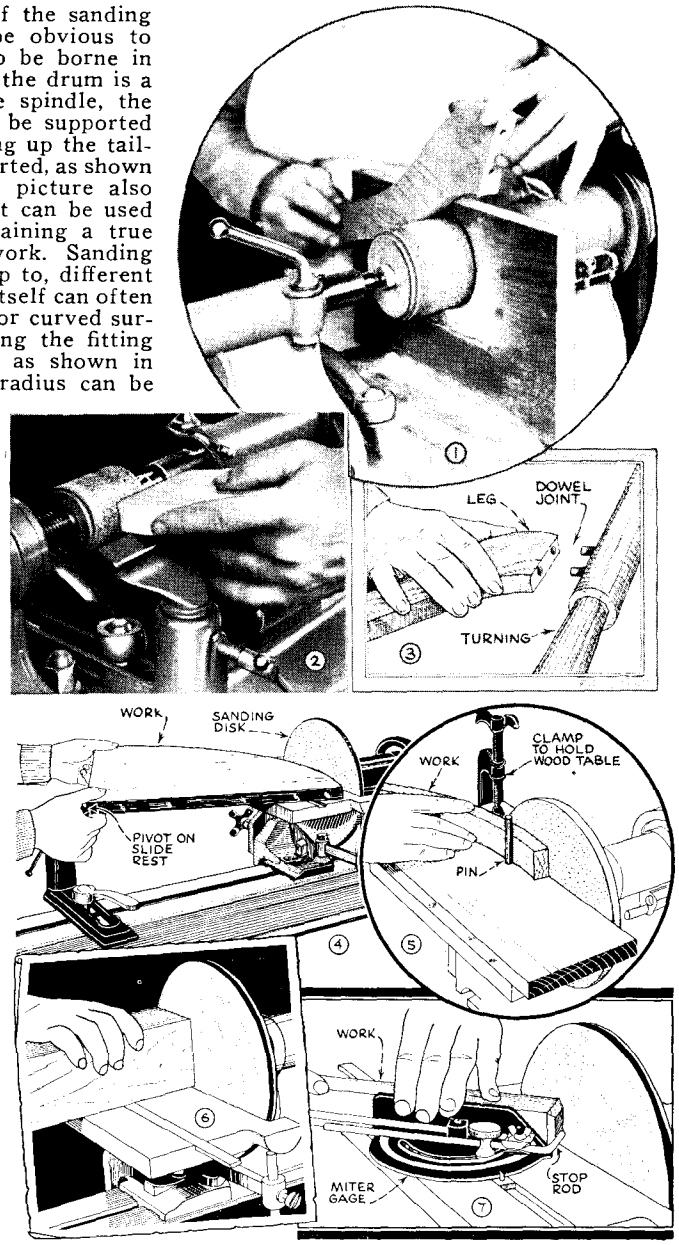


CHAPTER SIX

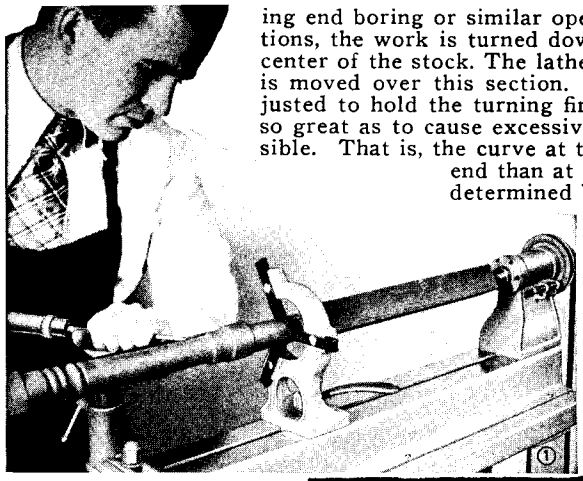
USING LATHE ATTACHMENTS

Sanding Drums.—The use of the sanding drum on the lathe should be obvious to every worker. One point to be borne in mind is that, if the shank of the drum is a Morse taper to fit the lathe spindle, the free end of the drum should be supported whenever possible by bringing up the tailstock with a plain center inserted, as shown in the photo, Fig. 1. This picture also shows how a vertical support can be used to good advantage in maintaining a true edge when sanding curved work. Sanding drums are, or can be made up to, different diameters, and the diameter itself can often be used as a surfacing gage for curved surfaces, a typical example being the fitting of legs to a round turning, as shown in Figs. 2 and 3. Almost any radius can be made in this manner by slightly rocking the work.

The Sanding Table. — The sanding table or the sanding disk alone is an indispensable part of the lathe. Its many uses in finishing work of all kinds should be evident. A few special operations with the sanding table are shown in Figs. 4 to 7, inclusive. Fig. 4 shows how circular curves can be sanded to a uniform radius by pivoting the work against the tool rest. The use of a pivot pin, as in band sawing circles, can also be used to advantage. Curved surfaces can be sanded to uniform width by first band sawing and smoothing one side, and then using the spacer pin, as shown in Fig 5, to set the finish cut on the opposite side. Fig. 7 shows one of the many uses of the miter gage—beveling the edges of a piece of square stock. The gage sets the right angle, while the stop rod controls the depth of cut. In general use, the table should be within ⅛-in. of the sanding disk and slightly above the center of the disk. The table can be lowered, however, to accommodate large work, as shown in Fig. 6. Sanding, in all operations, should be



The Photographs Above Show a Few of the Many Uses of Sanding Drums on the Lathe. The Drawings Picture Typical Operations Using the Adjustable Sanding Table in Connection with the Sanding Disk.



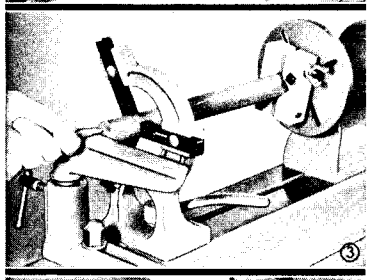
Above, Using the Steady Rest. The Center Photos Show Other Applications.

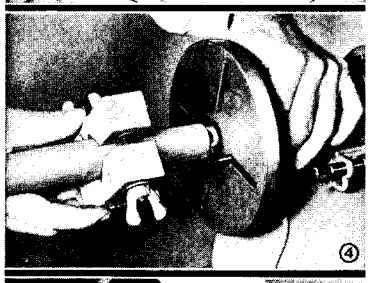
done on the front half of the disk. If the work extends past the center, firm pressure should be applied to prevent it from being kicked upwards. The tilting table is a useful asset in beveling work to any required angle.

Other Accessories. — Other accesories which are frequently used on the lathe include the grinding wheel, the wire brush, and the cloth buffing wheel. The use of the grinding wheel should be familiar with the reader; the wire brush is handy for removing rust and burrs from metal work and for applying a scratch brush finish; the cloth buffing wheel has a wide range of uses in buffing and polishing metal work. All of these wheels are interchangeable on one arbor. The two halves of the wire brush are reversible so that frayed edges can be turned to the inside.

The Steady Rest.—The steady rest or center rest has two important uses in lathe operation: (1) It is used as a support when making long turnings of small diameter, and (2) it forms a bearing for the free end of the turning when doing end boring or similar operations. In the first of these operations, the work is turned down to a cylinder somewhere near the center of the stock. The lathe is then stopped, and the steady rest is moved over this section. The three supporting arms are adjusted to hold the turning firmly, but the pressure should not be so great as to cause excessive heating. All three arms are reversible. That is, the curve at the end of each arm is greater at one end than at the other, and the end to use will be determined by the size of the turning.

In operation, that portion of the turning between the steady rest and the dead center is usually turned first; then the live center end is turned and the steady rest is removed. Finishing cuts at or near the point occupied by the steady rest can be run in by making light cuts, supporting the back of the turning with the left hand while using the chisel with the right. In most cases the rest can be shifted a little to permit access to all parts of the turning. You will find that the supporting arms burn the work to some slight extent. Friction can be avoided by wrapping the contact point with adhesive tape.





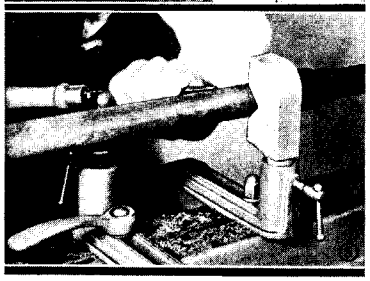
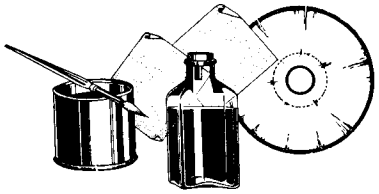


Fig. 2 shows the steady rest being used to support the free end of the turning for end boring. The same general procedure applies, the rest being properly adjusted before the tailstock is set free from the turning. If possible, the steady rest should contact a shoulder or similar cut so that it will not only center the work, but also keep it pressed against the live center. This is not strictly essential for end boring since the drill itself will exert enough end pressure, but it is a necessity when doing end turning. Fig. 3 shows one method of holding the work to the live center when there is no shoulder on the turning against which the steady rest can press. The jig is shown in detail in Fig. 4. As can be easily seen, it consists of two vee-blocks which bolt around the work, the blocks, in turn, being bolted through the slots in the 6-in. faceplate. Fig. 5 shows a simple back rest. This is simply a variation of the steady rest, and is most useful as a support for long turnings.



CHAPTER SEVEN

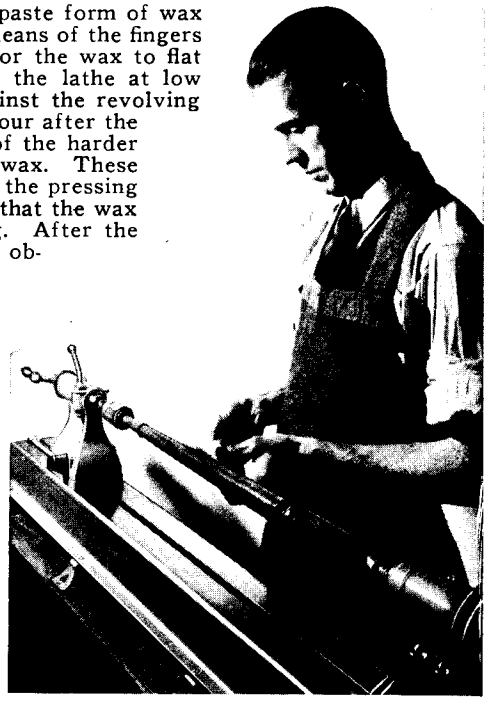
WOOD FINISHING

Wax Finish.—By this is usually meant the paste form of wax which can be applied direct to the work by means of the fingers or a cloth. About ten minutes is allowed for the wax to flat out; then the piece is polished by running the lathe at low speed and holding a piece of soft cloth against the revolving spindle. A second coat can be applied one hour after the first. The wax finish also includes the use of the harder waxes—Carnauba wax, beeswax or paraffin wax. These are in lump form, the application calling for the pressing of the lump against the revolving spindle so that the wax will become soft and adhere to the turning. After the piece is evenly coated, the actual polish is obtained by rubbing with a soft cloth.

Frictional Polish.—A handful of fine shavings taken from the work are cupped in the hand and pressed against the revolving spindle. This will bring out some measure of shine to the work, but is usually done only as an initial step for some other form of finishing.

Oil Finish.—This entails the use of hot, boiled linseed oil as the only polishing medium. The oil is brushed on, and then thoroughly rubbed with a soft cloth as the lathe revolves. Considerable rubbing is necessary to entirely dry the oiled surface.

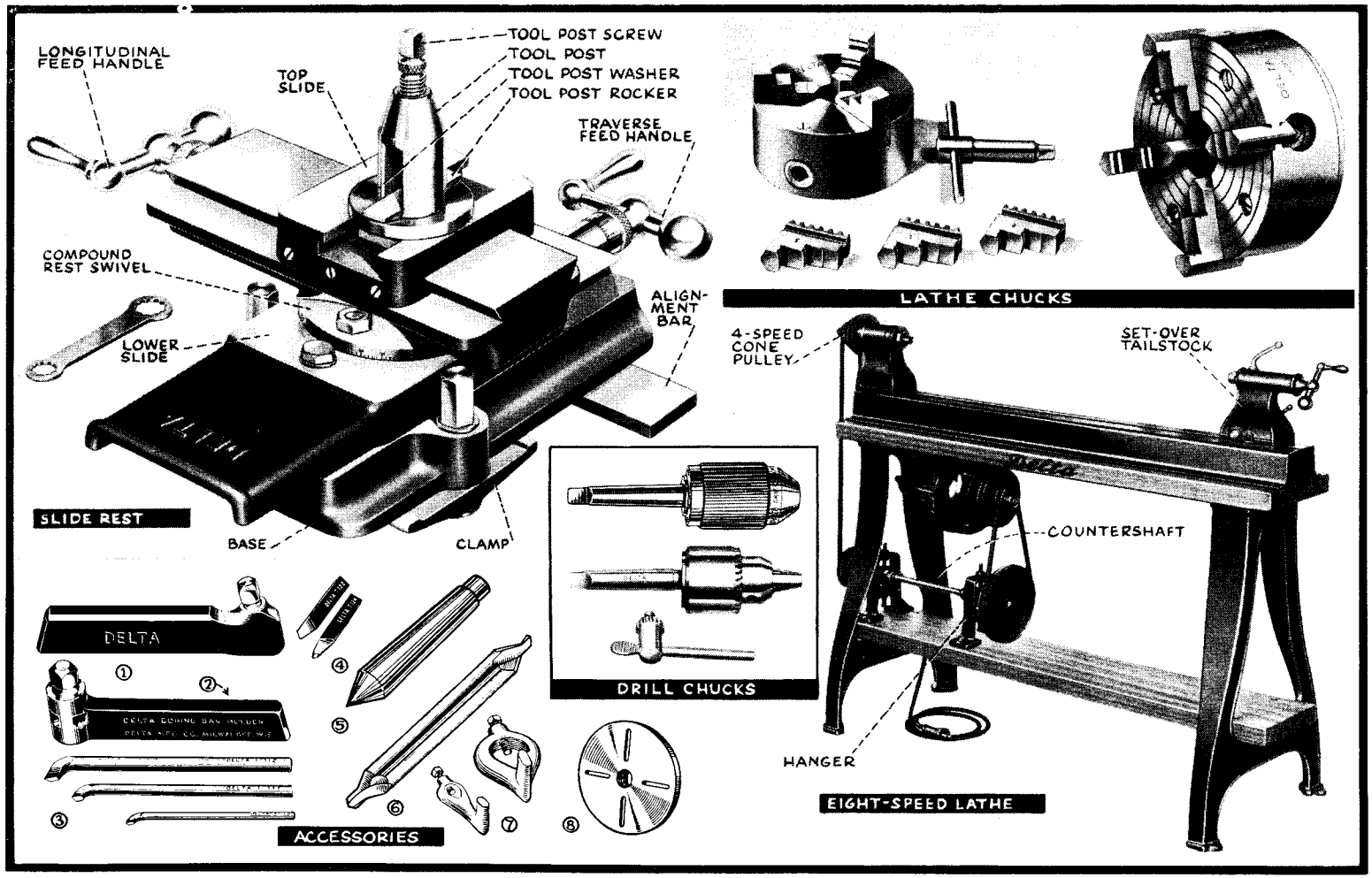
Varnish.—The varnish finish is applied to turnings much the same as for any other form of cabinet work. The finishing is not done on the lathe, with the possible exception of paste filler, if required, which may be rubbed off at a low spindle speed.



