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Four-Wheel Bandsaw Popular Mechanics No. X36

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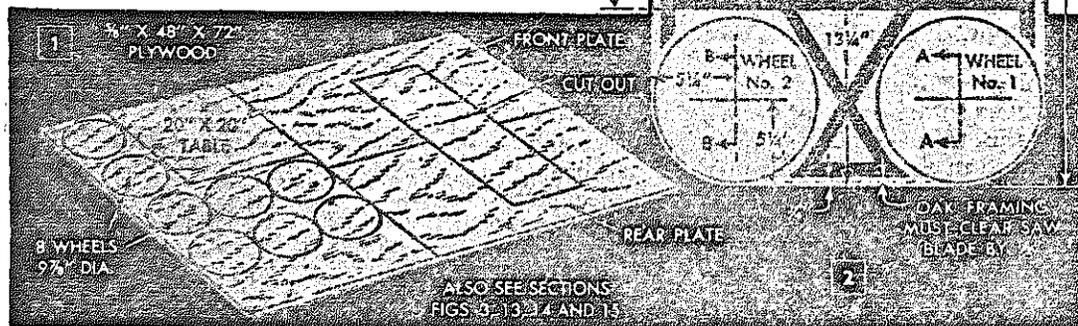
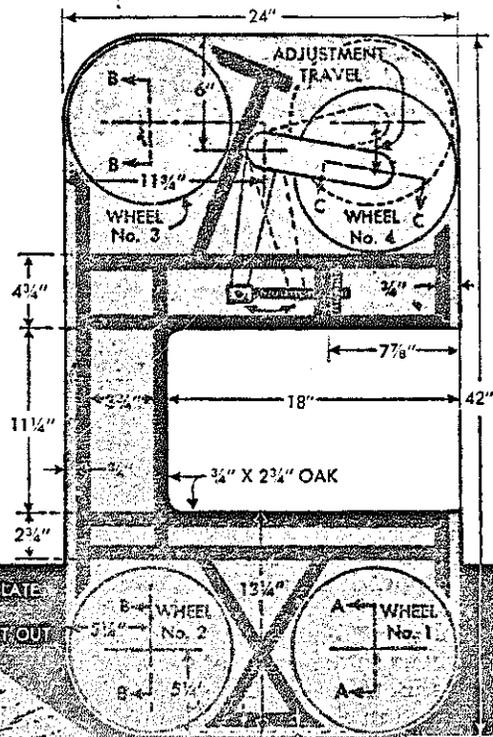
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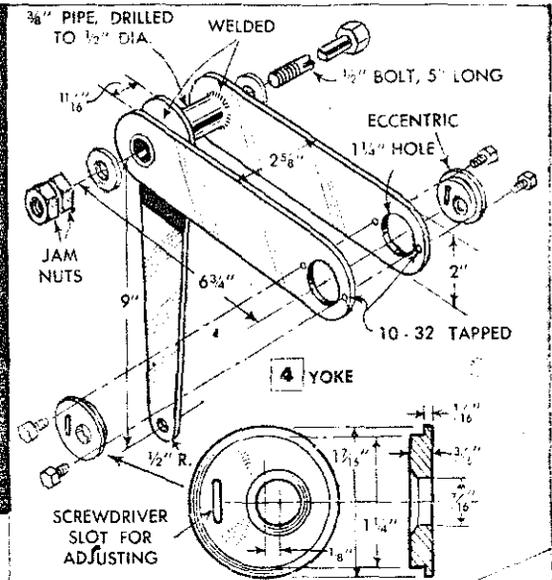
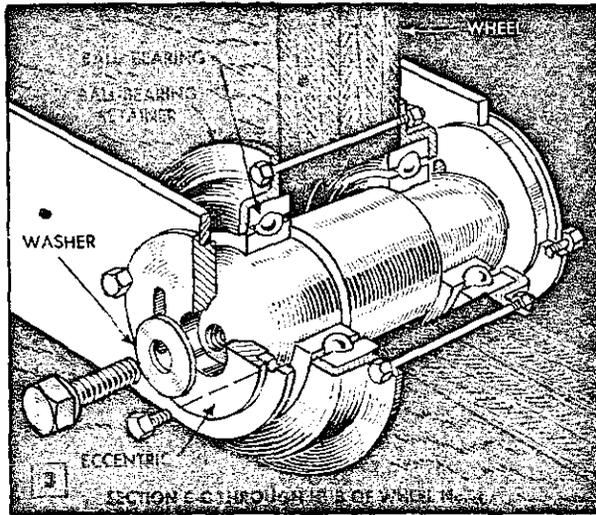
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# 4-Wheel BANDSAW

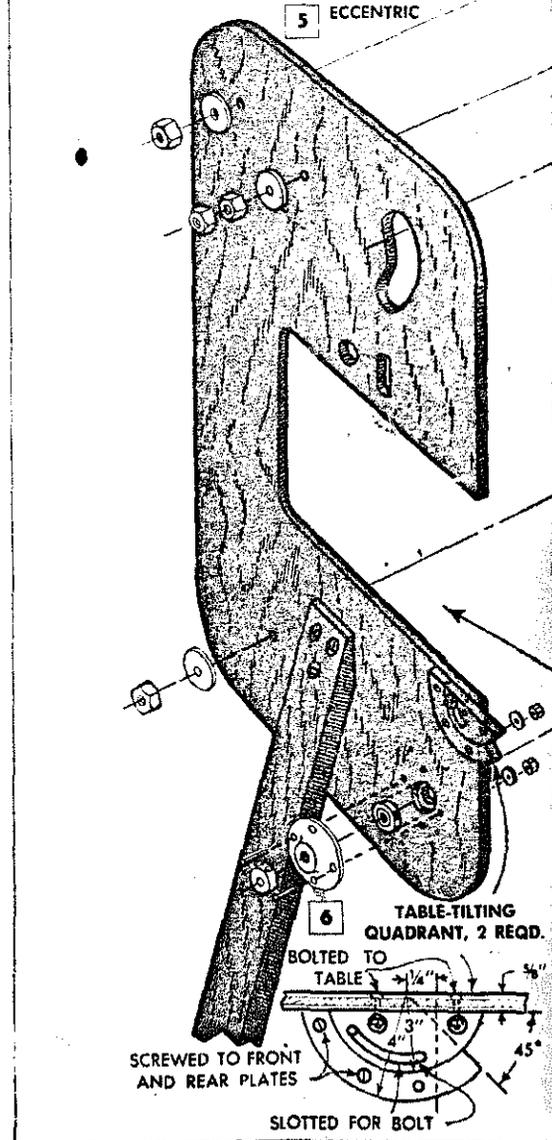
BY USING four band wheels instead of two, big-machine capacity is built into this bandsaw of home-workshop size. The 18-in. throat makes it possible to work at the center of panels up to 36 in. wide. Except for ball bearings and retainers, metal yokes, sheet-metal cover, and such shafts and bolts as are necessary in the assembly, the machine is made entirely of wood. Most of the parts are cut from a single piece of  $\frac{5}{8}$ -in. plywood as in Fig. 1. The box-type spacer frame between the front and back plywood cover plates, Figs. 2 and 8, is made from oak. When assembling the frame, special care must be taken to build it to exact dimensions, as the frame alone is depended upon for strength and rigidity to maintain exact alignment of the band wheels. Attach all the hardwood parts of the box frame to the back plate first, using screws and glue at all the joints. Next, make each band wheel by gluing together two disks of  $\frac{5}{8}$ -in. plywood. True up the wheels in the lathe and crown each tread  $\frac{1}{16}$  in. The wheels are fitted with rubber treads which consist of bands cut from a truck-tire inner tube. Details of the ball-bearing wheel hubs are shown in Figs. 3, 13, 14 and 15. Construction of the idlers, wheels No. 2 and 3 in Fig. 2, is shown in Fig. 14, but it should be noted that the bearing construction of wheel No. 2 can be the same as that of wheel No. 1. This provides two driving wheels and each can be fitted with a V-pulley of a different size, thus permitting two speeds by merely shifting the belt. Fig. 3 shows how the tracking wheel is tilted by two eccentrics

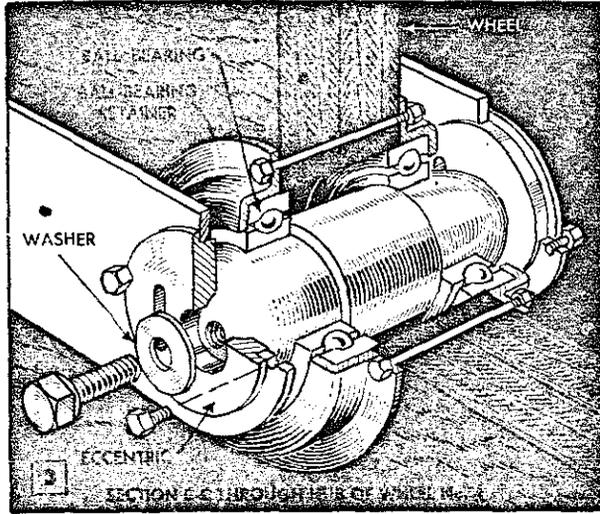




which support the shouldered shaft on which the wheel bearings are mounted. The sectional view, Fig. 15, shows the assembly of the bearing with the eccentrics mounted on the tensioning yoke. Construction of the eccentrics and yoke is shown in Figs. 4 and 5.

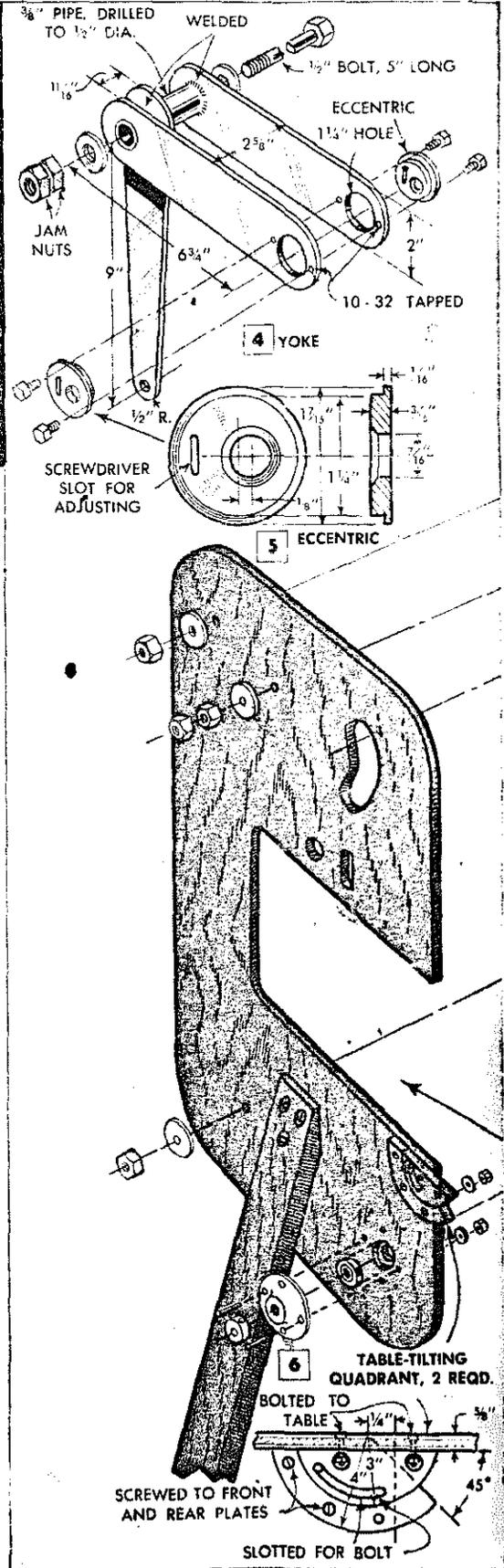
Locate the wheel centers on both the front and back plates and cut the curved access slots in both plates to expose the hub of the tracking wheel. Then mount the tracking wheel on the yoke and pivot the wheel unit in the frame. After attaching the clevis bolt and the thumb nut, Fig. 7, mount the front plate with screws only, so that it may be removed if necessary. Install the upper and lower idlers, checking to see that they line up. Note that holes for the driving-wheel bearings are counterbored in both the front and back plates, Fig. 13. This must be done with care so that when in place the wheel will line up with the other three wheels. Now, mount the machine on its three hardwood legs to stand at a convenient working height. The table, Fig. 8, is slotted in from one edge to a hole drilled at the center to allow easy removal of the blade. Swivel latches are fitted near the edge on the underside to level the adjoining sections of the table. Hardwood tilting quadrants, or trunnions, are bolted to the bottom of the table in the manner shown in Fig. 6. Lower halves of the trunnions are screwed to the front and rear plates. A locking bolt, passing through curved slots cut in the upper halves of the two trunnions, provides a means of locking the table in both the level and tilted positions. A leveling bolt is attached to the frame at some point under the table. Both blade guides, the upper one being detailed in Fig. 11, consist of three ball bearings mounted between the legs of a piece of channel iron. The lower guide is the shorter of the two and is bolted to the box frame, Fig. 8, while the upper guide is bolted to a length of hardwood, grooved as in Fig. 9 to allow for





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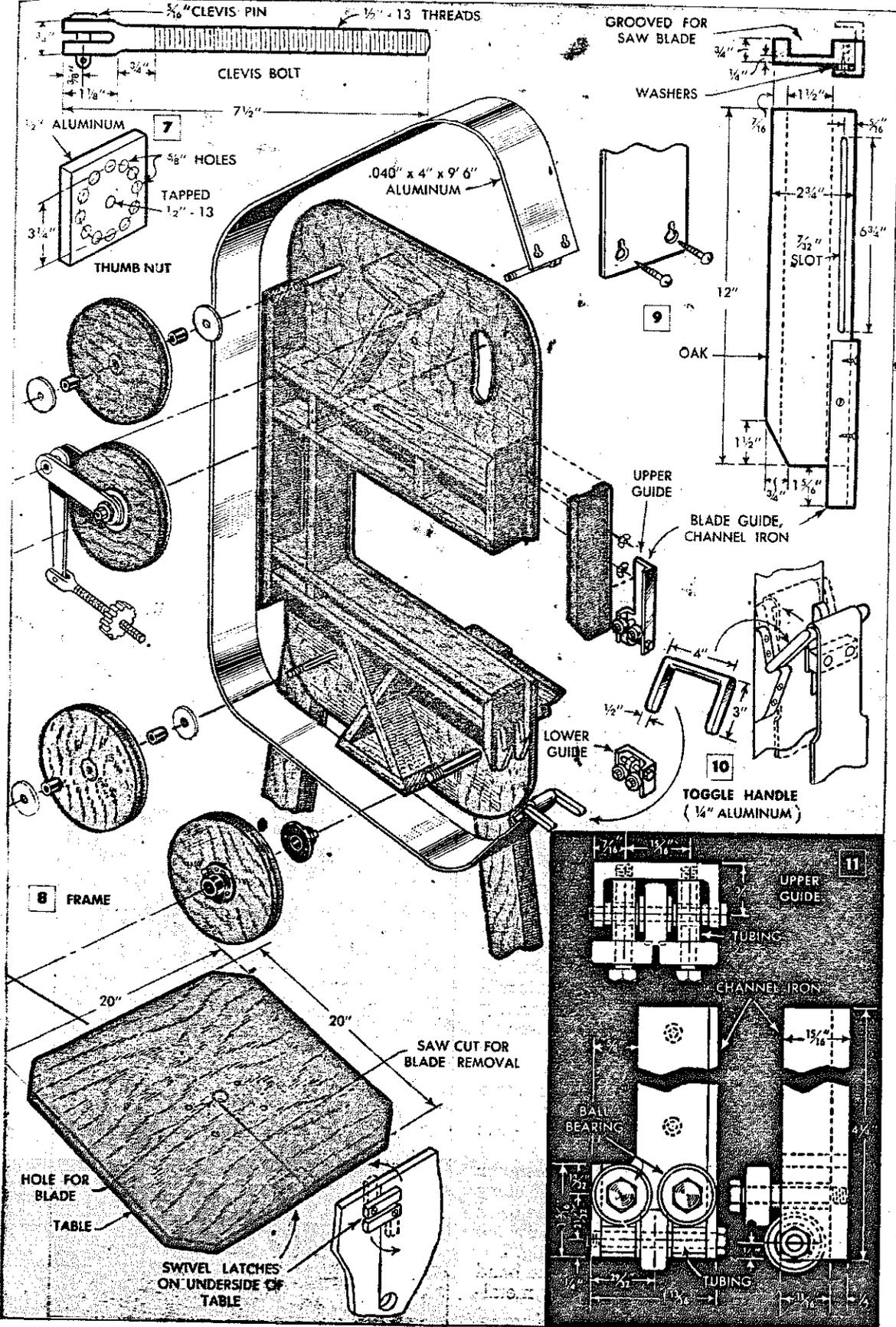
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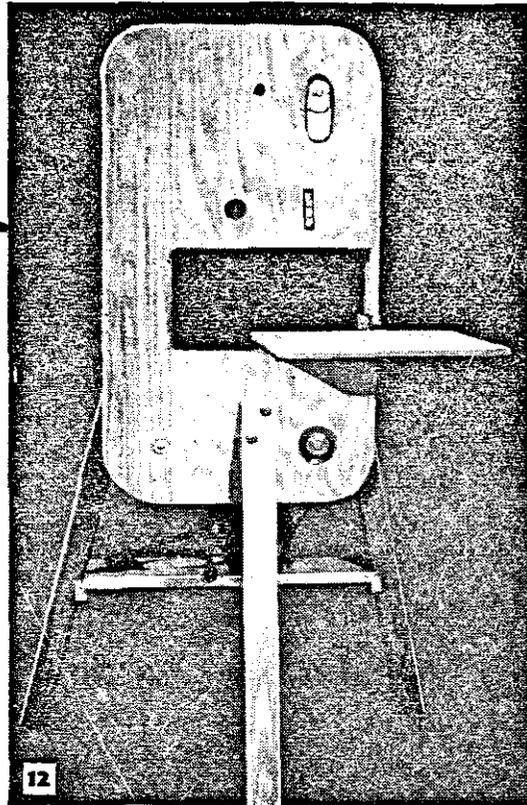


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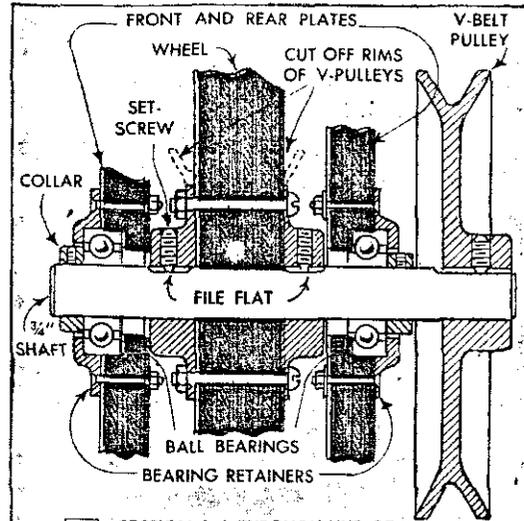
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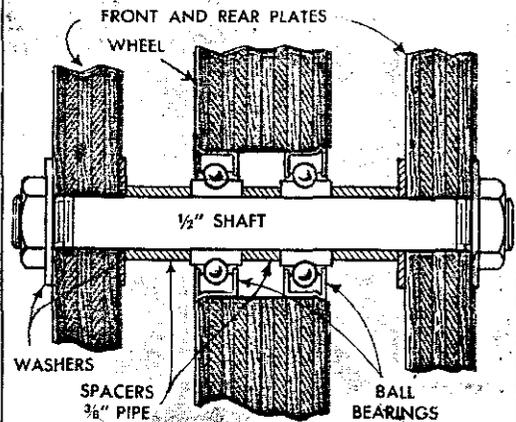
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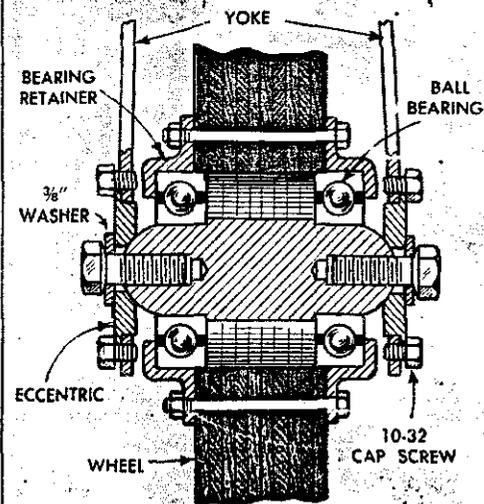
clear passage of the blade. Note how the hardwood support is slotted and attached to the frame so that the guide can be moved up and down to clear different thicknesses of stock. Projecting edges of the front and back plates serve as a guide for the hardwood supports. Blade length on the original machine is 10 ft. (120 in.), and blades up to  $\frac{1}{2}$  in. wide may be used, although narrower blades have a somewhat longer life. After installing the blade, check alignment on the wheels, adjusting the tracking wheel and guides so that the blade runs smoothly and centers on the wheels. Set the guides so that all three rollers turn when the blade is moved, but be sure that they are not too tight, as this will cause the blade to vibrate and possibly break. Then, make and fit the sheet-metal cover. The toggle handle, Fig. 10, provides a quick, easy way of locking the cover in place. Attach the motor support to the two back legs, as in Fig. 12. The position of the support depends on the length of V-belt used. Although a  $\frac{1}{3}$ -hp. motor will supply ample power for light work, a  $\frac{1}{2}$ -hp. motor is recommended as being more satisfactory for all-around work. The speed of the band wheels should not exceed 600 r.p.m. for the best results in average woodworking. For cutting light metals the speed of the band wheels should be reduced and a metal-cutting blade used.