Proper Application of Pad in Applying French Polish. The Lathe Should Be Operated at Low Speed.

French Polishing.—For a first project, best results can be obtained by using maple, with boiled linseed oil or paraffin oil as a first coat. The polish is made of pure white shellac, boiled linseed oil and denatured alcohol. These are not mixed in one bottle, but are kept in three separate bottles. A soft rag (no lint) or absorbent cotton completes the equipment. Both are sometimes used—a pad of cotton wrapped in, say, cheese cloth. The pad should be about ½ inch thick by 2 inches in diameter. Place the pad over the mouth of the shellac bottle, and tip the bottle to fairly well saturate the rag; then, place the pad to the mouth of the alcohol bottle and put on about half as much alcohol as shellac. Add two or three drops of oil. Run the lathe at low speed and apply the pad to the spindle. Hold the pad lightly at first, increasing the pressure until the cloth is almost dry, then, add a little more shellac and an equal amount of alcohol, and apply again until the pad is almost dry. The operation is repeated until the whole surface of the work is evenly coated. After the first coat has hardened (24 to 48 hours) apply a second coat. The second coat is unusually more difficult than the first coat. Whereas the first coat can be put on with a fairly wet pad, the second and all later coats should find the pad just damp with the necessary mix. Gradually increase the proportion of shellac, using just enough alcohol and oil to prevent rings from forming on the work as the shellac piles up. A pure water or alcohol rub is necessary as a final step to completely remove any oil film.

Shellac Finish.—This is a polished shellac surface, somewhat similar to French polish. The lathe is turned by hand and a coat of pure white shellac applied. The shellac is allowed to dry for about ten minutes, and is then lightly sanded with worn sandpaper. Using the same kind of pad as for French polishing, moisten the cloth with a very little thin shellac and apply to the revolving work. A drop or two of linseed or machine oil can be used as a lubricant. After the necessary polish has been obtained, wash with clear water.


LONGITUDINAL FEED HANDLE
TOP SLIDE
TOOL POST SCREW
TOOL POST
TOOL POST WASHER
TOOL POST ROCKER
TRAVERSE FEED HANDLE
COMPOUND REST SWIVEL
LOWER SLIDE
ALIGN-MENT BAR
BASE
CLAMP
SLIDE REST
LATHE CHUCKS
4-SPEED CONE PULLEY
SET-OVER TAILSTOCK
COUNTERSHAFT
HANGER
EIGHT-SPEED LATHE
DRILL CHUCKS
DELTA
ACCESSORIES

BOOK TWO
METAL TURNING

CHAPTER EIGHT

EQUIPMENT for METAL WORK

WITHOUT any special equipment, metal turning can be done "free-hand" on the wood lathe, using handled lathe tools of hardened steel in much the same manner as in wood turning. This method of working is ideal for the very soft metals, especially where intricate cutting of curves and beads is involved. Metal turning in its true sense, however, demands the addition of several other pieces of equipment, the most important of which is

The Compound Slide Rest.—This is the name given to the whole of the unit which slides along the bed of the lathe. It is supported by a base casting which extends across the lathe bed, the base being securely clamped at any position along the bed by means of a heavy clamp and two screws. Above the base is the cross slide or lower slide which is used to feed the cutting tool across the work. The lower slide supports the compound rest swivel which in turn carries the longitudinal or upper slide. At the very top is the tool post, with its adjusting screw, washer and rocker.

Accessories.—Figs. 1 to 8 inclusive, on the opposite page picture the essential small tools for metal turning. Fig. 1 shows the straight tool holder, while Fig. 2 shows a boring bar holder. Either type of holder can be clamped in the slide rest tool post by tightening the tool post screw. The holders carry the various tools which actually do the cutting, the straight tool holder housing any of a dozen standard forms of tool bits, Fig. 4, while the boring bar holder will accommodate both the regular bits and also boring bars, Fig. 3, which are used for internal cutting. Fig. 5 shows a plain center. This is ground to a 60° point, and this angle must be maintained. Two plain centers are necessary, one each for the headstock and tailstock, the shanks being tapered to match the headstock and tailstock spindles.

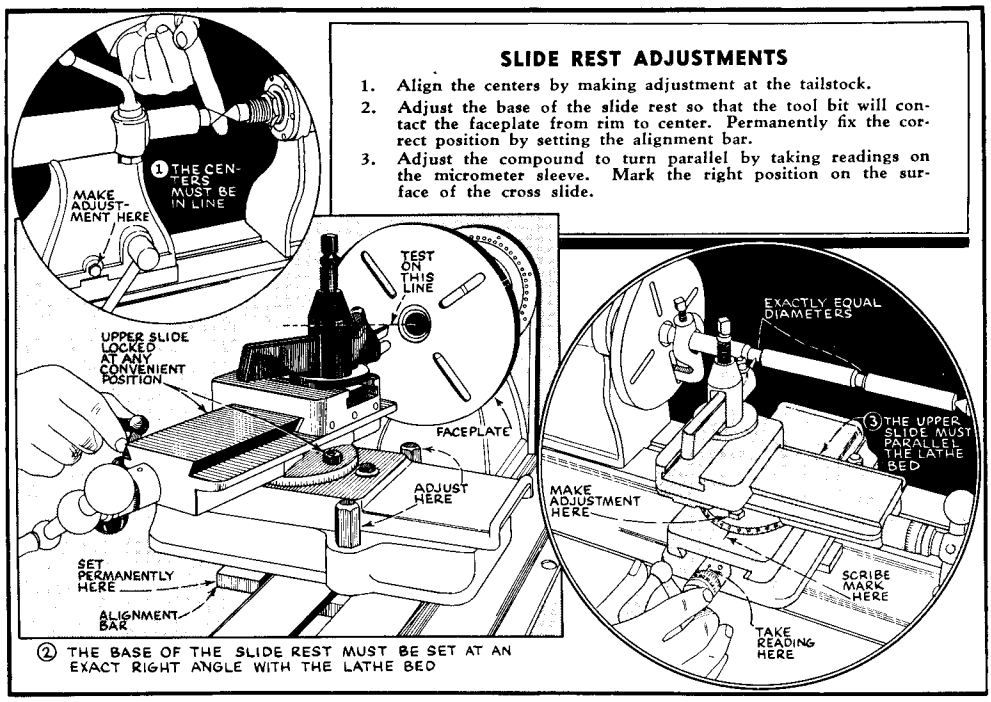
Holes must be drilled in the ends of the work to take the plain centers, and this is usually done with a combination drill and countersink, Fig. 6. These are available in different sizes to suit the diameter of the work. Fig. 7 shows one type of lathe dog. There are many different types and assorted sizes, the purpose of all being to grip the work, while the extended shank fits through one of the slots in the faceplate, Fig. 8, to furnish a positive method of driving the work.

Lathe Chucks.—When the work is not mounted between plain centers, it is generally held and driven by one of two kinds of lathe chucks. The one shown at the left in the picture on the opposite page is known as a universal chuck, the three jaws moving in or out simultaneously through the use of one key. This automatically centers any round stock without further adjustment other than tightening the jaws. The inside and outside jaws are interchangeable to accommodate a wide range of work. The second type of chuck is an independent four-jaw chuck, so-called from its four jaws which are moved in or out independently from each other. The jaws can be adjusted to center round stock, while irregular stock can also be centered by means of the independent adjustment.

Drill Chucks.—Whereas a lathe chuck holds the work, drill chucks are intended primarily for holding drills, reamers, etc. The two types shown are a plain drill chuck and a geared drill chuck, both of which have taper shanks to fit either the headstock or tailstock spindle of the lathe.

Eight-Speed Lathe. — The typical wood lathe is a high speed machine, and does not offer the slow speed required for metal turning. This range of speeds, however, is easily obtained by the use of a countershaft, as shown. Thus equipped, the countershaft has a high and a low speed from the motor, while the four-step cone pulley drive gives four speeds in high and four speeds in low—a total of eight different speeds. With countershaft slow speed, the cone pulley drive gives speeds of approximately 300, 500, 800 and 1100 R.P.M.—this range readily accommodating all average metal work, while different pulleys can be easily substituted for special work. The power required ranges from ⅓ to ½ H.P., depending upon the nature of the work. For average homeshop use, ⅓ H.P. is sufficient.

Set-Over Tailstock.—A set-over tailstock is a necessary part of the metal-turning lathe, not only to put the centers in perfect alignment, but to permit the machining of long tapers. This type of tailstock differs from the fixed type in that it can be moved crosswise with the lathe as well as lengthwise. The adjustment is made by means of two screws, one on either side of the tailstock. These work through a fixed block, and by loosening one screw and tightening the other, the upper portion of

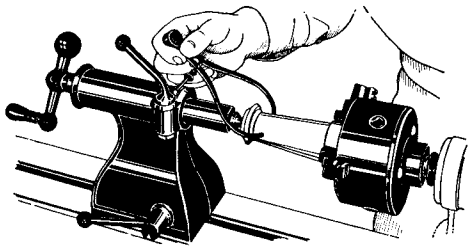


the tailstock may be adjusted in either direction from the centerline.

Adjustments.—The tailstock and the slide rest must be properly adjusted to the lathe before any metal work can be done. To make the first of these adjustments, insert the plain centers in the headstock and tailstock spindles. Advance the tailstock until the two centers are barely touching, as shown in Fig. 1 above. If the centers are out of alignment, loosen the tailstock clamp and make the necessary corrections at the set-over screws. Tighten the clamp and recheck. When the centers are in perfect alignment, scratch a mark across the joint between the tailstock and the tailstock base to indicate zero. Other marks can be scratched on either side of the zero mark so that the set-over can be measured in this manner. Most workers, however, prefer to measure direct from the plain centers.

The slide rest is now clamped in place, as shown in Fig. 2. The first adjustment concerns the base only, so the upper portion of the rest can be clamped at any convenient position. With the set-up as shown and with the lathe stopped, advance the tool bit to touch the rim of the faceplate; then, use the cross feed to run the bit to the center of the faceplate. It should maintain its contact, just touching the faceplate all the way from rim to center. Make the necessary adjustments on the base clamp until the right position is found, and then, after setting the clamp bolts firmly, push the alignment bar hard against the front of the lathe and fasten it securely in this position. The cross feed is now accurately across the lathe, and it will stay that way regardless of how often the slide rest it removed from the lathe.

The upper slide must now be set so that it will make a parallel cut. To do this, set the slide as nearly as possible by eye or square; then, mount a length of work between centers and turn two collars. Make the first of these cuts at the extreme end of the longitudinal feed toward the faceplate. Make the second cut about 4 in. from the first cut. Caliper these collars exactly and continue turning until both are the same *exact* diameter. Now stop the lathe, and run the tool bit in until it lightly jams against one of the collars. Mark the reading on the micrometer sleeve, say, 65. Back off and run the bit up to the other collar. Advance the bit to the collar until it jams lightly as before. Take the reading on the sleeve. It will probably not be the same as the first collar, say, 95. This represents a difference of 30 between the previous reading. Jam the tool bit against the collar with the higher reading, and then back off half the difference, or to 75. Loosen the adjusting screws and swing the rest until the bit again jams against the work. Tighten the screws. Both collars will now read at 75, and the rest is set to turn parallel. Recheck, and when the final adjustment is made, scribe a mark with a fine, sharp point on the top surface of the cross slide exactly opposite the zero mark on the compound swivel. Split hairs about doing this—it is an important adjustment.



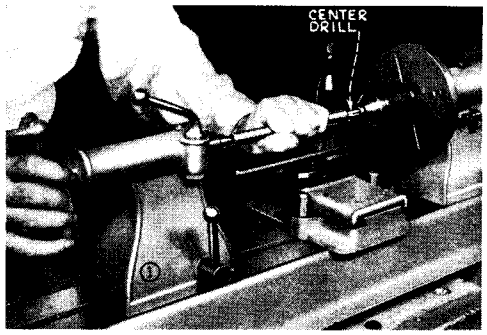
CHAPTER NINE

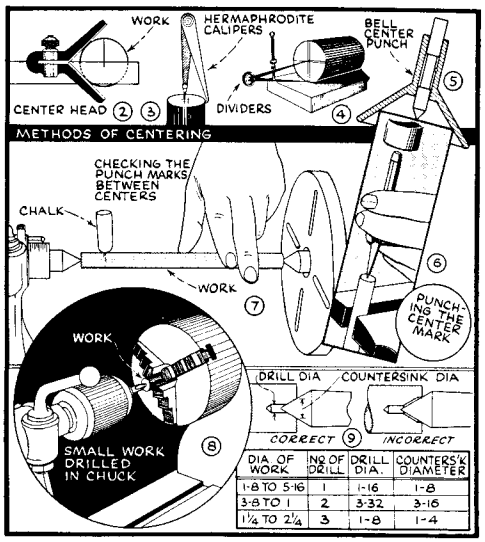
OPERATIONS in METAL TURNING

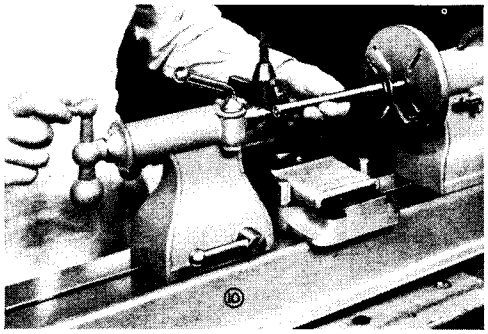
Centering Spindle Work.—As in wood turning, the metal stock must be properly centered before it can be turned. One notable difference is that the metal stock is usually round instead of square, demanding a slightly different procedure in marking the centers. Various methods of doing this are shown. Fig. 2 shows the most common method for average work—lines at approximate right angles being scribed on the stock with the use of the center head to mark the center. Fig. 3 shows how the center is set off with hermaphrodite calipers, while Fig. 4 shows the same general method as applied with dividers. The bell center punch, Fig. 5, will accommodate various diameters. Tapping the punch with a hammer after it has been placed over the end of the stock centers and punches the work in one operation.

Where the center mark is simply a mark, the work must next be center-punched, as shown in Fig. 6. The punch marks are then tested by mounting the work between the lathe centers, as shown in Fig. 7, and checking for high points with chalk as the stock is rotated by hand. Any variation from the true center is thus noted and can be corrected by re-punching. The work is now ready for drilling. The most common method of doing this is shown in the upper photo. A suitable center drill (see Fig. 9) is placed in the lathe drill chuck which is mounted in the headstock spindle. The punch mark at one end of the work is placed on the tailstock center, and the work advanced to meet the revolving drill, using either a pushing movement against the entire tailstock or feeding the work with the tailstock handle. The free hand grips the work firmly, preventing it from rotating. After the hole has been drilled to the proper depth (see Fig. 9) the work is reversed and the opposite end drilled in the same manner. Slow speed should be used, with oil as a lubricant for the drill. Fig. 8 shows how small-diameter work can be held in the universal chuck for center-drilling, the free end of the work extending through the headstock spindle.

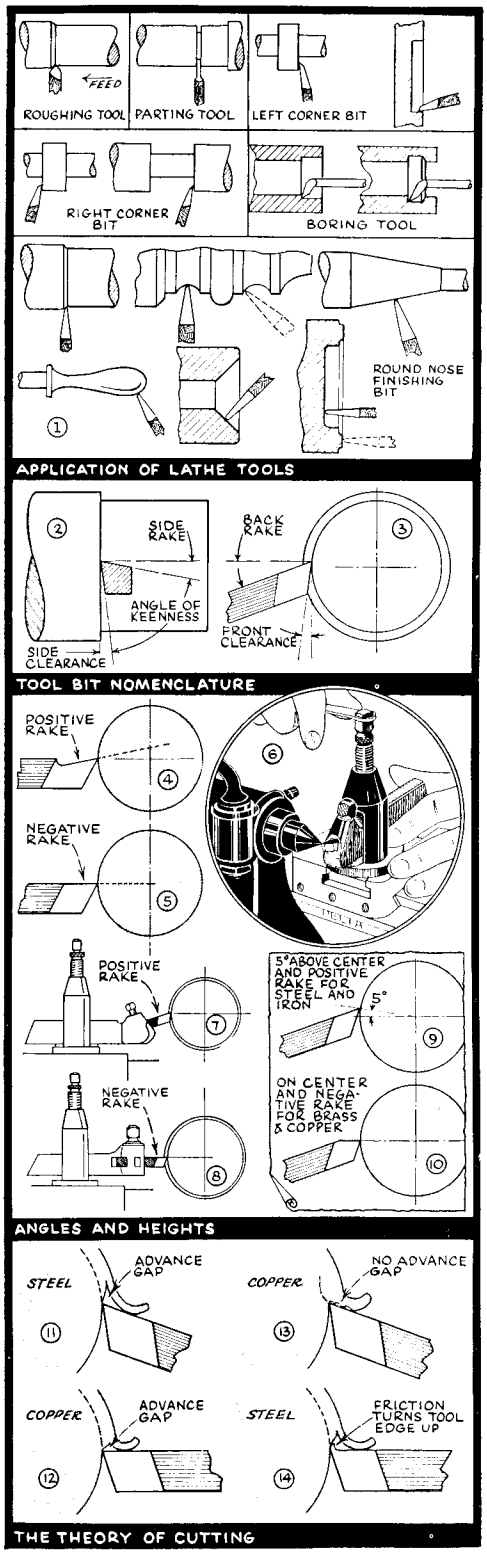
Mounting Work Between Centers.—Fig. 10 shows the work being mounted between centers. The driving dog is clamped to one end of the stock, while the tail of the dog engages one of the slots in the faceplate. The dog should not bind against either the sides or ends of the slot, since this might cause the work to be forced off-center. The tailstock center is brought up snugly but not too tightly against the work. Lubricate the tailstock center with a mixture







Photos and Drawing Above Show Various Operations in Preparing and Mounting Metal Work for Turning.



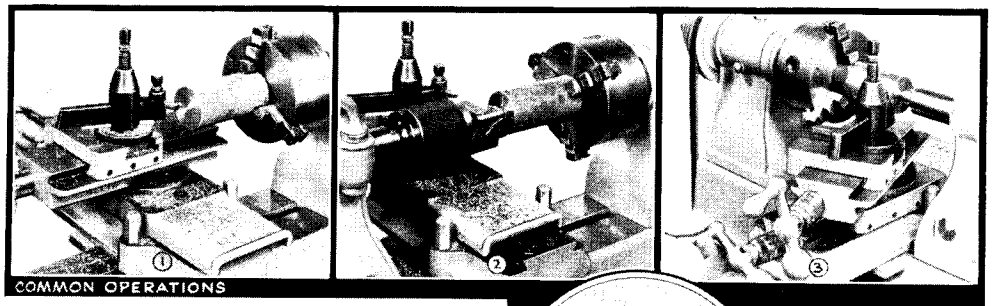
of white lead and oil or plain machine oil. Always rotate the work a few times by hand to see that everything is in proper order before throwing the switch.

Application of Lathe Tools.—Fig. 1 shows the application of a few common forms of lathe tool bits, the drawing demanding little other explanation. Other shapes can be readily ground to suit the nature of the work. For light cutting, the round-nose finishing bit can be used for practically all operations except cutting up to a square shoulder.

Tool Bit Nomenclature.—Certain terms are used in describing any form of lathe tool bit, as shown in Figs. 2 and 3. It is apparent that all bits demand rake and clearance. Side clearance is necessary to permit the cutting edge to advance freely along the work without dragging at the heel of the tool. Front clearance permits the point of the tool to cut without having the whole edge of the bit in contact with the work. Back and side rake are necessary to reduce friction, these angles being governed somewhat by the nature of the work. For example, mild steel is worked best with a bit having extreme back and side rakes; harder steels require slightly less rake; brass and copper are worked with a bit having no back or side rake. For general work, one form of grinding can be used for practically all metals, as shown in

Angles and Heights.—Fig. 4 shows a tool bit which is held in a horizontal position in the tool holder. It is apparent that positive back rake can only be obtained by grinding the bit as shown. The bit in Fig. 5 is held in a boring tool holder and acquires negative rake automatically by its position in the holder. It can be seen that by using the right tool holder, either rake can be obtained, as in Figs. 7 and 8; also, positive or negative rake can be obtained by grinding, Figs. 4 and 10, if the tool holder does not give the bit the required position. In general work, steel and iron demand positive rake, and the cutting point of the bit should be slightly above center—about 3/64 in. for each inch diameter of work, as shown in Fig. 9. The adjustment is best made by advancing the tool bit directly to the plain center, as shown in Fig. 6. The tool for brass or copper has negative rake (level with center or pointing slightly down), and the cutting point should be exactly on the centerline, as shown in Fig. 10.

The Theory of Cutting.—Fig. 11 shows a positively-raked tool cutting steel. The positive rake gives minimum friction, allowing a sliding action as the bit cuts into the metal. A tool with negative rake is cutting copper in Fig. 12. The advance gap is lower and wider, the increased friction serving to "hold up" the soft metal. Now, consider Figs. 13 and 14, which show improper use of tool bits. Fig. 13 shows a positively-raked tool cutting copper. The

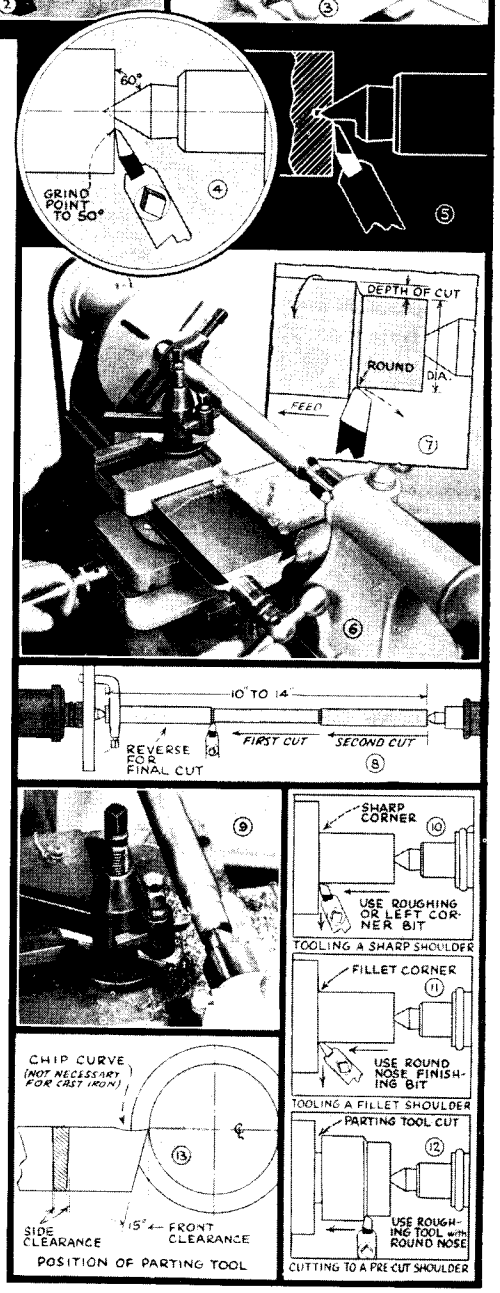


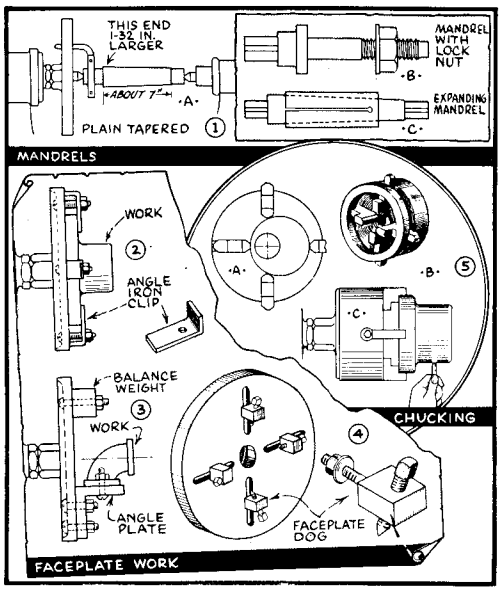
COMMON OPERATIONS

minimum friction of the positive rake permits the advance gap to collapse, and the piled-up metal on top of the tool bit tends to draw the tool into the work. Fig. 14 shows a tool with negative rake cutting steel. Excessive friction soon turns the tool edge up, preventing further cutting.

Common Operations.—The first operation in turning is generally facing the ends of the work, which also cuts it to the proper length. Where the work is of sufficient body to be driven with the chuck alone, the ends are often faced or squared previous to centering, as shown in Fig. 1. After squaring, the work can be center-drilled, as shown in Fig. 2, and then reversed to treat the opposite end in the same manner. The tool bit to use is a left corner bit. It should be exactly on center. The tool should feed from the center to the outside of the work. Two or three light cuts will usually square the end and remove any hacksaw marks. Where the work is supported by the tailstock center, the operation proceeds as before, as shown in Fig. 3. The compound can be rotated to any angle to permit access to the work. The bit to use is a left corner bit, with the point ground to about 50° so that it will clear the tailstock center, as shown in Fig. 4. Grinding in this manner weakens the bit considerably; the bit should be used only for this one purpose. Some operators prefer to grind a portion of the center away, as shown in Fig. 5, so that facing can be done with the more rugged roughing tool.