13 SECTION A-A THROUGH HUB OF WHEEL No. 1 (DRIVING WHEEL)



14 SECTION B-B THROUGH HUBS OF WHEELS No. 2 AND No. 3 (IDLERS)



15 SECTION C-C THROUGH HUB OF WHEEL No. 4 (TRACKING WHEEL)

X5585

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10-Inch Table Saw Popular Mechanics No. X585

by: Elman Wood

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Popular Shop 1947 150 Power Tools

# HAS TILTING-ARBOR

## By Elman Wood

### Part I

Hinged side and back extensions increase the size of the table so that the ripping fence can be set 25 in. from the saw blade. Rips to the center of 48-in. plywood panel



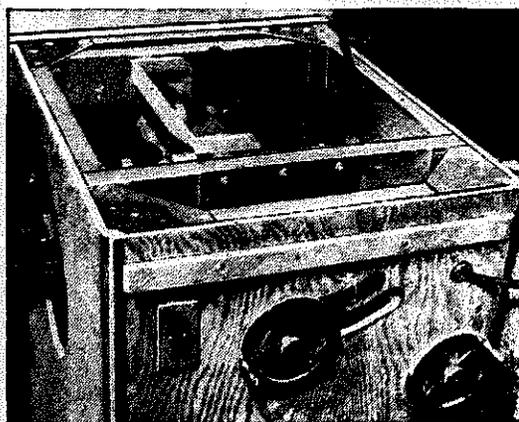
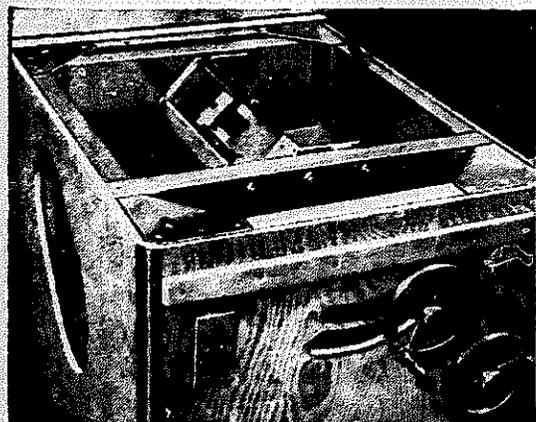
WOODWORKING craftsmen will rate this tilting-arbor table saw "tops" because of its versatility, speed and accuracy. By turning one handwheel the blade is raised or lowered for any depth setting within its capacity. A few turns of another handwheel tilt the blade for any angle cut up to 45 deg., the settings being indicated by a degree scale and pointer. The saw table remains always in a horizontal position; only the saw arbor tilts. The hardwood table with hinged extensions is plenty large enough to handle a 4 by 8-ft. plywood panel. An enclosed base catches all the sawdust, and swivel casters fitted to built-in foot lifts enable the operator to roll the saw to any part of the shop.

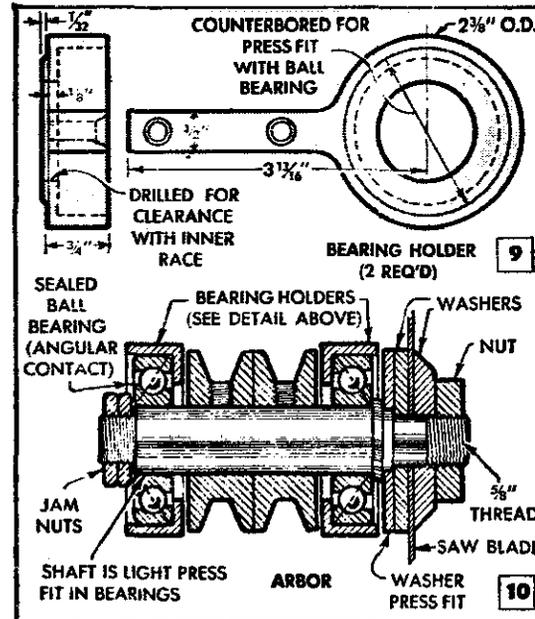
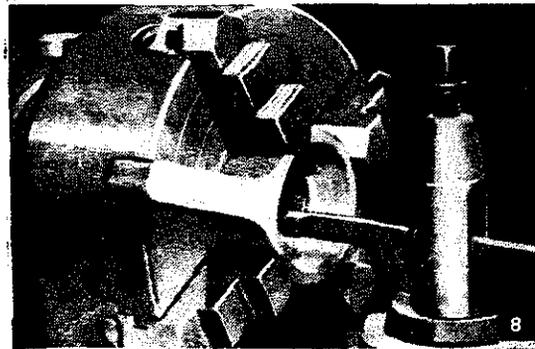
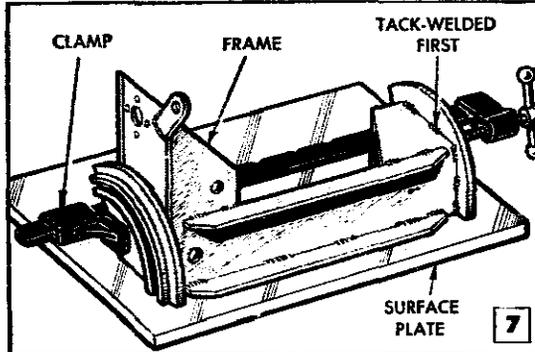
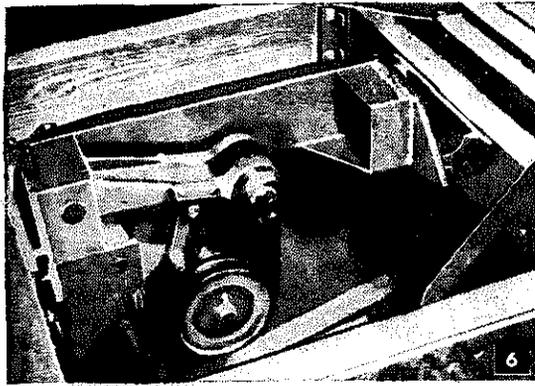
Construction should begin with the saw-base frame, Fig. 3. Building the base requires care in cutting and fitting as it must be strong and rigid to support the motor and arbor assembly. Use well-seasoned, selected oak for legs and rails. Rabbet the legs on adjacent sides as in Fig. 4 to take side and end panels flush. Both top and bottom rails are mortised into the legs, but note that the upper side rails are 4½ in. wide and that the end ones are 3 in. The tenons are glued and keyed with screws, and after the joining is completed, steel gussets are mortised into the

top rails across the four corners, and the bottom rails are braced to the legs with steel corner plates cut, bent and attached as in Fig. 5. Caster rails, one across each end, are hinged to the underside of the

An accurate scale with pointer shows all angles from 0 to 45 deg. Here blade is tilted to full 45-deg. angle

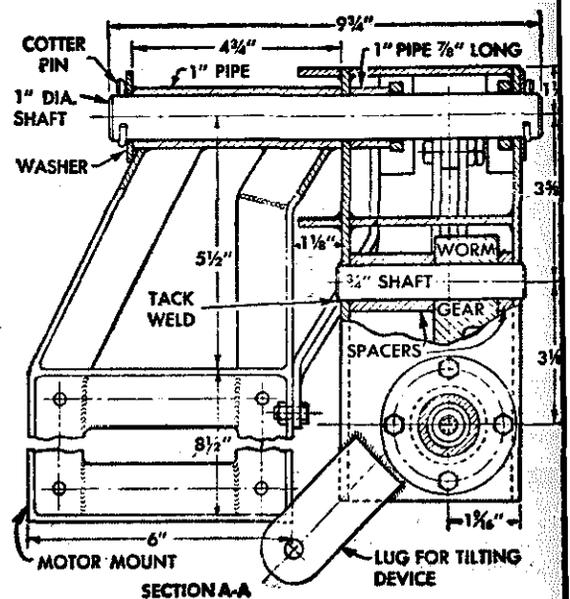
Saw frame and arbor assembly completed ready for the table. Base is painted before table is installed