The general set-up for cutting to diamter, which is usually the next operation, is pictured in Fig. 6. The feed is preferably from tailstock to headstock. The first cut should be sufficiently deep to get under any scale which may be on the work. The tool bit to use is the roughing tool, with the sharp corner slightly rounded, as can be seen in Fig. 7. The height and rake of the bit will be dependent upon the metal being cut. The bit should point slightly away from the direction of feed. This permits a smoother cutting action, and also permits the bit to swing away from the work if anything occurs while machining to change the position of the tool. Rough turning should continue with





Drawing Above and Photos at Right Show Various Methods of Mounting Work in the Lathe.

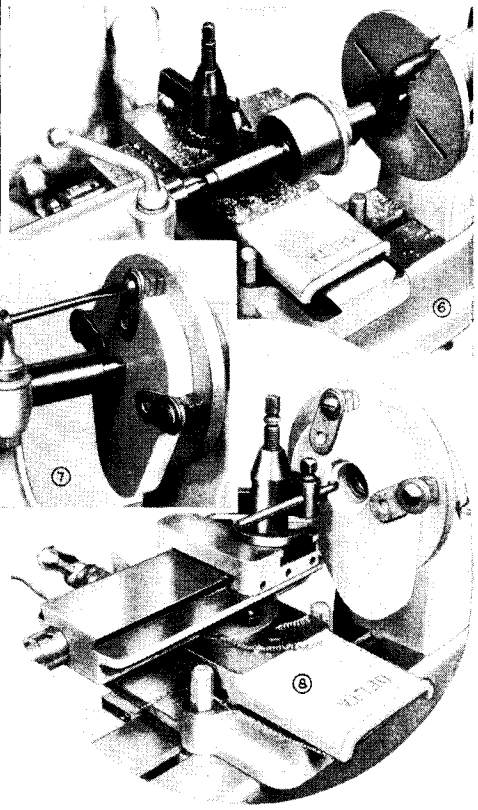
successive cuts until the work is reduced to about 1/32 in. of the required diameter.

The longitudinal feed of the average slide rest is about 5 in. It follows, therefore, that work up to about 9½ in. long can be machined overall by first turning one end and then reversing the work. Where the stock is between 10 and 14-in. long, the first cut is best made in the center, as shown in Fig. 8 on the previous page. The slide rest is then moved to cover the tailstock end of the work, after which the usual reversal of the work will take in the remaining portion. Longer work can be handled by simply taking new positions.

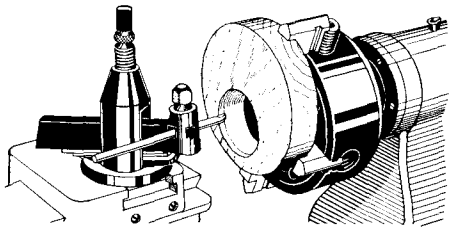
Fig. 9 shows the roughing tool bit being advanced along the work with successive cuts to form a shoulder. The finishing cut is made along the work and then across the face of the shoulder, as shown in Fig. 10. For a fillet corner, the finishing cut would be made with the round-nose finishing bit, as shown in Fig. 11. Fig. 12 shows how a shoulder is pre-cut with the parting tool and then rough turned to size. The parting tool cut is shown in Fig. 13. This bit advances directly into the work and should be always on center.

Mandrels.—The mandrel is usually tapered so that it can be driven into the work to hold it securely. The drive is between centers, as shown in Fig. 1-A and in Fig. 6. Another type of mandrel is shown at B. The expanding mandrel shown at C has a tapered sleeve which slips over the shaft. The sleeve has a number of saw cuts along its length to permit expansion. In use, the sleeve is placed inside the work, and the shaft is then driven in to expand the sleeve.

Faceplate Work.—Work which cannot be driven otherwise can always be clamped to the faceplate. Fig. 2 shows a typical set-up using angle iron clips to hold the work. Fig. 3 shows how a flanged coupling is mounted on an angle plate for machining. Fig. 4 pictures one form of faceplate dog. Figs. 7 and 8 show the set-up and boring of a cam. Methods of mounting work in this manner are almost endless.



Chucking.—The use of both three and four-jaw chucks has been fairly well represented in previous pictures. The three-jaw, self-centering chuck is most useful in holding round work of small diameter, while the independent chuck can be used for both round and odd-shaped work. Fig. 5-A is an example of off-center chucking with the independent chuck. Fig. 5-B shows how the jaws are reversed to grip work internally. Fig. C shows how work is centered in the independent chuck by holding a piece of chalk against the work as it is revolved by hand. The chalk mark indicates which side is "high," the correction being made by loosening the jaw or jaws opposite the mark.

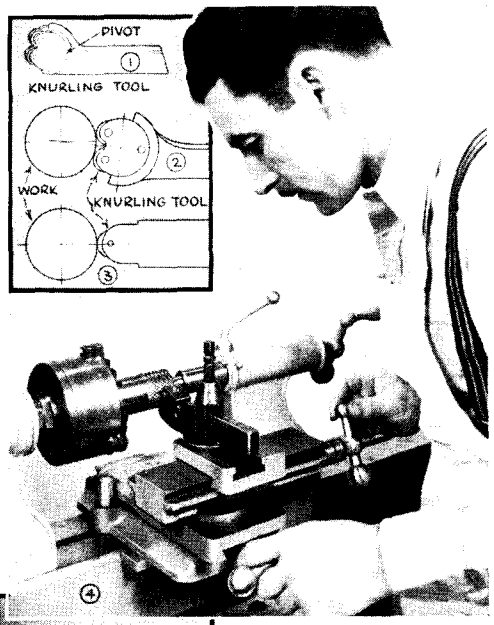


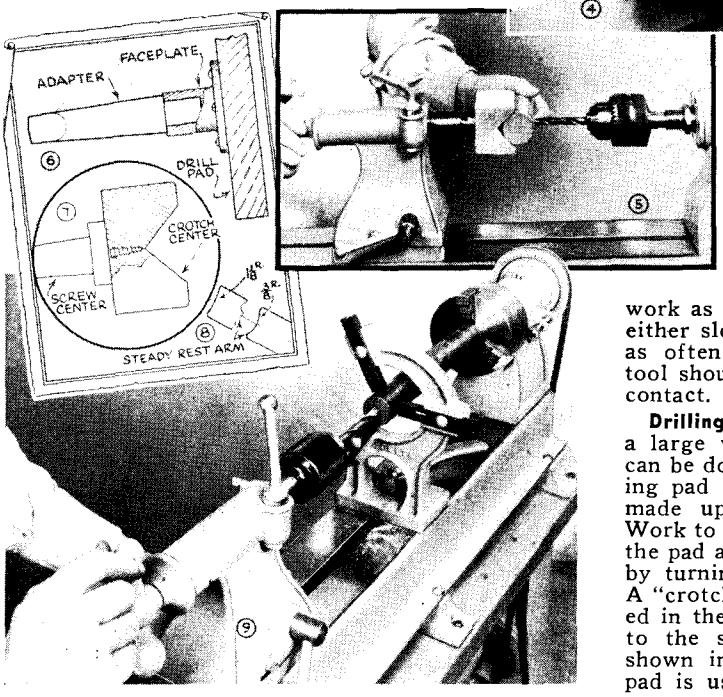
CHAPTER TEN

Miscellaneous METAL OPERATIONS

Knurling.—Knurling is frequently used on metal turnings, both for ornamentation and for traction on the otherwise smooth metal. This operation is done with a knurling tool which is clamped in the slide rest tool post. Fig. 1 shows a common style. The cutting wheels are interchangeable for cutting fine, medium or coarse knurls. In use, the knurling tool should be centered with the work, although a certain degree of deviation from a true position is automatically corrected, as shown in Fig. 2. The single knurling wheel, which is often used, must be absolutely on center, as shown in Fig. 3. The single wheel scribes a single, thread-like knurl, while the double-wheel knurling tool gives the familiar criss-cross pattern.

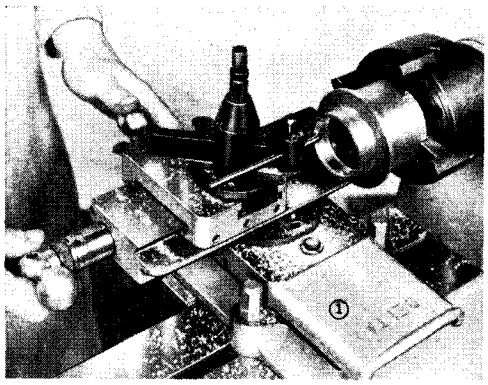
In use, the knurling tool is firmly clamped in the tool post. The lathe is operated at lowest speed. The work to be knurled is lubricated with machine oil. The tool is then fed to the work, the wheels being forced about $\frac{1}{64}$ in. into the metal. The tool is now advanced along the work in the usual manner. A second or third cut can be taken to get the desired depth. Once in contact with the metal, the tool should not be removed from the work. The lathe can be stopped to inspect the work as desired; the feed can be either slow or fast and reversed as often as necessary, but the tool should maintain its original contact.





Above, Knurling on the Lathe. Photos and Diagram at Left Show Operations in Drilling.

Drilling.—Lacking a drill press, a large variety of drilling jobs can be done on the lathe. A drilling pad is necessary, this being made up as shown in Fig. 6. Work to be drilled is held against the pad and advanced to the drill by turning the tailstock handle. A "crotch center" can be mounted in the same manner, or fitted to the single screw center, as shown in Fig. 7. This type of pad is useful for drilling round



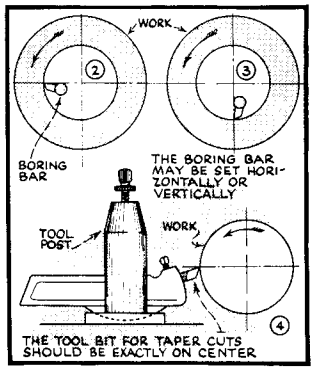
Above, Internal Cutting Using a Boring Bar in the Boring Bar Holder.

stock, as shown in Fig. 5. End drilling in metal stock is done with the aid of the steady or center rest, as shown in Fig. 9, the operation being the same as for boring in wood (see page 26). One point which is again stressed is the radius at the ends of the steady rest arms. One end of each arm has a radius of 3/8 in., as shown in Fig. 8, and this end should be used for work up to 3/4 in. in diameter. Work over 3/4 in. and up to 2 1/4 in. should be supported with the larger radius. Oil should be used at the contact point to prevent over-heating.

Internal Cuts.—This phase of metal turning demands little explanation beyond what has already been given. A boring bar instead of a regular tool bit is used as the cutting tool, the bar being held in the boring bar holder, as can be seen in Fig. 1. The tool can contact the work in either a vertical or horizontal position, as shown in Figs. 2 and 3. Use the largest boring bar which the work will allow, and adjust the bar carefully in the tool holder for proper rake and clearance.

Bevels.—Beveled shoulders or fast tapers are usually expressed in degrees, as, for example, a 45° shoulder, a 30° bevel, etc. Cutting to the angle specified is simply a matter of setting the compound to the required reading. For accurate work, the tool bit should be on center, as shown in Fig. 4, this rule applying positively to all but very short tapers. The general position of the slide rest for cutting a beveled shoulder can be seen in Fig. 5.

Taper Cuts.—There are two methods of making taper cuts on the lathe—by setting the compound or by setting-over the tailstock. In either case, the first essential is a bit of arithmetic to determine the required setting. Typical cases which turn up in average work are covered by the three rules given in Fig. 3 on the opposi page. Notice that rule No. 1 applies on where the work is to be tapered its fi length. In rule No. 2, the specified tap is the difference in diameters in 1 ft. stock. Specified tapers are always figur on diameters and not on the radii of t work.



In applying the tailstock set-over met od in making the cut, the necessary se over is first determined by the rule. Wh this has been found, the tailstock clamp loosened, and one of the adjusting screw backed-off while the other is turned in set the tailstock over the required di tance as shown in Fig. 2. If the tailsto is set towards the operator, the taper wi be from headstock to tai stock; if the tailstock is s away from the operato the taper will be from tai stock to headstock. Th exact amount of set-over checked by rule, as show in Fig. 2, and the tailsto is clamped to the lat when the proper setting reached. Turning then pr ceeds in the regular ma ner, as shown in Fig. 1, th tool bit being exactly c center. After completin the taper, the tailsto should be carefully r

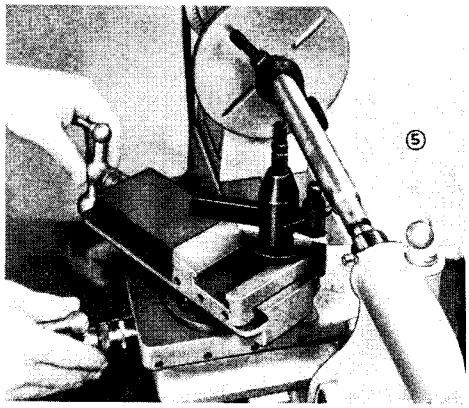
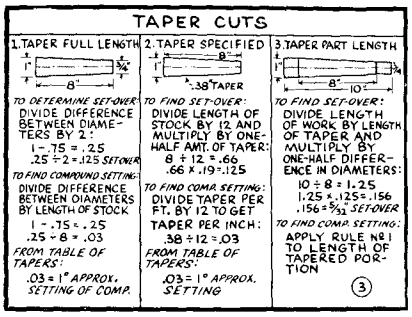
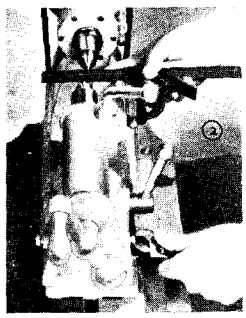


Diagram Shows Tool Positions for Internal Cutting an Tapering. Above, Turning a Beveled Shoulder.

turned to its normal position for straigh turning.

When the lathe is not equipped with set-over tailstock, slow tapers can be cu equally well by using the compound set ting. This method is also used when th application of the tailstock set-over rul results in a figure greater than the tail stock can be set-over—3/16-in. Actually, little less than this marks the limit of set ting-over which can be done without hav ing the work mar the tailstock center. In setting the compound, the application o

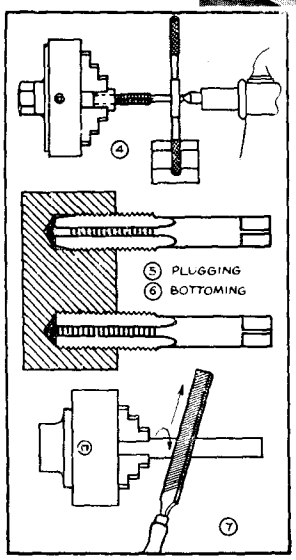




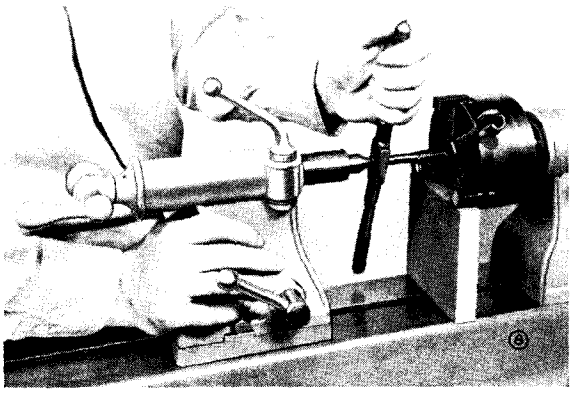
Above, Turning a Taper with the Tailstock Set Over. Inset Shows Lathe Adjustment.

the rules given in Fig. 3 give the amount of taper per inch, and the table of tapers on page 47 converts this figure into the required degree setting. Where the setting is a fractional part of a degree, the division of space on the compound is simply set off by eye. The result will be sufficiently accurate for average work. When the work must be turned to within a few thousandths of a specified dimension, any method of taper turning must be checked repeatedly with micrometer calipers in order to determine the final adjustment.

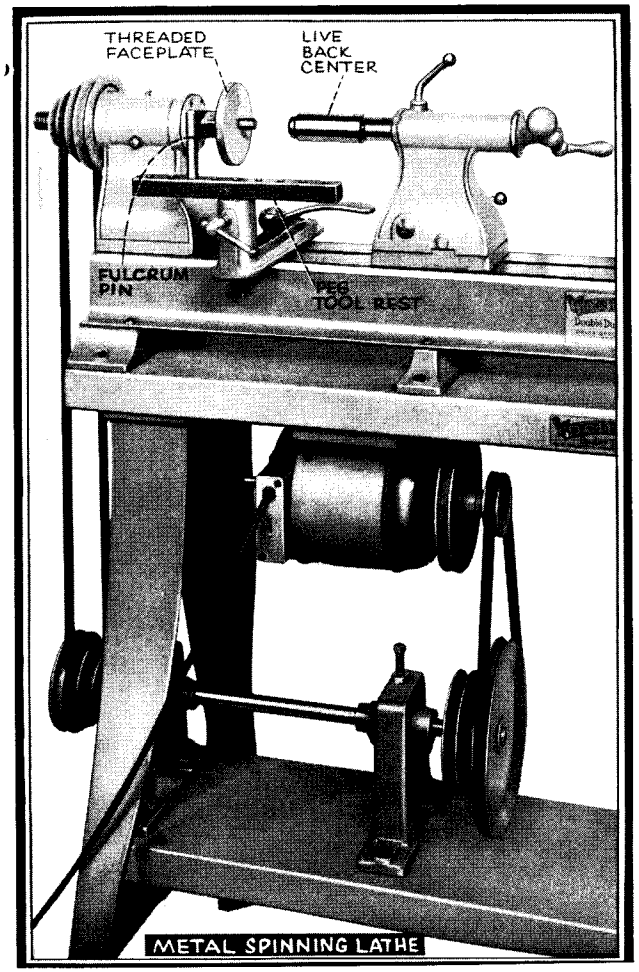
Tapping and Reaming.—Tapping and reaming are often done on the lathe, the main value of the lathe for such work being that the set-up for the job can be maintained, thereby resulting in greater accuracy. Fig 8 pictures a typical example. Here, a hole has been drilled in a lever, and, without changing the set-up, a tap is used to thread the hole as required. The lathe is not under power, the tap simply being held in a regular tap wrench and rotated by hand as the tailstock is pushed by hand to advance the tap into the work. A block of wood under the chuck prevents the work from turning. In another method of working, the arm of the tap wrench is stopped against the slide rest or the bed of the lathe, as shown in Fig. 4, while the work is rotated by using the hand wheel. In tapping a blind hole in the lathe, the hole is first entered with a tapered tap, after which the work can be removed to the bench for plugging and bottoming, as shown in Figs. 5 and 6. Reaming is done in much the same manner as tapping, with the possible exception that some work may be power driven. In this case, the reamer is held in the drill chuck which is placed in the tailstock spindle. Tap and die work, however, should always be done by hand unless special tools are used for this purpose.



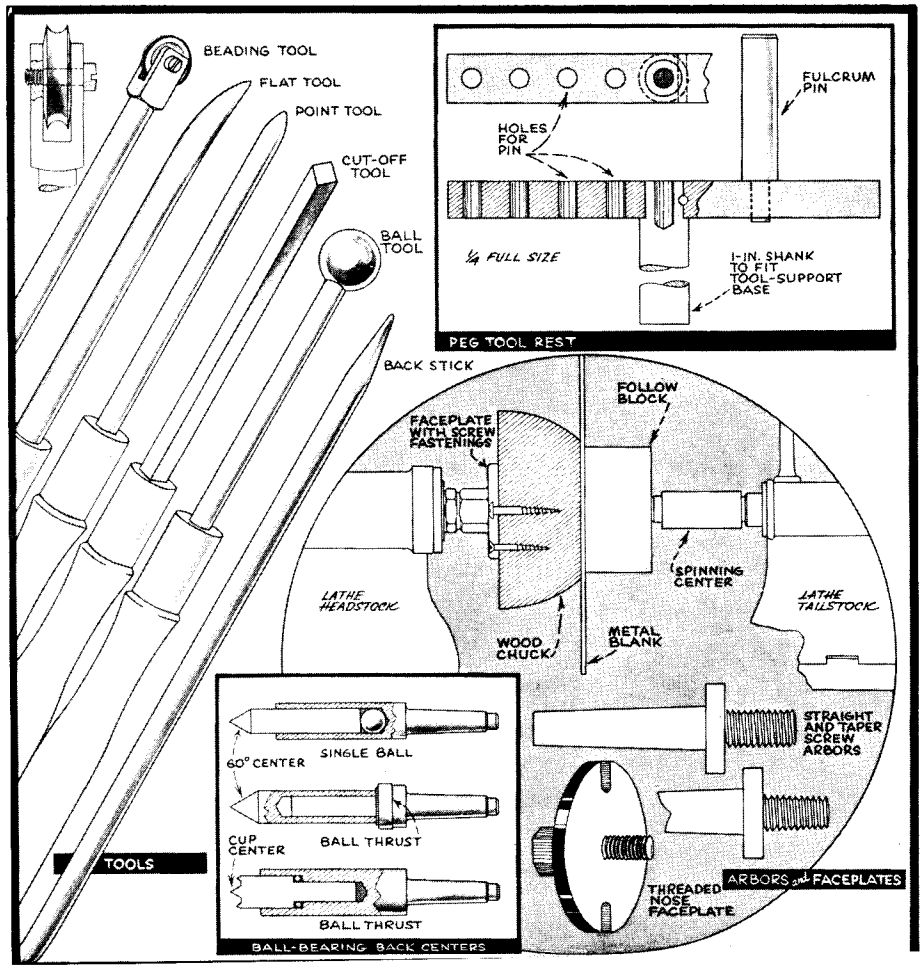
Center Diagram and Photo Below Show Tapping Operations in the Lathe.



Filing and Polishing.—While the tool bit itself leaves a remarkably smooth finish when fed slowly along work revolving at maximum speed, it is usually necessary to file and polish the work for the smoothest kind of finish. A double-cut file is used for roughing, while a single-cut file is used for finish-filing. In all filing, the point of the file should point away from the headstock, as shown in Fig. 7.



METAL SPINNING LATHE



TOOLS

BOOK THREE
METAL SPINNING

CHAPTER ELEVEN

SPINNING EQUIPMENT

METAL SPINNING is an enjoyable and novel branch of lathe work. Unlike either wood or metal-turning, the work is not cut away to form a desired shape, but is formed by means of "spinning" the metal blank over wood or metal chucks. The work is not difficult, especially where the softer metals are used.

The Lathe for Metal Spinning.—The first requirement of the lathe for spinning is a substantial headstock spindle. Suitable bearings must be provided to take up the heavy end and lateral thrust. There must be absolutely no end play. The speed range should be between 900 and 1400 R.P.M for average work, with speeds somewhat lower than this useful but not necessary. A speed range above 1400 R.P.M. is useful for polishing and finishing operations, but is seldom necessary for actual spinning. The power unit is preferably ½ H.P. although a wide range of light spinning can be done with a less-powerful motor.

Tools.—There are many shapes of spinning tools, the more or less standardized types being those shown on the opposite page. The Beading Tool is a specialized form used to turn the rim of the disk into a lip or a true bead. It is also useful to start bending the metal where the edge is to be folded to a double thickness. The pulley rotates freely within the holder, and is interchangeable with other sizes to suit a wide variety of work.

The Flat Tool is the most important tool in the spinner's kit. It is a double-surfaced weapon, being round on one side and flat on the other. The round side is used to "break down" the metal blank almost to the chuck surface, while the flat side completes the operation of smoothing the metal snugly to the chuck.

The Point Tool is both a forming and finishing tool, being particularly useful on small work. Its pointed end surface is useful in shaping fillet corners or forming sharp internal bends in the metal surface.

The Cutting-Off Tool, Parting Tool or Graver, is simply what its name implies—a tool for cutting. It is used to trim away surplus metal at the neck of the spinning; also, it makes an excellent tool for scraping down high spots on the metal.

The Ball Tool is used to break down the surface of hard metals. It is not a finishing tool and should not be used to bring the metal snug to the chuck surface.

The Back Stick is an auxiliary aid to the various spinning tools. Its purpose is to back up the metal on one side as the pressure of the spinning tool is brought to bear on the opposite side. The stick should be made from hard wood, either rectangular or round in section, and should have a blunt point similar to a chisel.

All spinning tools should be properly tempered and then polished to reduce friction. The overall length of each tool should be about 2 ft. in order to give the required leverage necessary for spinning.

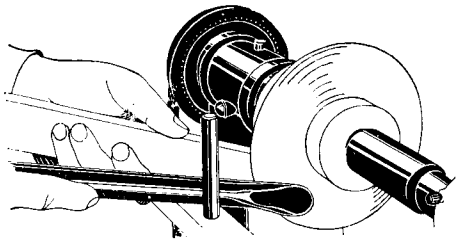
The Tool Rest.—The support for the spinning tools is a peg or fulcrum type of tee rest. It should have a shank to fit the tool-support base. The rest is drilled with a number of holes, as shown, to permit various settings of the fulcrum pin to suit the work.

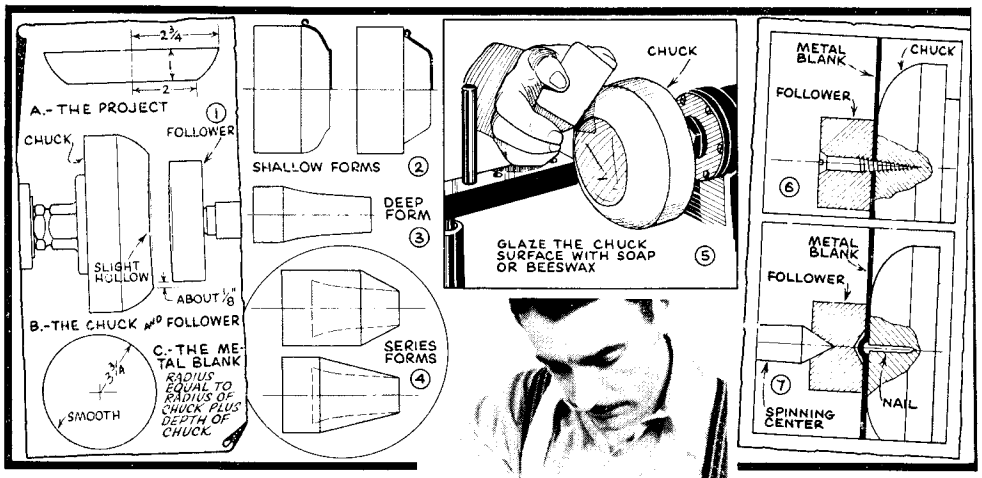
Tailstock Center.—The tailstock center for metal spinning must revolve with the work. Three different types are shown on the opposite page. Each features a tapered shank which fits the tailstock spindle. This portion of the center is fixed. The rotating center is housed within the fixed body, and is given a free movement by some form of ball-bearing. A good spinning center is essential.