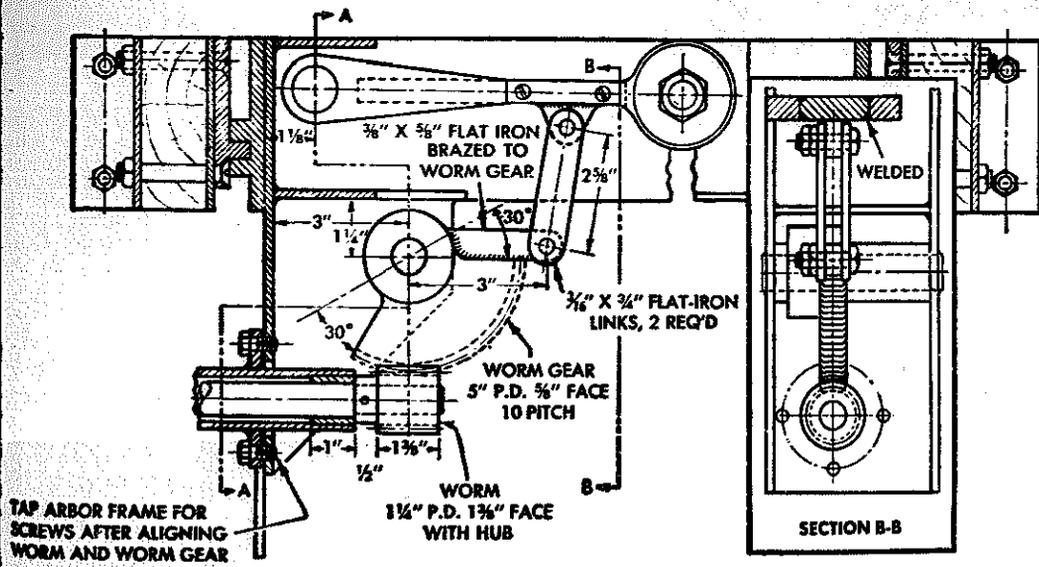
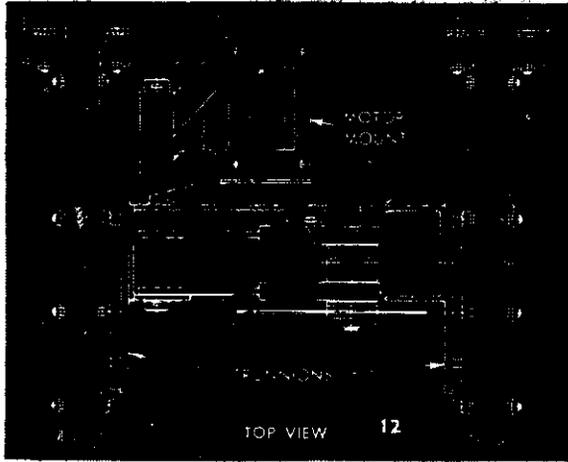
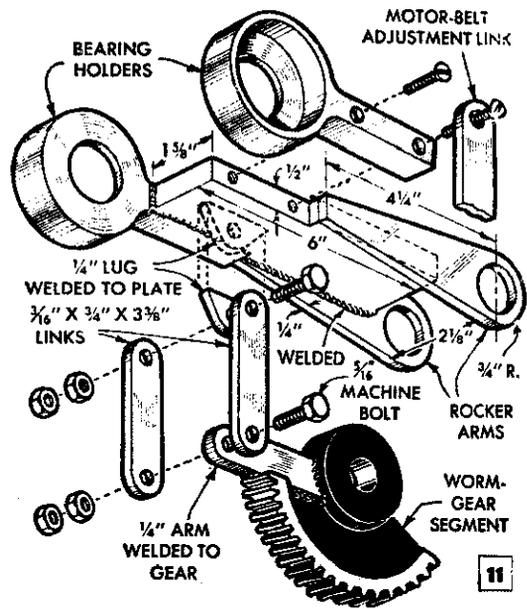
frame rails as in Figs. 3 and 5. The plywood bottom and the rear and right-side panels can now be installed, but the front and left-side panels are omitted at this stage as it is necessary to determine later the location of the handwheels and the size of the opening for the motor.

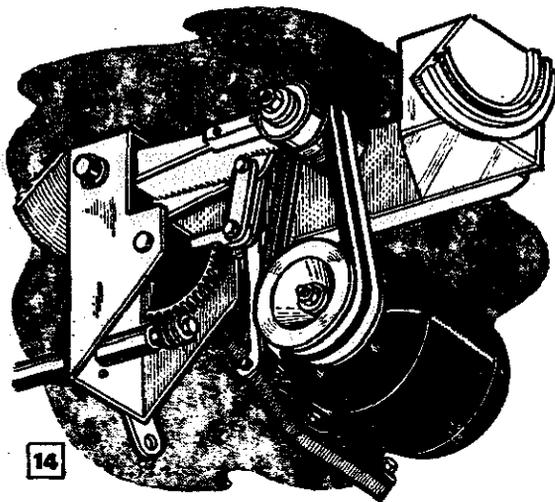
The arbor frame, shown in front and rear views in Fig. 1, comes next. This consists of a number of parts cut from steel plate and welded together to form the unit shown. This frame swings on trunnions made as detailed in Fig. 2. Each trunnion consists of an inner and outer segment, the two trunnions requiring four segments in all. These four segments are obtained from 3/4-in. mild-steel plate turned first to the form of disks, which are then cut into segments as indicated in Fig. 2. Inner segments are welded to the arbor frame while the outer ones are attached to the steel-faced cross members in Fig. 3. In installing a trunnion-mounted saw arbor there are two precise requirements: The center line of the blade must coincide exactly with the center line of the outer trunnion segments and the center of rotation of the trunnions must be at that point where the plane of the blade intersects that of the saw-table top. Fig. 6 shows the arbor and arbor frame in position and Fig. 7 shows the first step in positioning the inner trunnion segments on the arbor frame. Use a surface plate or other flat surface and make sure that the parts are exactly in line before welding. This done, measure the length of the arbor frame, plus the four trunnion segments. This gives you the distance between the two trunnion-support members, Fig. 1. Face the members with steel plates as



shown and drill the bolt holes. While the members are temporarily in position determine the center line of the saw base and scribe it on both members for guidance in locating the trunnions. Then slip the arbor frame and trunnions between the supports. The arbor frame should fit snugly but should swing on the trunnions with only a slight frictional drag. With all parts located on the center line of the saw base, clamp the outer trunnion segments to the cross members and lift out the whole assembly. Using each trunnion segment as a drilling jig, drill holes and bolt the segments to the cross members.

Next, come the arbor-bearing holders shown in detail in Fig. 9, and in section in Fig. 10, with the arbor, pulley and bearings in place. Holders are rough-cut from  $\frac{3}{4}$ -in. steel plate with a cutting torch or metal-cutting bandsaw and are recessed and bored through to suit the bearings as in Fig. 8. Bearings should be a fairly tight press fit in the recesses. The arbor or spindle is machined from steel and finish-ground to final dimensions. Note that it is flanged at the saw-blade end to form a seat for the press-fitted spacing washer. The spindle is shouldered and threaded at the left-hand end for jam nuts for pre-loading the bearings. Pulleys are locked on the spindle with socket-head setscrews, the ends of the setscrews seating on a flat, milled or filed on the saw spindle. Dimensions of the spindle through the bearings, Fig. 9, and also the bearing-recess diameter in Fig. 10, have been



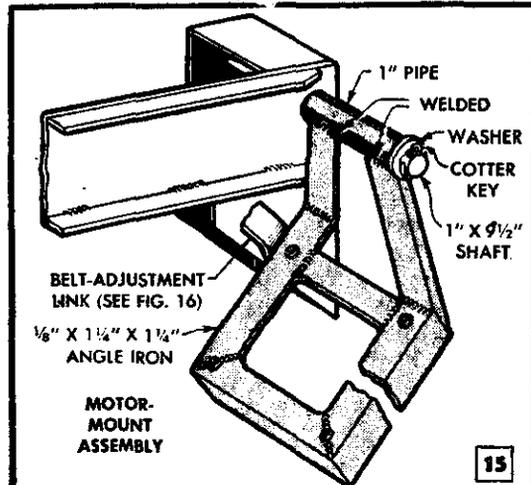


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purposely omitted. These measurements must be taken from the bearings at hand.

Now, before going farther, study carefully sections A-A and B-B in Fig. 13, also the perspective and top views in Figs. 11 and 12. From Fig. 11 you will see that a 1/2-in. steel plate forms the mounting base for the saw-arbor assembly. Notches milled in opposite edges take the ends of the bearing holders, and rocker arms welded to the mounting base allow it to pivot on a rocker shaft for raising and lowering the saw blade and motor as a unit. When this assembly is complete, the saw spindle should turn freely in the bearings. Check this before finally welding the bearing holders in place. The motor mount, a separate assembly built up by welding together steel angles and flats, is welded to a length of 1-in. pipe which telescopes over the rocker shaft and fits snugly against the rocker arms. See Fig. 13, section A-A, and also the top view, Fig. 12. Shaft, pipe sleeve and arbor mounting are held in place in the arbor frame by washers and cotter keys. When assembled, the parts should move freely but without any end play. The motor mount is not fully dimensioned as it must be made to fit the base of the motor you are to use. Final unit in this assembly is the belt-adjustment link, Figs. 15 and 16. It's made from flat iron, bent to approximately a 2-in. offset and drilled and slotted as indicated. Upper end is bolted to the left bearing holder, Fig. 12, and the lower end to the motor mount. Loosening the lower bolt allows the motor to be moved up or down to obtain correct belt tension.

The raising-and-lowering mechanism consists of a worm and worm-gear segment, the latter made from an ordinary gear by simply cutting away all but a 120-deg. segment. An arm made from 1/4-in. flat iron is welded or brazed to the segment as in Figs. 11 and 13. This arm is connected to

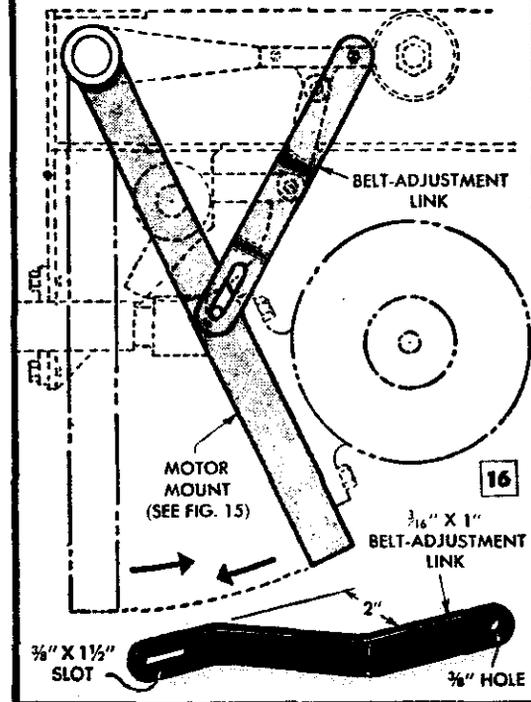


BELT-ADJUSTMENT LINK (SEE FIG. 16)

1/8" X 1 1/4" X 1 1/4" ANGLE IRON

MOTOR-MOUNT ASSEMBLY

15



BELT-ADJUSTMENT LINK

MOTOR MOUNT (SEE FIG. 15)