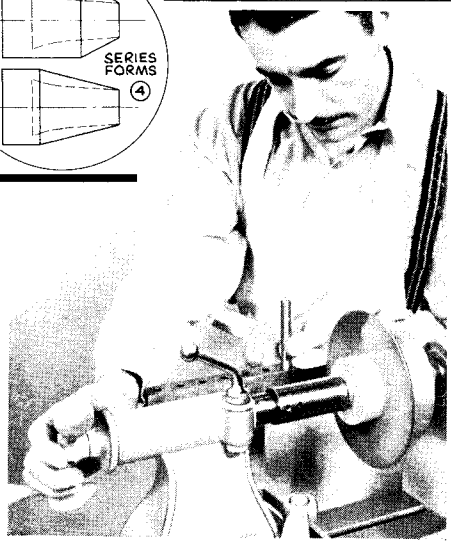
Arbors and Faceplates.—Metal spinning is faceplate work, the wood or metal form or chuck over which the metal is spun being fastened to a suitable plate or arbor. A 3-in. faceplate with screw-fastenings into the chuck can be used, but the threaded nose faceplate offers a quicker and more substantial form of mounting for this particular work. The threaded nose can be either straight or tapered. Straight and tapered screw arbors are also used extensively, especially for small work.

CHAPTER TWELVE

METHODS of WORKING







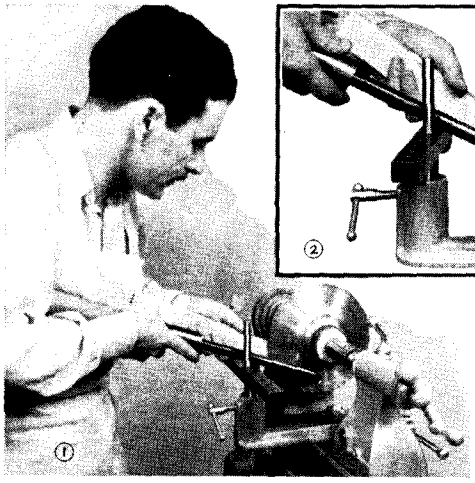
Drawing Above Shows Types of Chucks and Methods of Centering. Photo at Left Shows Centering with the Back Stick.

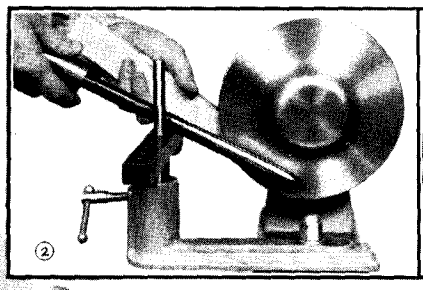
Setting-Up. — Any spinning demands (1) a chuck, (2) a follow block, (3) the metal blank. Fig. 1-A shows a typical simple project — a shallow tray. A wood chuck must be made up to the exact shape of the proposed tray, using any good-grade hardwood. It is good practice to turn the chuck an inch or so longer than the proposed spinning so that there will be some space between the finished spinning and the faceplate. The follow block or follower is now turned to shape, either on a separate faceplate or by simply gripping it between the chuck and the spinning center. It should be at least 1 in. thick, and of a diameter from 1/8 to 1/4-in. less than the base diameter of the project, as shown in Fig. 1-B. The drawing shows the base of the chuck slightly concave and the end of the follower slightly convex. This form of shaping should be followed wherever practical, since it affords better gripping of the metal blank while adding to the stability of the finished spinning. Fig. 1-C shows the metal blank for this particular spinning. In all metal spinning, the radius of the blank should be equal to the radius of the project plus the depth of the project. The blank should form a perfect circle with a smooth edge all around.

Fig. 2 shows other representative forms of shallow chucks or forms. Fig. 3 shows a deep form, such as would be required for a metal cup. It is evident that the deeper form is more difficult to spin than the shallow form since the metal must be drawn to a greater extent. Series chucks are sometimes employed in spinning deep forms, as shown in Fig. 4, the metal being successively spun over three or four different shapes to gradually result in the finished form. The idea, of course, is to afford a positive support for the metal throughout the various stages of spinning.

All wood chucks should be glazed with soap or beeswax, as shown in Fig. 5. This is done after sanding, the soap or wax being forced into the pores of the wood with the flat tool while the chuck is revolving.

Centering.—The final operation before spinning is to center the metal blank





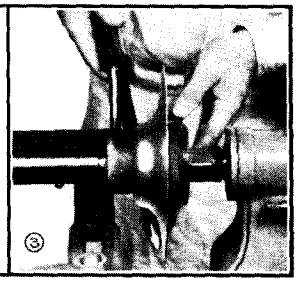
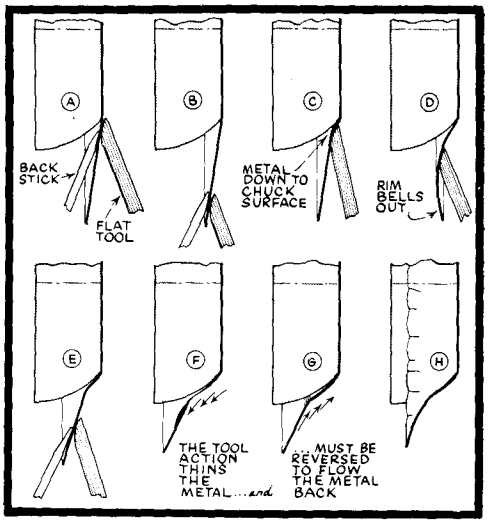


Photo at Left Shows the General Position of the Operator in Doing Metal Spinning. The Pictures Above Show Two Views of Proper Tool Placement. Diagram Below Shows Various Points in Spinning.

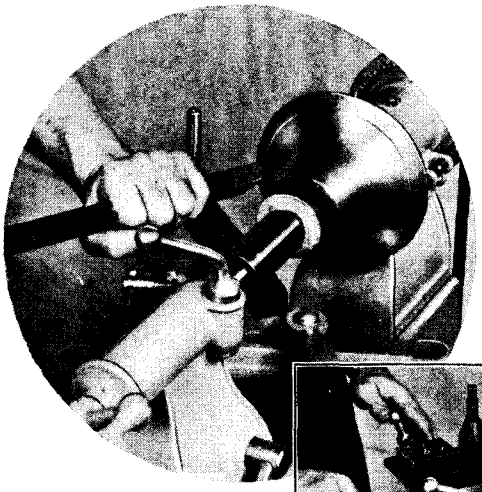


Where a hole in the center of the spinning is permissible, the blank can be fastened directly to the chuck, as shown in Fig. 6. In another method, an indentation is made in the center of the blank, the indentation fitting over a round-head nail driven in the center of the chuck. This readily locates the center of the blank, after which the follow block is brought up firmly to clamp the disk in place. In the ordinary method of centering, the disk is inserted between the chuck and follower, centering as closely as possible by eye. The tailstock is run forward to clamp the blank firmly but not too tightly in place. The lathe is now started on low speed, and the back stick is placed on the rest, to the left of the fulcrum pin, as shown in the photo. The tailstock is now backed off slightly, and the stick advanced to touch the edge of the revolving disk. If the edge of the blank is smooth, the disk will center itself perfectly, after which the follower is again set firmly against the metal. After the disk is centered, lubricate the metal on each side with cup grease. You are now ready to spin.

Spinning the Metal.—Spinning the metal over the wooden form is not at all difficult providing a few hard and fast rules are observed. The work cannot be hurried. Practically all craftsmen realize that it takes time to finish a wood or metal turning, yet think that a similar operation in spun metal can be done in a few minutes. The beginner should keep this point well in mind.

The first operation in actual spinning calls for the flat tool. This is placed on the rest, to the left of the fulcrum pin, the pin being placed in the hole which will set it slightly to the right of the metal blank. Now, with one or two sweeping strokes of the flat tool (the rounded edge contacts the metal), the disk is "seated" against the base of the chuck. The back stick is now brought into play, holding up the metal on one side while the flat tool presses against the opposite side. The general position of the operator can be seen in Fig. 1. The tool contacts the work well below center, as can be seen in Fig. 2. Notice, also, in this picture, that there is a fairly wide gap between the metal disk and the tool rest. Fig. 3 shows the same tool position as viewed from the front. Notice how the fulcrum pin is located so that the tool can bear against the disk without the point digging into the metal. The back stick follows the point of the tool, leading it slightly.

The forming action of the tool becomes readily apparent on attempting actual work. The object is to force the metal around the chuck, and to do this the tool is simply brought to bear, with considerable pressure, against the revolving metal surface. The tool must not remain in any one spot because of the liability of burning right through the metal. Instead, a sweeping action of the tool takes place, the tool moving constantly from the center to the rim of the disk. This movement is ef-



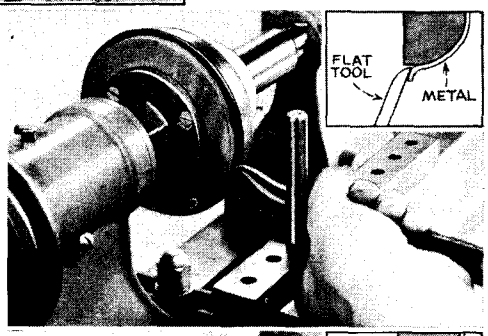
Photos Above and Center Show Operations in Trimming Off Surplus Metal. The Pictures Below Show the Forming of a Bead, Using the Flat Tool and Beading Tool.

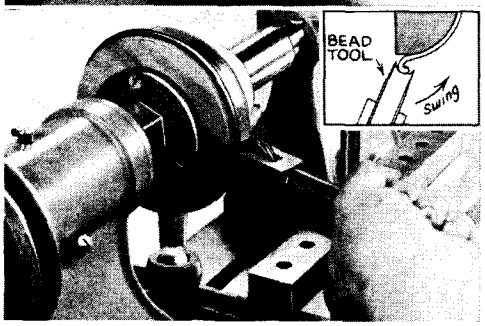
fected by a "hunching" movement of the shoulders, the body of the operator moving to the right. Since the action is quite natural, there is little difficulty encountered on this score.

Various points essential to good spinning are shown in the diagram on the previous page. At A is shown the initial operation, the flat tool pressing against the disk while the back stick supports the opposite side. The closer the tool is to the chuck, as in C, the less need there is for the support of the back stick; the farther the tool from the chuck, as at B, the more necessary it becomes to properly "back up" the metal. The first stage of the spinning brings the metal to the shape shown at B. The metal should be kept straight, like a shallow funnel, and should not be allowed to bell out, as shown at D. After the position shown at B has been attained, the flat tool alone can be used to force a small portion of the metal closer to the chuck surface, as shown at C. This action should not be too prolonged or over too much territory, either of which will result in the rim of the disk turning out, as shown at D. As soon as the rim begins to bell, the back stick should be used and the metal again spun to a true funnel shape, as shown at E. Notice, here, that the funnel-shape is much sharper than shown at B. These two essential operations —crowding a small portion of the metal to the chuck surface and keeping the rest of the disk funnel-shaped—are carried out in successive operations until the whole shape has been made.

Fig. F illustrates a point which can only be completely learned from experience. It can be seen that the constant stroking of the tool towards the left has a tendency to thin the spun portion of the metal. If carried to extremes, the metal will burn completely through. To avoid this, the stroking action of the tool must be reversed, stroking in the direction shown by the arrows in Fig. G to flow the metal back to normal thickness. This operation is especially important where the metal is to be spun around any sharp bend. At H is shown a common difficulty in spinning—buckling. It is caused largely by forcing the work. That is, in attempting to get an immediate finished shape, the operator will press the work hard at the position shown at D. This causes the rim to bell out, and later attempts to spin it back to a true funnel-shape usually results in a buckled edge instead of smooth metal.

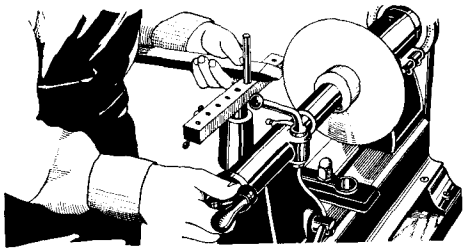
Cutting-Off.—The two top photos picture operations in trimming off





the surplus metal as performed with the hand cut-off tool and with the slide rest. In either case, the point of the tool should be on center.

Beads.—The trimmed edge of the metal is frequently turned over to form a bead, this operation being done with the beading tool. As shown in the two photos illustrating the operation, the point of the flat tool is first used to lift a small portion of the metal from the chuck surface, the beading tool is then used to work the metal into a true bead.

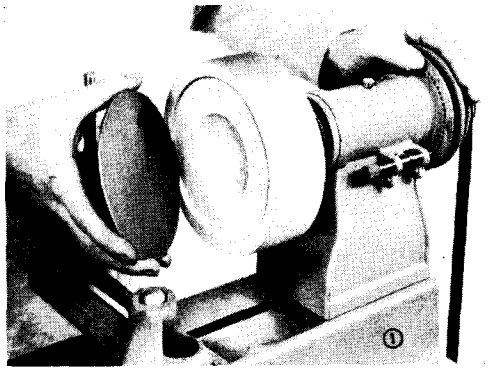


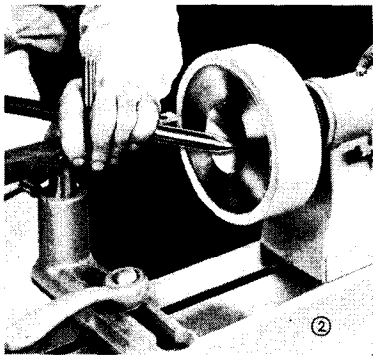
CHAPTER THIRTEEN

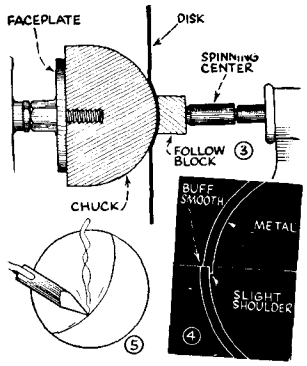
SPECIAL SPINNING CHUCKS

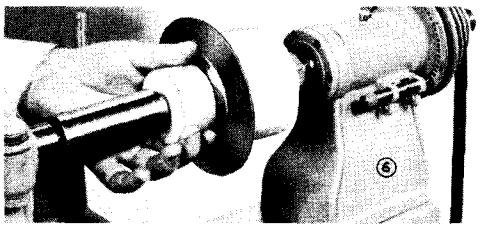
Spinning a Sphere.—The spinning of a sphere differs somewhat from work previously described, the essential difference resting in the fact that the curved surface of the spherical chuck does not permit the immediate use of a follow block. Instead, a starting chuck must be made up, as shown in Fig. 1. This has a recessed rim to take the metal blank snugly, while the center portion is turned out to the same spherical shape as the intended finished spinning. The metal is spun into this recessed center portion, as shown in Fig. 2, the recessed rim holding the blank quite firmly. The partly-formed disk can then be placed over the regular chuck, as shown in Figs. 3 and 6, for finishing. You will notice that the follow block is concave so that it will fit snugly against the metal. If the spinning is to be a perfect ball, two hemispheres must be made up and then soldered together. The joint can be simply butted and buffed smooth after soldering, or a very slight rim can be cut on one portion of the ball, as shown in Fig. 4, as an aid in making the joint.

In a similar manner, any other spinning with either a round or pointed end surface must be started by first using a concave starting chuck. Where the end curvature is very slight, the follower can sometimes be forced against the metal to give sufficient traction so that the metal can be spun.



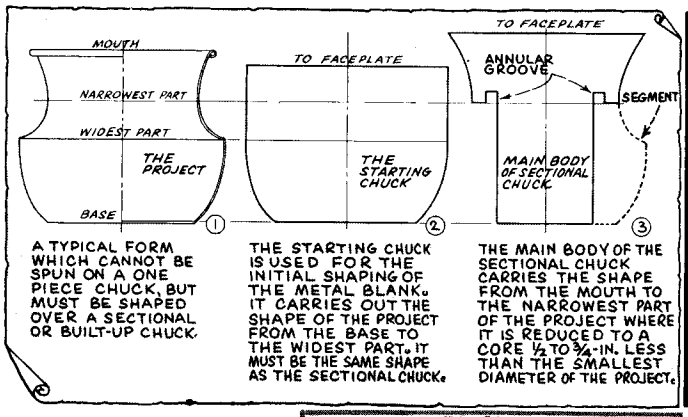


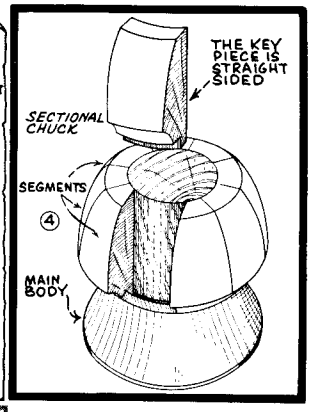




Above, Successive Operations in Spinning a Sphere. The Drawing Shows the Assembly.

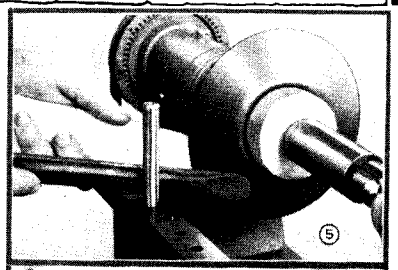
Sectional Chucks.—Any form having a neck or opening smaller in diameter than some other portion of the work (see Fig. 1 on the following page) must be spun on a sectional chuck. The sectional chuck, as its name implies, is simply a built-up form, so arranged that the various pieces can be removed one by one from the inside of the finished work. The typical example shown covers in a general manner the basic rules which must be observed in the making of any simple sectional chuck. A starting chuck is always used in connection with the sectional chuck, the metal being spun over this and then switched to the built-up form. As far as it goes, which is to the widest part of the proposed project, the shape of the starting chuck must be identical with the shape of the sectional chuck. The sectional chuck itself consists of a main body which carries the shape from the mouth of the project to its narrowest part, as can be seen in Fig. 3. At this point, the main body is reduced to a cylindrical core having a diameter from ½ to ¾-in. less than the smallest diameter of the project. Around this core are grouped the various segments, all of which are wedge-shaped with the exception of

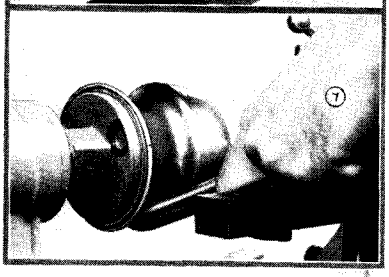




the key piece which is straight sided. The annular groove in the main body of the chuck takes a corresponding rim turned on the segment portion.

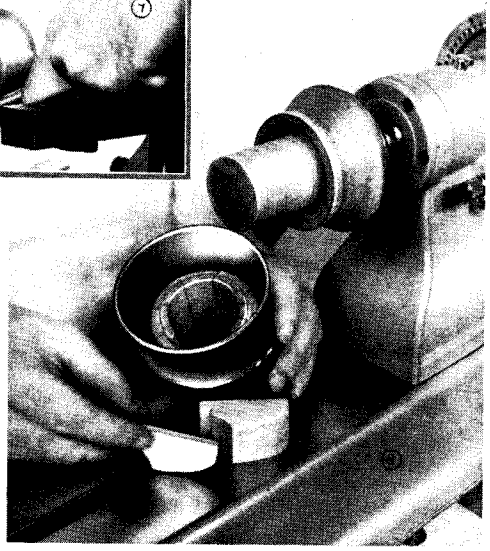
In making a sectional chuck, the main body is turned first. The segment portion, in a solid block, is then rough turned to approximate dimensions. A ¾ in. hole is drilled through the center. The turning is then removed from the lathe for the cutting of the various segments. These range in number from 6 to 12 pieces, depending upon the size of the opening through which they must be withdrawn. The saw cuts are then sanded smooth and the segments glued back in their original position, using glazed paper at the joints. The turning is then finished to exact size, carrying out the shape of the project externally and fitting the main body of the chuck internally. After sanding and glazing, the various segments are again separated.





Spinning over a sectional chuck is carried out in much the same manner as spinning over a one-piece chuck. Fig. 5 shows the initial shaping over the starting chuck. After this is finished, the sectional chuck main body is mounted in place, with the segments held in place by hand, as shown in Fig. 6. It is apparent that the partly-formed spinning will hold the segments securely in place so that the rest of the shape can be formed, as shown in Fig. 7. After the spinning is completed, it can be slipped bodily from the main body of the sectional chuck, after which the key piece and then the other segments can be withdrawn, as shown in Fig. 8.

For average work, the glueing of the sectional chuck can be dispensed with by simply turning the segment portion to finished size and then sawing apart with a very fine scroll saw or band saw blade. By allowing a little for the various saw kerfs, a sufficiently accurate form can be made in this manner. If the chuck is to be made in metal, the same general procedure as first described is followed, sweating the segments together with solder for



finish turning and then heating to separate.

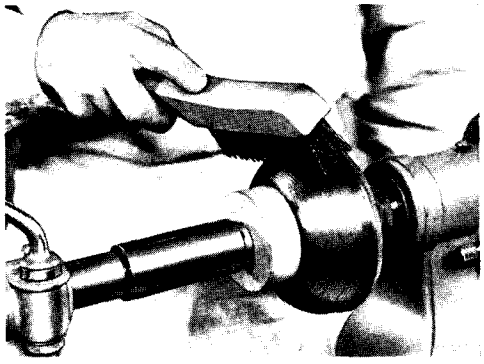
Metals.—Pewter is the ideal metal for metal spinning. It is soft enough to work readily, yet offers sufficient stiffness in finished project shape. It is one of the few metals which can be completely finished without removing the work from the lathe at various stages for annealing. The other common metals which can be spun without annealing are lead and aluminum. The aluminum must be dead-soft grade, and from dead-soft it will spin to just the right degree of stiffness during the course of spinning. Aluminum works much harder than pewter. That is, it does not give as readily as the softer metal, but requires firm pressure to bring it to the chuck surface. This firmness of the metal has one good feature in that the spun surface is generally not marred with rings which are usually in evidence when pewter or lead are being worked.

Lead is easily spun, but does not have sufficient stiffness in finished form. Its extreme softness permits it to burn through readily and great care must be exercised to keep all portions of the spinning of normal thickness. It is a useful metal for spinning over wood forms as a permanent covering, and is also used extensively for making containers to hold acids, etc.

Brass and copper are good spinning metals, but must be annealed frequently throughout the spinning process. The proper time for annealing is not difficult to establish—the metal showing a positive resisting action against further shaping. When this occurs, the disk is removed from the lathe and annealed by bringing it to a cherry red heat. Cooling is best done in the open air, but the scale formed by the quicker method of cooling in water is not particularly detrimental to later work.

Speaking generally of all metals, the stock should not be too thin. Light-gage metal is extremely prone to wrinkling and buckling. The heavier gages require more pressure to shape, but are better suited for the necessary expansion and contraction of the metal. All metals work well in a speed range from 800 to 1200 R. P. M., although stock heavier than .03 in. thick is best worked somewhat slower. The main difficulty encountered in the use of light-gage stock is buckling. This makes itself known by a rapping noise as the ridges strike the tool surface. When this happens, do not attempt to spin the wrinkles out, but remove the work from the lathe. After annealing, if necessary, the ripples can be usually leveled with a wooden mallet.

Finishing.—All finishes demand an original smoothness of surface. Rings and other tool marks must be completely removed from the spinning with firm strokes of the flat side of the flat tool. High spots must be scraped level with the cut-off tool. After a fair and smooth surface has been obtained, the project can be finished in any of several different ways. A very simple yet effective finish is obtained by scratch brushing, as shown in the photo above. The project is simply left in place on the chuck and the scratch brush applied against the metal as it revolves at high speed. A fine wire brush will give a smooth, satiny surface, while a coarser brush will result in a "spun" finish comprising many minute rings.



Above, Finishing a Spun Project by Scratch Brushing. Other Methods of Finishing Are Described in the Text.

Polishing is the most common form of finish. The first stages are best done while the work is revolving in the lathe, successive applications of abrasives being applied with a pad. The final polish is best applied by a buffing wheel, with the project held to the wheel but still housing the wooden chuck. Rough polishing should be done with a stitched mop, while a mop with loose disks is best for the later stages of the work. Of the many abrasives, emery or pumice stone are sufficient to cut rather fast while still imparting some degree of polish to the work. For a higher degree of polish, applications of tripoli and rouge can be used. All of these abrasives are in powder form and should be mixed with grease or wax for application to a cloth pad or wheel. Considerable waste is bound to occur when the abrasive is used in loose powder form.

After polishing the metal, it yet remains to color the surface and give it some form of protective coating. The natural color of the metal itself is often satisfactory. Various other colors for different metals are given in the appendix. The protective coating can be either wax or clear lacquer. For a wax finish, the object is gently warmed, the wax (beeswax is commonly used) being applied while the metal is warm. After cooling, the surface can be highly polished with a soft cloth. The lacquer finish is best applied by immersion or by spraying, although good work can be done with a soft camel-hair brush. A thin mixture should be used. Care must be exercised in cleaning the project previous to lacquering, since any grease film will prevent the lacquer from adhering.

APPENDIX

COMMON WOODS

Mahogany. — Finest grades come from Central America. Philippine hardwood, commercially known as Philippine mahogany, is the most common and least expensive variety. Good turning stock. Straight, open grain. Color from light chestnut to deep reddish brown. Medium hard.

Black Walnut.—Ideal for turning. Select stock is expensive. Straight, coarse grain. Usual color is chocolate brown. Hard.

Birch.—Good turning stock. Very durable. Color, reddish tone or brown with red and yellow. Medium hard.

Chestnut.—Light in weight. Turns easily, but splits readily and warps badly. Color, chestnut to darker brown at heartwood. Medium hard.

Maple.—Close, crooked grain. Usual color, pale reddish white. Turns to a very smooth finish. Hard.

Poplar.—Fine texture and easily worked. Usual color pale creamy brown. Soft.

Oak.—Extensively used in furniture work. Heavy and strong. Open, coarse, grain. Checks and warps badly. Color, light brown, some reddish brown. Hard.

White Pine.—Very straight, close grain. Easily and quickly turned. Ideal for paint or lacquer finish. Color white to light brown. Very soft.

Ash.—Straight-grain and heavy. Color gray-brown to brownish black. Good turning stock. Medium hard.

Red Gum.—Close, straight grain. Good turning stock. Light red brown in color. Medium hard.

Cypress.—Beautiful grain. Can be turned readily. Does not warp. Splinters easily with the grain. Usual color is reddish brown. Soft.

Basswood.—One of the lightest woods. Straight-grained and easily worked. Good for paint or lacquer finish. Color is brownish white, very light. Very soft.

SHOP DATA

Spark Tests for Steel and Iron.—*Cast Iron*—Gives off many small sparklers when held to grinding wheel. Red and yellow sparks. *Wrought Iron*—Very few sparklers. Color is yellow close to wheel and white farther out. *Low-carbon Steel.*—Few sparklers. All white, and forked. *High-carbon Steel.* Many sparklers, all white.