3/16" X 1" BELT-ADJUSTMENT LINK

3/8" X 1 1/2" SLOT

3/8" HOLE

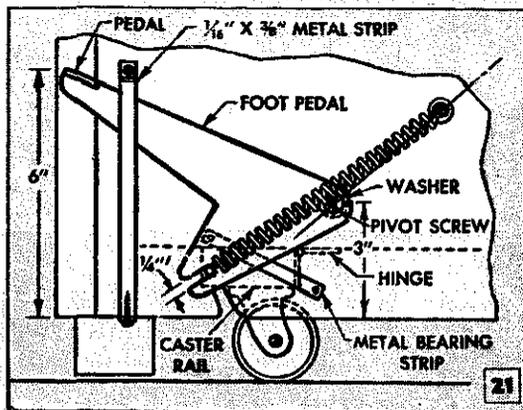
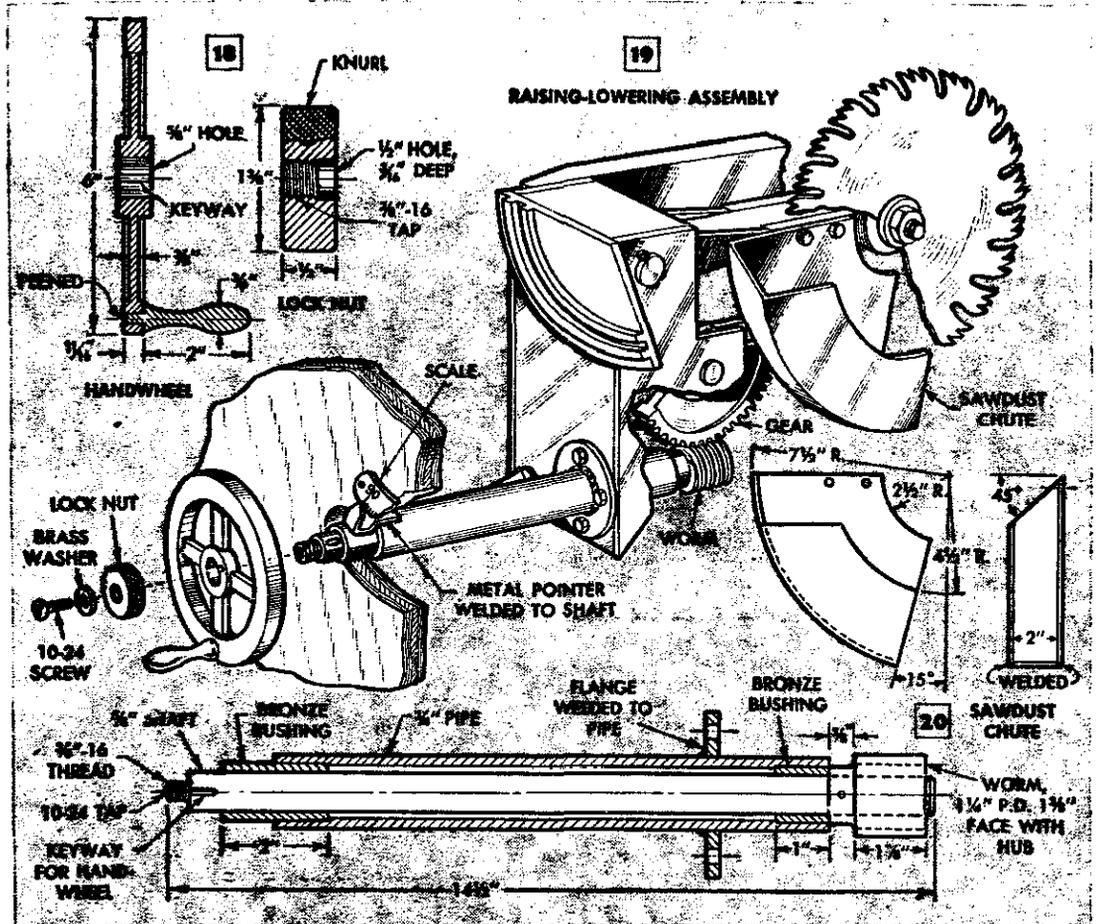
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a lug welded to the underside of the arbor plate by two links as shown. The gear segment turns on a shaft passing through the sides of the boxed end of the arbor frame as in Fig. 14. The shaft is made a drive fit in the holes drilled in the frame. Spacers cut from pipe position the worm-gear segment on the shaft, as shown in Fig. 13, section A-A. Although not detailed, the raising mechanism will operate more smoothly if the gear segment is fitted with a bronze bushing. If this is done, the bushing should be a tight drive fit in a reamed hole. Fig. 13 shows worm and worm shaft in position.

(To be continued)

☐ A set of socket wrenches can be made by using the heads of hexagon socket screws and welding handles to them.

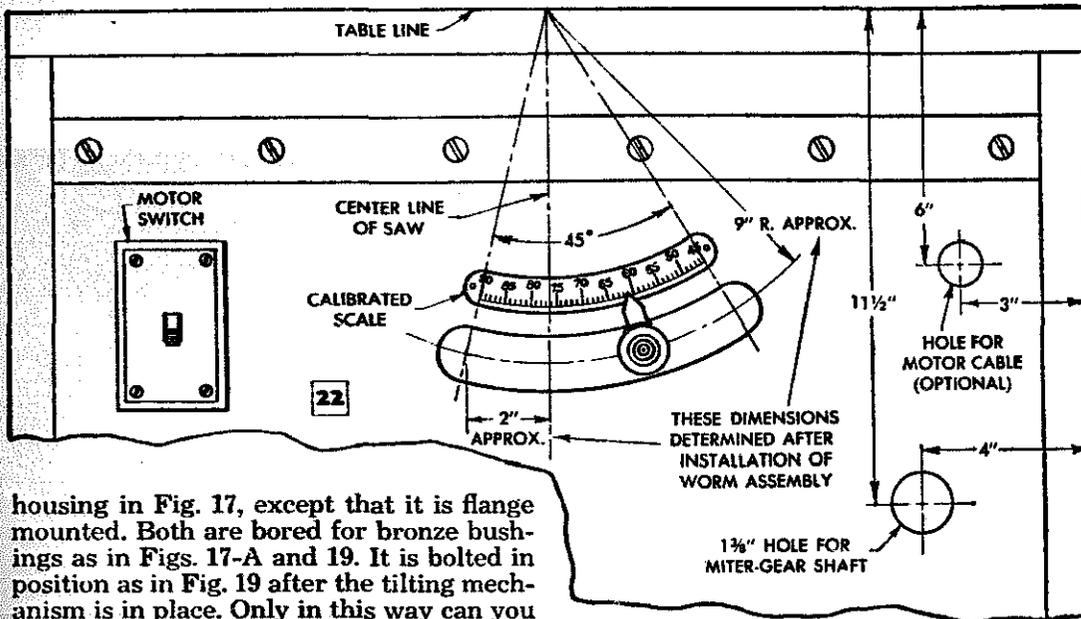




which is pinned to the handwheel shaft. Likewise, the driven gear is pinned to a threaded tilting shaft. Pivoted in this way the shaft and gears can swivel with the arbor frame when it is tilted to any angle up to 45 deg. The tilting shaft is threaded with a  $\frac{5}{8}$ -11 thread.

The tapped block, into which the threaded tilting shaft turns, is bolted to an angle bracket that pivots on the tilting lug welded to the arbor frame. This end of the tilting assembly is carried on a spring-loaded toggle supported by a triangular metal bracket bolted to the bottom of the saw stand as in Fig. 17. The toggle partially supports the weight of the motor and arbor through the 45-deg. tilt and thereby eases the load on the tilting handwheel. The toggle-spring guide rod is welded to an angle bracket bent from flat iron and bolted to the tilting lug as in section A-A, Fig. 17. Handwheels and knurled lock nuts for both the raising-and-lowering and the tilting mechanisms are detailed in Fig. 18. Both are keyed to the shaft in the same way, Figs. 17 and 19.

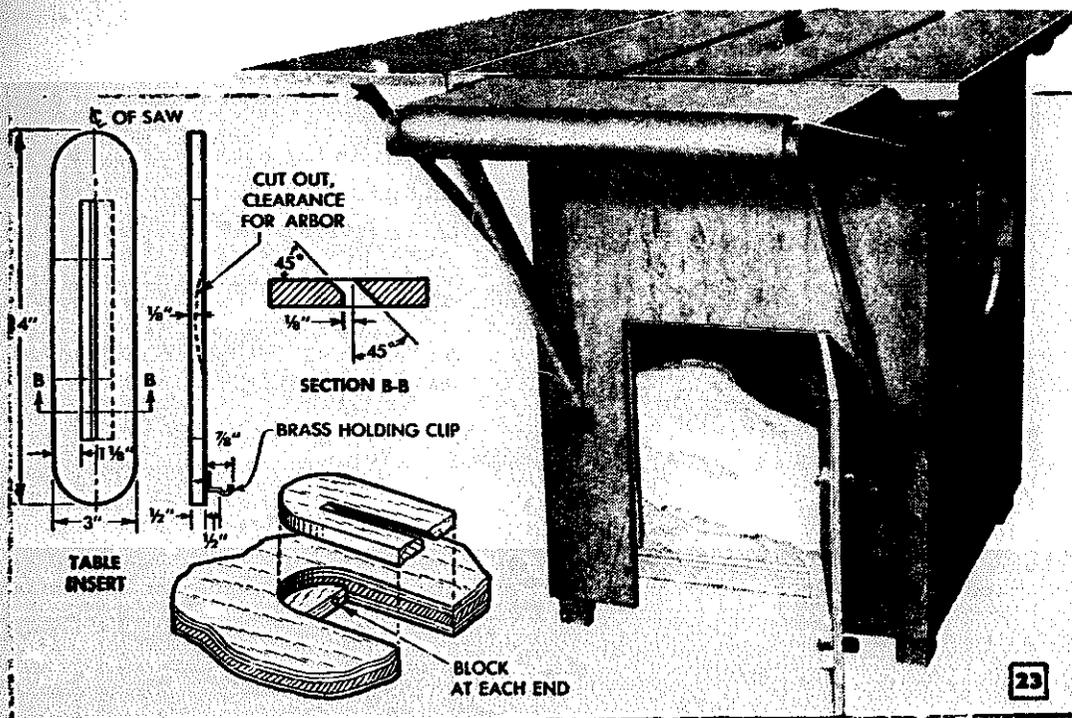
The worm shaft and housing, not fully described in Part I, is detailed in Fig. 19. It is similar to the tilting-gear shaft and

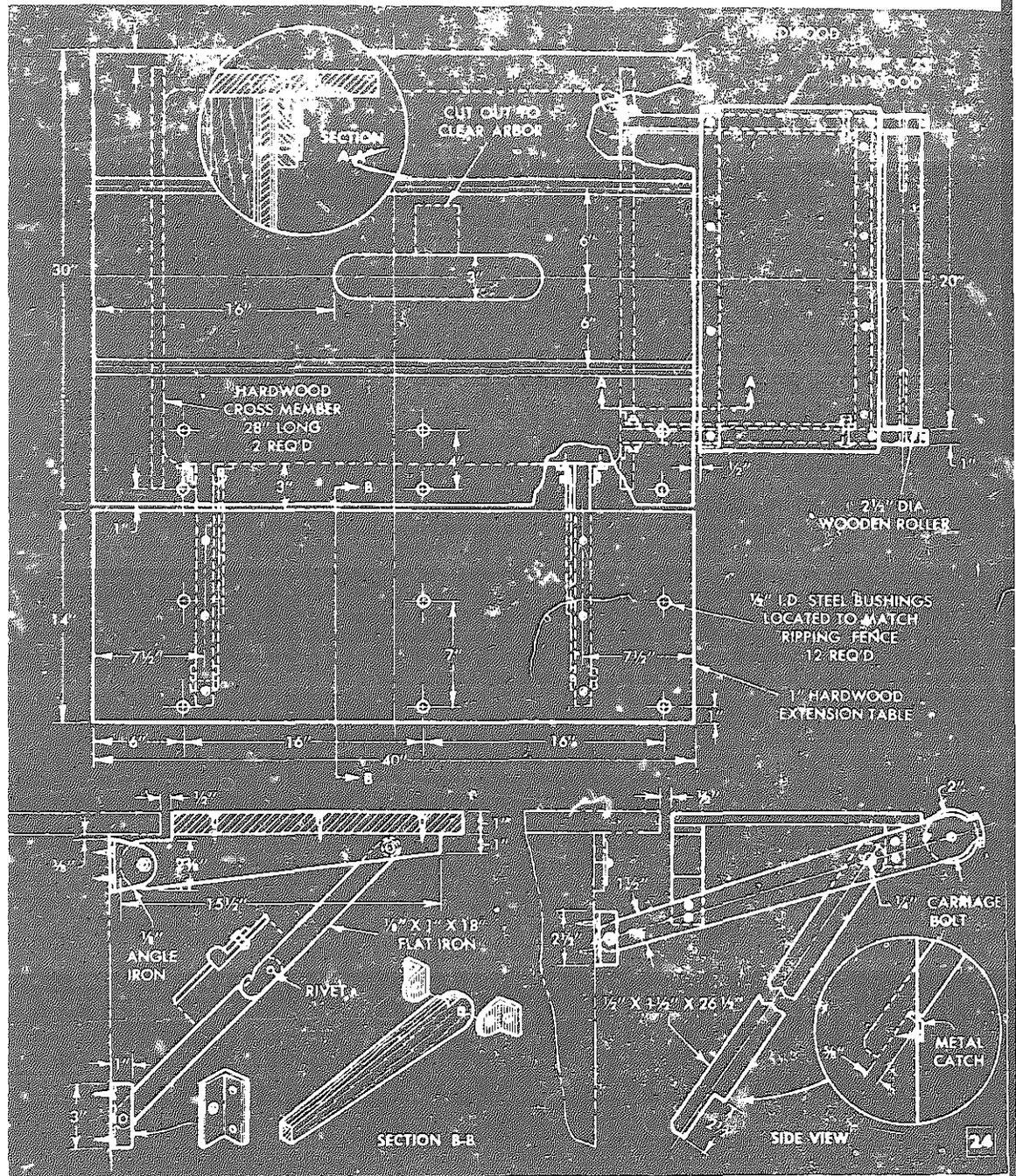


housing in Fig. 17, except that it is flange mounted. Both are bored for bronze bushings as in Figs. 17-A and 19. It is bolted in position as in Fig. 19 after the tilting mechanism is in place. Only in this way can you determine the exact dimensions and location of the curved clearance slot in the front panel of the saw base, Fig. 22.\* The best way to determine the exact location of the curved slot and the location of the hole for the miter-gear shaft in the front panel, is first to assemble the tilting mechanism, as in Fig. 17, with the flat support plate attached to the leg with screws, as shown. This will support the completely assembled mechanism in place. Then it is easy to determine the location of these openings in the front panel. After the

slot has been located and cut and the hole for the miter-gear shaft has been bored, the panel is screwed permanently in place.

The calibrated scale, Fig. 22, can be made from thin sheet metal with figures and divisions stamped into the metal by hand with a numeral stamp of the type used for stamping numerals on tools. For stamping the divisions, a 1/4-in. lathe bit ground to a blunt chisel edge will do. The degree scale must be laid out very accurately, and care should be taken when stamping not to cut

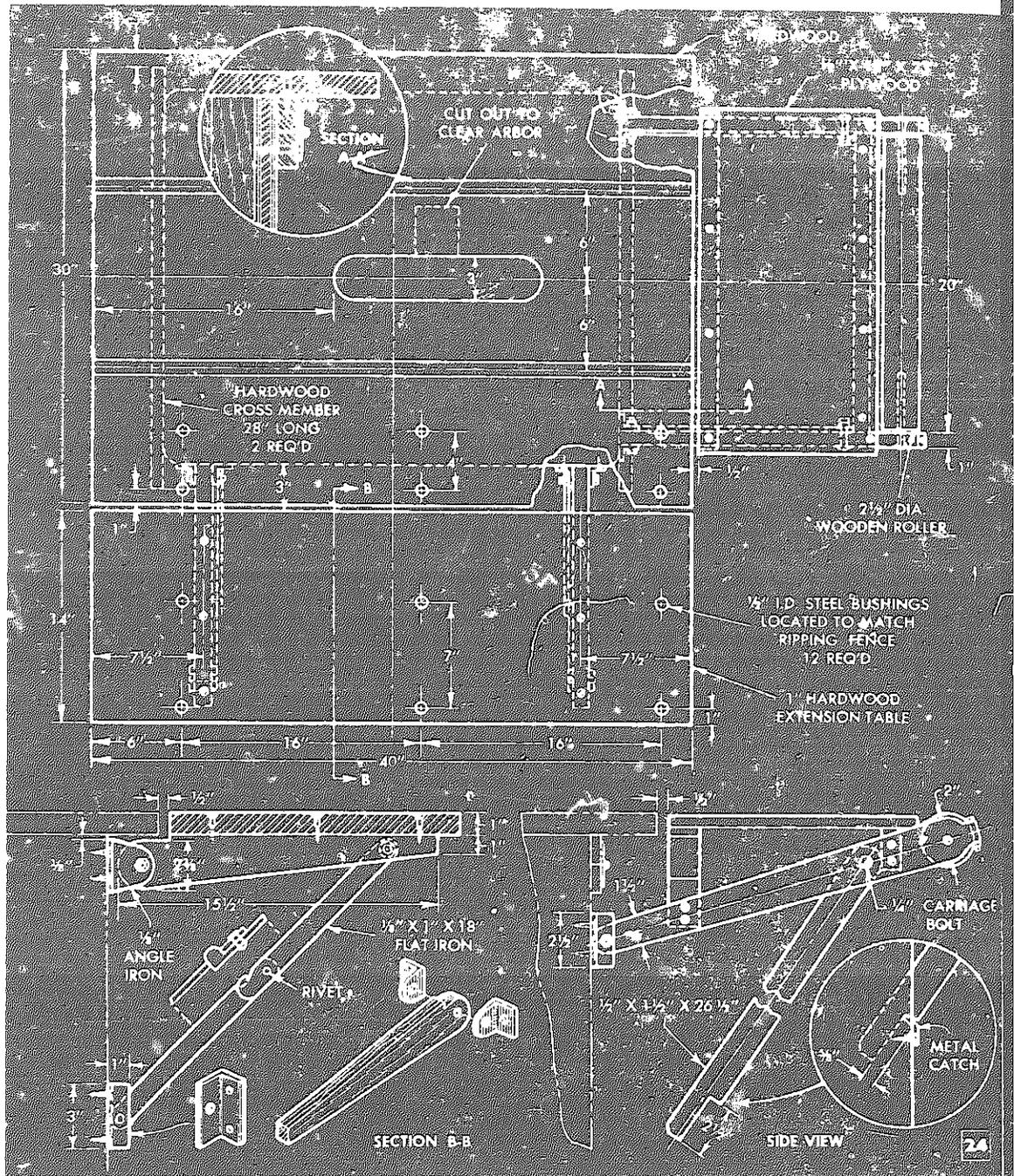




the numerals or divisions through the metal. To make the scale easy to read, coat the face with black enamel and allow to dry. Then follow with a thin coat of white. Wipe this off immediately with a single quick sweep of a dry cloth. This will remove all the white enamel except that in the indentations. After the enamel has dried, locate the 45 and 90-deg. positions of the saw blade and position the scale accordingly. Attach it to the panel with small screws. Cut a pointer from heavy-gauge sheet metal and weld it to the worm-shaft housing as

in Figs. 19 and 22. The sawdust chute, detailed in Fig. 20, is optional, its only purpose being to direct dust and chips to the rear of the enclosed base. If you do include the chute, make it from heavy sheet metal, welding where indicated in Fig. 20. Bolt it to the arbor frame in the position shown in Fig. 19 and be sure to allow for ample clearance when the saw is tilted 45 deg.