Rules Relative to the Circle.—*Circumference* of circle equals diameter times 3.1416.

Diameter of circle equals circumference times .31831.

Area of circle equals square of diameter times .7854.

Area of circle equals circumference times one-fourth diameter.

Coloring Copper. — *Black* — Potassium Sulphide (about 1 in. cube) and water (1 pt.) Apply by brush or immersion. *Red-Brown*—Barium Sulphide (2 oz.) and water (1 gal.) Apply by immersion. Use luke-warm. *Antique Green*—Copper Sulphate (12 oz.), Ammonium Chloride (2 oz.), water (1 gal.). Dissolve the copper salt and then add the ammonium chloride. Use at boiling point.

Colors Produced During Heating of Steel.—

430° F	Pale Yellow
450° F	Straw Yellow
470° F	Deep Straw Yellow
490° F	Yellow-Brown
510° F	Red-Brown
530° F	Light Purple
550° F	Dark Purple
570° F	Dark Blue
600° F	Pale Blue
630° F	Blue-Green
725° F	Red (in dark)
885° F	Red (in room light)
1075° F	Red (in daylight)

Chemical Colors for Iron.—*Blue*—After polishing, pass through strong vinegar. Wipe uniformly with hydrochloric acid. Dry. Heat in sandbath. *Black*—Sodium Thiosulphate (4 oz.) and water (1 gal.). Use at boiling heat. Three or four successive applications may be necessary. *Various Colors*—Lead Acetate (1½ oz.), Sodium Thiosulphate (1½ oz.), Water (1 gal.). Apply by immersion. Use at boiling heat. Colors appear in successive order, light brown, dark brown, purple, light blue, steel gray, black.

Information on Steels.—*Hot Rolled Steel* includes any grade as it is hot rolled in its first commercial form, such as rounds, squares, etc. It is free-cutting and easy to machine. Hot rolled steel has a black surface scale of iron oxide. *Cold Rolled Steel* includes any grade after it is rerolled or redrawn. The cold rolled process gives the steel a smooth surface and improves its physical properties. *Alloy Steel* is made by combining steel with other metals for increased toughness, strength, ductibility, etc. The most common metals alloyed with steel are nickel, manganese, chromium, vanadium and tungsten. *High Speed Steel* is a tool steel which is hardened in its commercial form. The bar is then cut into smaller pieces.

TAP DRILL SIZES FOR 75 PER CENT THREAD

Tap	Threads	Drill
1/8	40 N.S.	38
3/16	24 N.S.	26
1/4	20 N.C.	7
1/4	28 N.F.	3
5/16	18 N.C.	1/4
5/16	24 N.F.	17/64
3/8	16 N.C.	5/16
3/8	24 N.F.	21/64
7/16	14 N.C.	3/8
7/16	20 N.F.	25/64
1/2	13 N.C.	27/64
1/2	20 N.F.	29/64
9/16	12 N.C.	31/64
9/16	18 N.F.	33/64
5/8	11 N.C.	17/32
5/8	18 N.F.	37/64
11/16	11 N.S.	19/32
11/16	16 N.S.	5/8
3/4	10 N.C.	21/32
3/4	16 N.F.	11/16
13/16	10 N.S.	23/32
7/8	9 N.C.	49/64
7/8	14 N.F.	13/16
7/8	18 N.S.	53/64
15/16	9 N.S.	53/64
1	8 N.C.	7/8
1	14 N.F.	15/16

FOR MACHINE SCREW THREADS

Tap	Threads	Drill
0	80 N.F.	3/64
1	64 N.C.	53
1	72 N.F.	53
2	56 N.C.	50
2	64 N.F.	50
3	48 N.C.	47
3	56 N.F.	45
4	40 N.C.	43
4	48 N.F.	42
5	40 N.C.	38
5	44 N.F.	37
6	32 N.C.	36
6	40 N.F.	33
8	32 N.C.	29
8	36 N.F.	29
10	24 N.C.	25
10	32 N.F.	21
12	24 N.C.	16
12	28 N.F.	14
1/4	20 N.C.	7
1/4	28 N.F.	3
5/16	18 N.C.	1/4
5/16	24 N.F.	17 64
3/8	16 N.C.	5/16
3/8	24 N.F.	11/32

NOTE: National Coarse Thread (N.C.) formerly U. S. Standard. National Fine Thread (N.F.), formerly S. A. E. Standard. National Special (N.S.), formerly U. S. F.

DECIMAL EQUIVALENTS

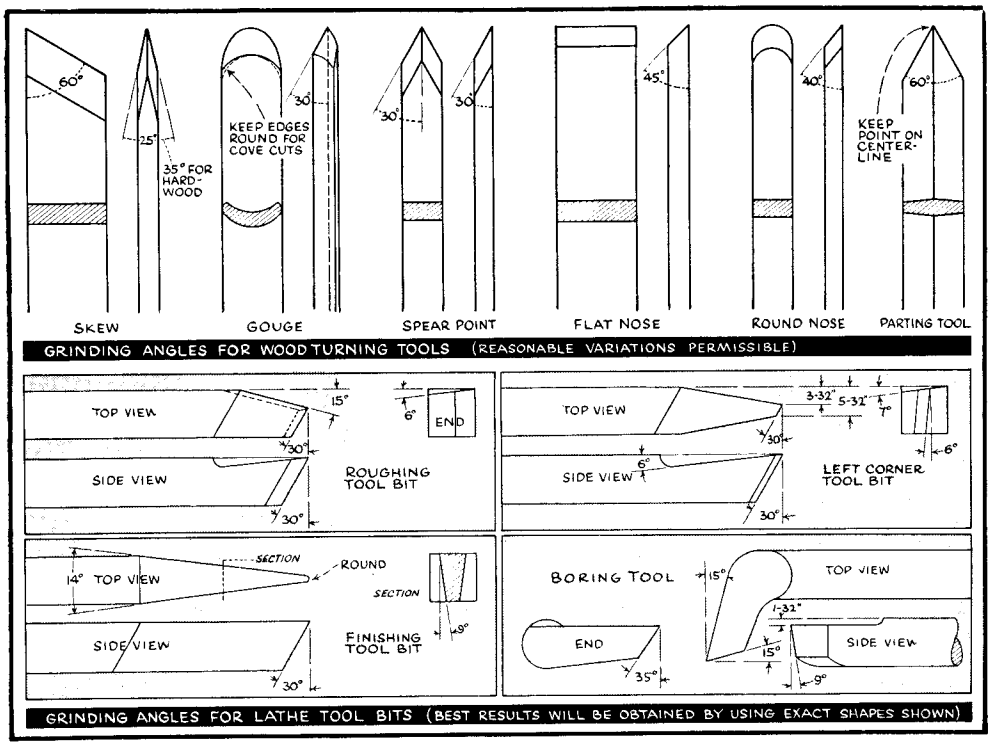
	1/64	= .015625
	1/32	= .03125
	3/64	= .046875
1/16 =	4/64	= .0625
	5/64	= .078125
	3/32	= .09375
	7/64	= .109375
1/8 =	8/64	= .125
	9/64	= .140625
	5/32	= .15625
	11/64	= .171875
3/16 =	12/64	= .1875
	13/64	= .203125
	7/32	= .21875
	15/64	= .234375
1/4 =	16/64	= .250
	17/64	= .265625
	9/32	= .28125
	19/64	= .296875
5/16 =	20/64	= .3125
	21/64	= .328125
	11/32	= .34375
	23/64	= .359375
3/8 =	24/64	= .375
	25/64	= .390625
	13/32	= .40625
	27/64	= .421875
7/16 =	28/64	= .4375
	29/64	= .453125
	15/32	= .46875
	31/64	= .484375
1/2 =	32/64	= .500
	33/64	= .515625
	17/32	= .53125
	35/64	= .546875
9/16 =	36/64	= .5626
	37/64	= .578125
	19/32	= .59375
	39/64	= .609375
5/8 =	40/64	= .625
	41/64	= .640625
	21/32	= .65625
	43/64	= .671875
11/16 =	44/64	= .6875
	45/64	= .703125
	23/32	= .71875
	47/64	= .734374
3/4 =	48/64	= .750
	49/64	= .765625
	25/32	= .78125
	51/64	= .796875
13/16 =	52/64	= .8125
	53/64	= .828125
	27/32	= .84375
	55/64	= .859375
7/8 =	56/64	= .875
	57/64	= .890625
	29/32	= .90625
	59/64	= .921875
15/16 =	60/64	= .9375
	61/64	= .953125
	31/32	= .96875
	63/64	= .984375

TABLE OF TAPER CUTS

Taper	Setting
.008	0° 15′
.016	0° 30′
.026	0° 45′
.034	1° 00′
.042	1° 15′
.052	1° 30′
.06	1° 45′
.068	2° 00′
.078	2° 15′
.086	2° 30′
.096	2° 45′
.104	3° 00′
.112	3° 15′
.122	3° 30′
.130	3° 45′
.138	4° 00′
.148	4° 15′
.156	4° 30′
.166	4° 45′
.174	5° 00′
.182	5° 15′
.192	5° 30′
.2	5° 45′
.210	6° 00′
.218	6° 15′
.226	6° 30′
.236	6° 45′
.244	7° 00′
.254	7° 15′
.262	7° 30′
.272	7° 45′
.28	8° 00′
.288	8° 15′
.298	8° 30′
.306	8° 45′
.316	9° 00′
.324	9° 15′
.334	9° 30′
.341	9° 45′
.352	10°
.398	11°
.424	12°
.46	13°
.498	14°
.534	15°
.572	16°
.61	17°
.648	18°
.688	19°
.726	20°

NUMBER-SIZE DRILLS

No.	Dia.	No.	Dia	No.	Dia.	No.	Dia.	No.	Dia.
1	.2280	17	.1730	33	.1130	49	.0730	65	.0350
2	.2210	18	.1695	34	.1110	50	.0700	66	.0330
3	.2130	19	.1660	35	.1100	51	.0670	67	.0320
4	.2090	20	.1610	36	.1065	52	.0635	68	.0310
5	.2055	21	.1590	37	.1040	53	.0595	69	.0292
6	.2040	22	.1570	38	.1015	54	.0550	70	.0280
7	.2010	23	.1540	39	.0995	55	.0520	71	.0260
8	.1990	24	.1520	40	.0980	56	.0465	72	.0250
9	.1960	25	.1495	41	.0960	57	.0430	73	.0240
10	.1935	26	.1470	42	.0935	58	.0420	74	.0225
11	.1910	27	.1440	43	.0890	59	.0410	75	.0210
12	.1890	28	.1405	44	.0860	60	.0400	76	.0200
13	.1850	29	.1360	45	.0820	61	.0390	77	.0180
14	.1820	30	.1285	46	.0810	62	.0380	78	.0160
15	.1800	31	.1200	47	.0785	63	.0370	79	.0145
16	.1770	32	.1160	48	.0760	64	.0360	80	.0135



*WOOD TURNING: LATHE SPEEDS

DIA. OF WORK	ROUGHING OFF	GENERAL CUTTING	FINISHING
Under 2 In. Diameter	900 to 1300 R. P. M.	2400 to 2800	3000 to 4000
2 In. to 4 In. Diameter	600 to 1000 R. P. M.	1800 to 2400	2400 to 3000
4 In. to 6 In. Diameter	600 to 800 R. P. M.	1200 to 1800	1800 to 2400
6 In. to 8 In. Diameter	400 to 600 R. P. M.	800 to 1200	1200 to 1800
8 In. to 10 In. Diameter	300 to 400 R. P. M.	600 to 800	900 to 1200
Over 10 In. Diameter	300	300 to 600	600 to 900

*METAL TURNING:

Material	Roughing	Finishing
Tool Steel	50 F. P. M.	75 F. P. M.
Cast Iron	60 F. P. M.	80 F. P. M.
Cold Rolled	90 F. P. M.	125 F. P. M.
Bronze	90 F. P. M.	100 F. P. M.
Brass	150 F. P. M.	200 F. P. M.
Aluminum	200 F. P. M.	300 F. P. M.

Figures are for HIGH SPEED Tool Bits.

*METAL SPINNING:

Material	Speed	Lubricant
Pewter	600 to 800 R. P. M.	Cup Grease
Aluminum	800 to 1000 R. P. M.	Cup Grease
Copper	800 to 1000 R. P. M.	Cup Grease
Brass	800 to 1000 R. P. M.	Yellow Soap
Zinc	1000 to 1200 R. P. M.	Tallow Candle

*Speeds can be varied within fairly wide limits. It is always advisable to use the lower speed until it can be seen that the work can stand an increase.

F.P.M. TO R.P.M.

	FEET PER MINUTE						
	20	25	30	35	40	45	50
Diameter	REVS. PER MINUTE						
½ in.	153	191	229	268	306	344	382
¾ in.	102	127	153	178	203	229	254
1 in.	76	96	115	134	153	172	191
1½ in.	51	64	76	89	102	115	127
2 in.	38	48	57	67	76	86	96
2½ in.	31	38	46	54	61	69	76
3 in.	26	32	38	45	51	57	64
3½ in.	22	27	33	38	44	49	55
4 in.	19	24	29	33	38	43	48
5 in.	15	19	23	27	31	34	38
6 in.	13	16	19	22	26	29	32
7 in.	11	14	16	19	22	25	27
8 in.	10	12	14	17	19	21	24
9 in.	9	11	13	15	17	19	21

Revolutions for a higher F. P. M. speed can be obtained by doubling or adding together separate speeds. Example: ½ in. cold rolled steel should run at 90 F.P.M.—382 plus 306 equals 688 R.P.M.