The table can be made from 1-in. plywood, but it is better to build it from strips of 1-in. hardwood doweled and glued. The most attractive job is made by gluing up



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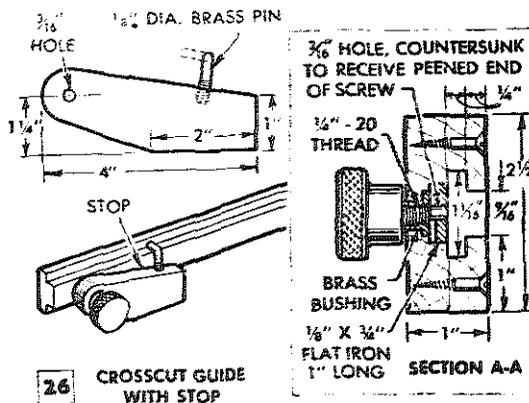
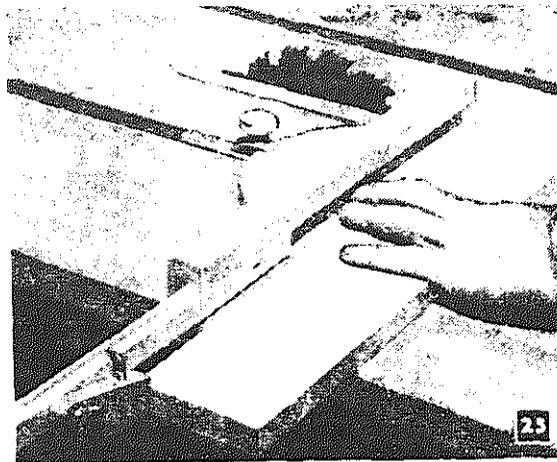
The table can be made from 1-in. plywood, but it is better to build it from strips of 1-in. hardwood doweled and glued. The most attractive job is made by gluing up



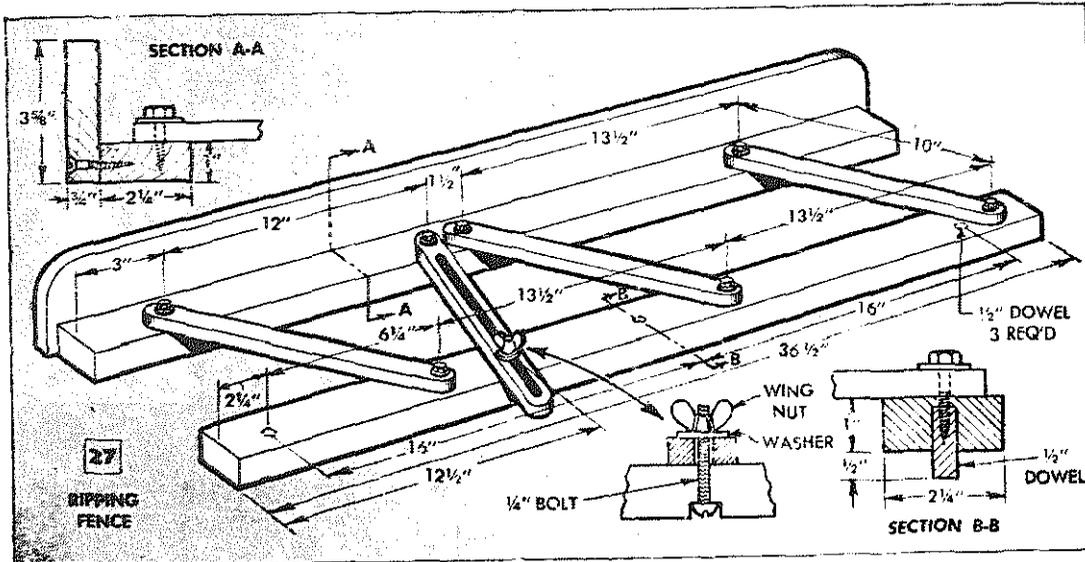
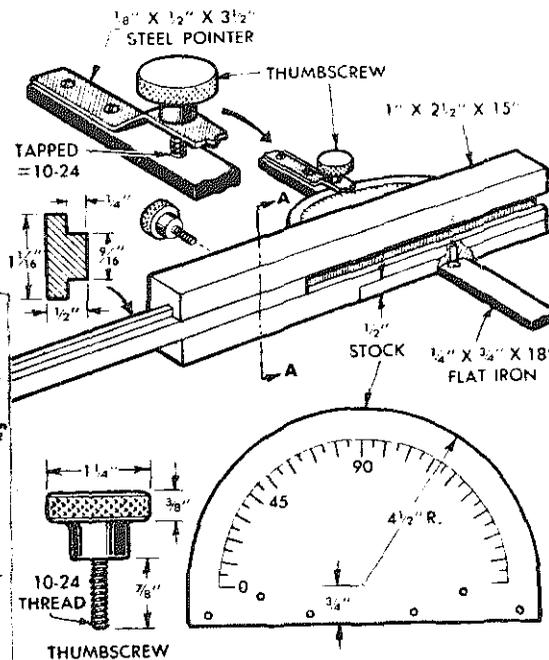
alternate 1 by 1-in. strips ripped from hardwoods of a contrasting color. Otherwise, using one wood such as maple, dowel and glue together 1-in. strips, each no wider than 2 in., to make the required table width as given in Fig. 24. Make the extension drop leaf in the same way and of the same material. After gluing, run grooves for the cross-cut guide and cut an opening for the blade insert as in Fig. 24. Make and fit the insert as detailed in Fig. 23. Attach the table to the base as in Fig. 24, section A-A, checking to assure that the cross-cut-guide grooves are aligned with the blade. Fig. 24, section B-B, shows how the side extension is mounted on the saw base. The back extension, Fig. 24, is optional equipment.

Use a regular crosscut guide or make one as in Figs. 25 and 26. Details on the hardwood ripping fence, Fig. 27, are self explanatory. Casters detailed in Fig. 21 also are optional. The lifting mechanism for each set of casters is fitted on diagonal corners of the base.

(The End)



26 CROSSCUT GUIDE WITH STOP



27 RIPPING FENCE

X245

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A project of Volunteers in Asia

Heavy Duty Drill Press  
Popular Mechanics No. X245

by: Arthur B. Farwell

Published by:  
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224 West 57th Street  
New York, NY 10019 USA

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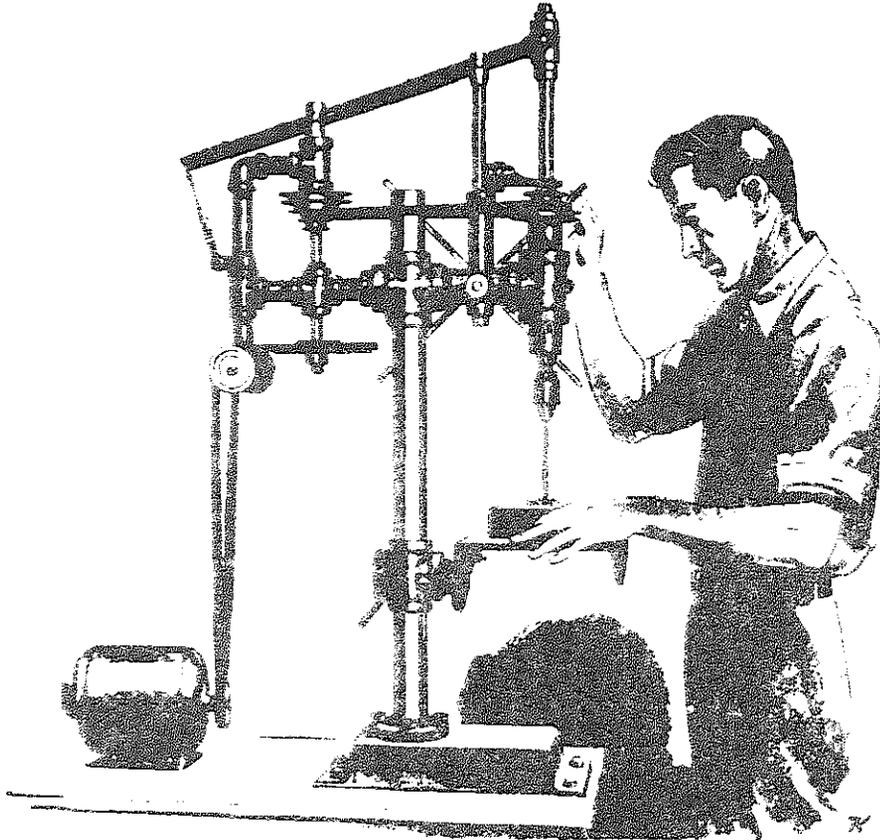
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# Shop Notes



## HEAVY-DUTY DRILL PRESS

By Arthur B. Farwell

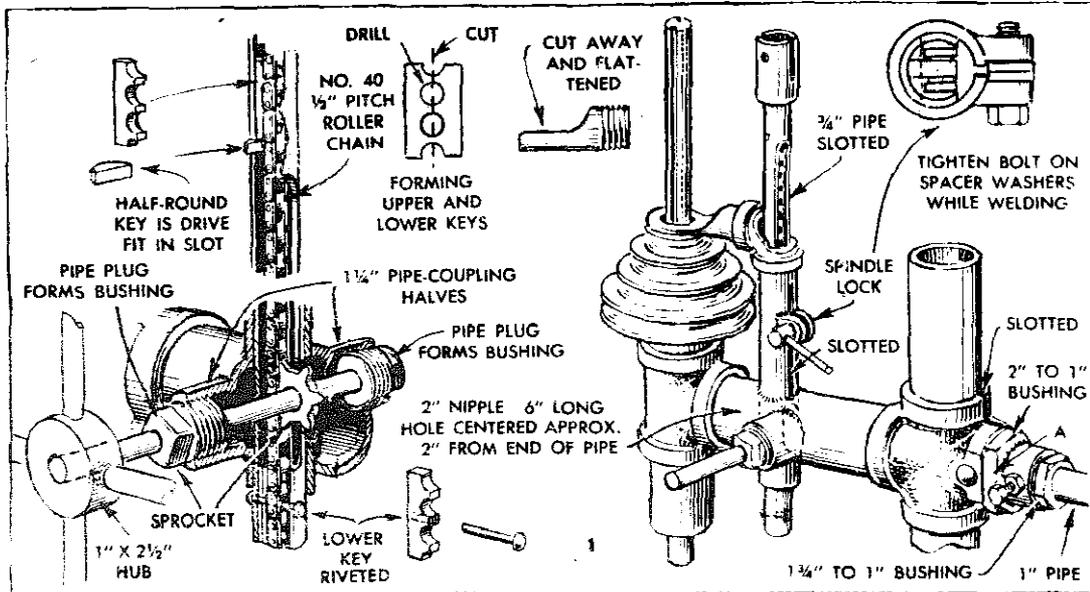
**S**PECIAL BUILT-IN FEATURES adapt this heavy-duty drill press to a wide range of shop work. The 7-in. vertical travel of the spindle permits deep drilling and reaming and the slow-speed jackshaft drive and 0 to 1-in. capacity provide power for heavy drilling in metals and wood. Any type motor can be used as it is mounted horizontally rather than vertically.

### Frame Construction

The frame is constructed of extra-strong pipe and fittings of the wide-flange type. At the outset it should be kept in mind that there are allowable variations in the manufacture of standard pipe and fittings. This makes it necessary to determine certain dimensions by trial assembly. Some filing must be done when fitting the spindle and spindle-lowering mechanism, also the

column must be draw-filed and smoothed with abrasive so that the pipe crosses will slide easily. Threads in the crosses are reamed out in the lathe to give an easy, sliding fit over the column. Both crosses are slotted and fitted with clamping bolts. Note particularly the assembly of the parts indicated in A in Fig. 1, also shown in detail A in Fig. 2. This assembly permits the jackshaft frame to slide, thus providing a means of adjusting the belt tension. Note also that the distance between the flats filed into the jackshaft and drill spindle is not specified. These flats provide seats for the setscrews holding the shaft collars and the spacing must be determined when the parts are assembled.

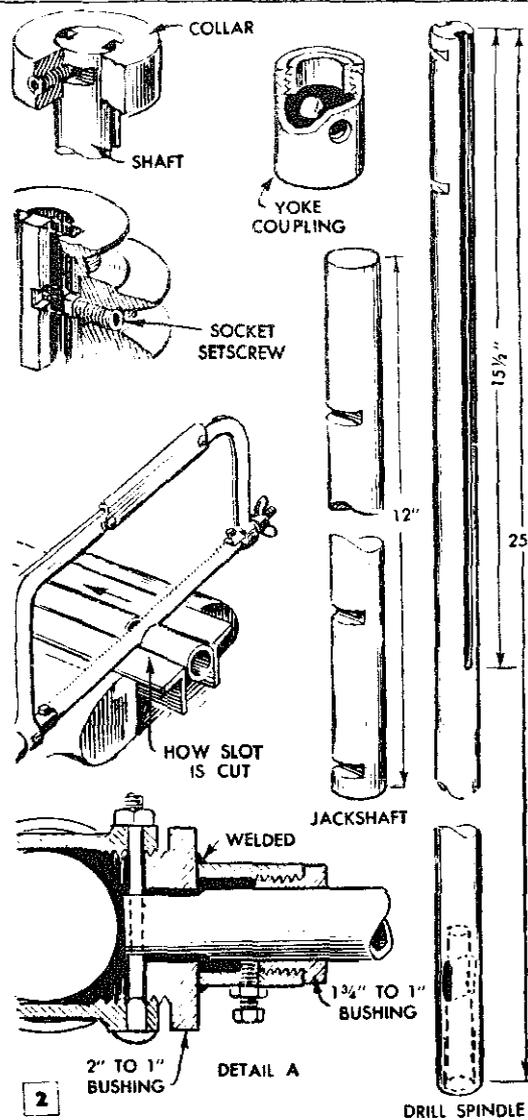
Usually it's best to begin with the base and column and then assemble the spindle and jackshaft frames as separate units. Fit

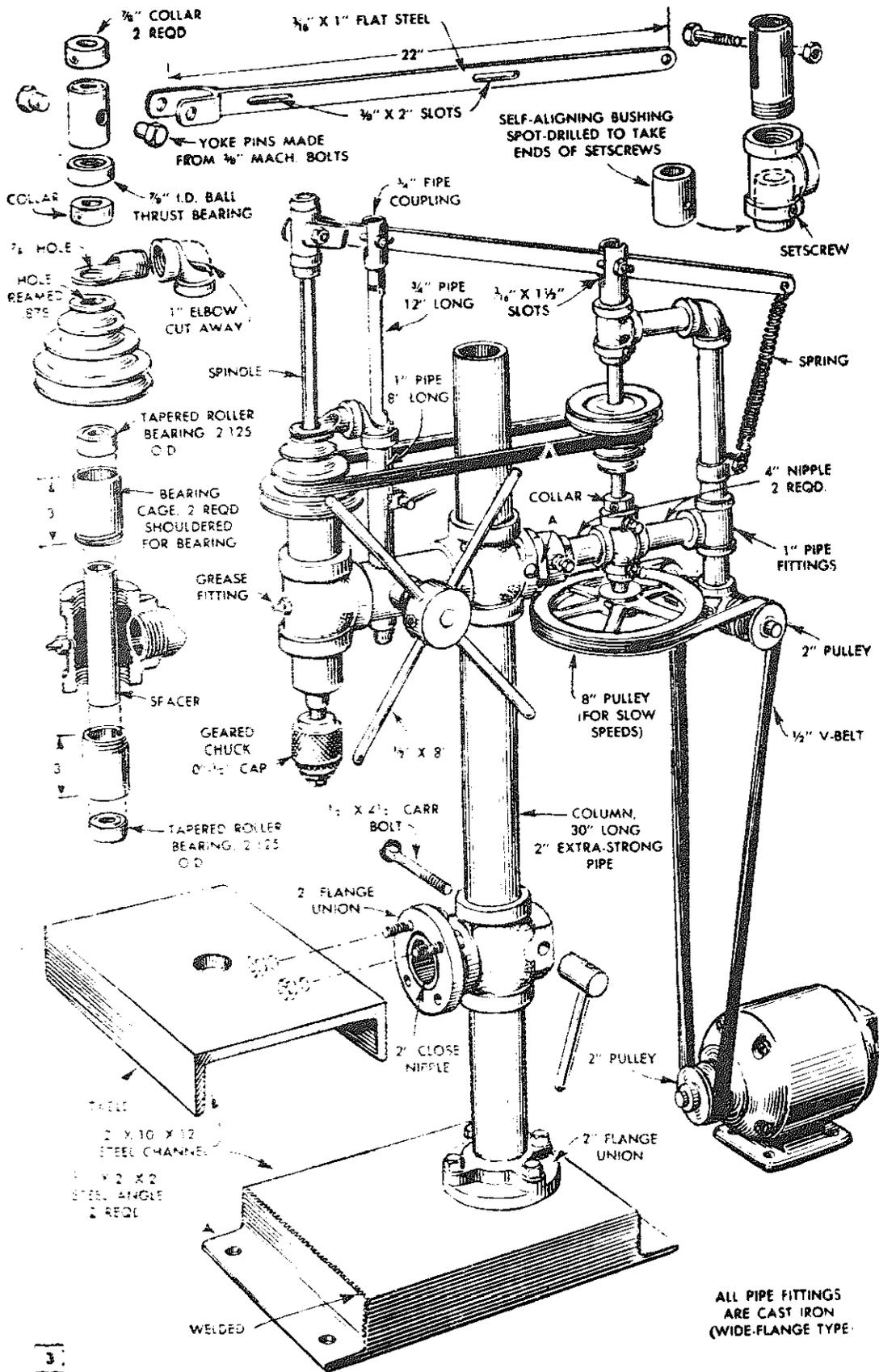


the sliding crosses on the column, bolt a flange union to the base and screw the second flange union onto a close nipple turned into the lower cross. Attach the table. Draw the column tight with a strap wrench (borrowed from your local plumber) to avoid marring the polished surface. Assemble the jackshaft frame and the parts A, Figs. 1, 2 and 3. Then assemble the spindle frame. The purpose of this preliminary assembly is to make sure that all pipe and fittings fit together in correct alignment when drawn tight. Before proceeding, note the assembly of the spindle raising-and-lowering device shown cut away in the left-hand detail, Fig. 1. Mark the location of the hole for the slotted pipe sleeve which passes through the hole in the arm and serves as a guide for the raising and lowering rack. The sleeve is 1-in. pipe, 8 in. long, and only the top end is threaded. A length of 3/4-in. pipe, 12 in. long, telescopes inside the sleeve and carries the roller-chain rack. This length of pipe is slotted with a hacksaw as in Fig. 2 to permit travel of the sprocket, which is carried on a 1/2-in. horizontal shaft turning in bushings made from solid pipe plugs. The bushings are mounted in pipe-coupling halves welded to the frame arm as indicated in Fig. 1.

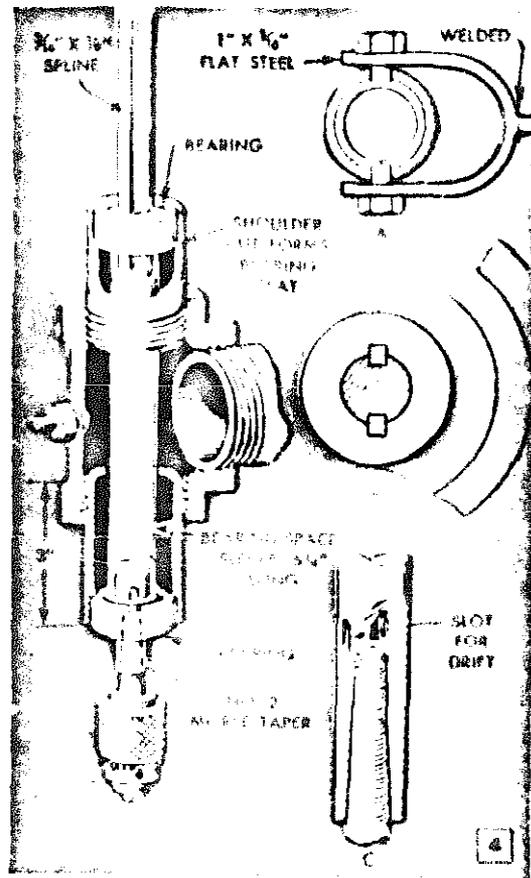
#### Spindle-Lowering Assembly

Note from the left-hand detail in Fig. 1 that the roller-chain rack is pinned at the lower end and supported at the top end by a toothed lug, or key, held in place in the pipe by a standard half-moon key. Care must be taken in the location of the slot for the half-moon key to assure that the chain is supported inside the slotted





3.



pipe without slack. Drive-fit the key in place and grind flush. The slotted-pipe carrier should be an easy sliding fit inside the sleeve. The sprocket is pinned to the 1/2-in. shaft and on completion of the assembly the sleeve is tack-welded to the arm. Two lugs are welded to the sleeve, one tapped, the other drilled with a body hole for a locking screw.

### Spindle Assembly

Details of the spindle assembly are shown in Figs. 2, 3 and 4. The pulled-apart view shows quite clearly the relationship of the parts. Matching 4-step V-pulleys are used on the spindle and jackshaft, but the hole in the pulley used on the spindle must be reamed to a sliding fit and it may be necessary to file the keyways deeper. The tapered roller bearings carrying the spindle are mounted in "cages" made by turning a shoulder into the plain ends of 3-in. lengths of pipe to receive the outer race of each bearing in a press fit. Note in Fig. 2 that the lower end of the spindle is drilled and taper-reamed to take taper-shank drill bits, detail C, Fig. 4, or a chuck fitted with a No. 2 Morse-taper adapter, Fig. 3. The two milled splines (have this job done at a machine shop) in the drill

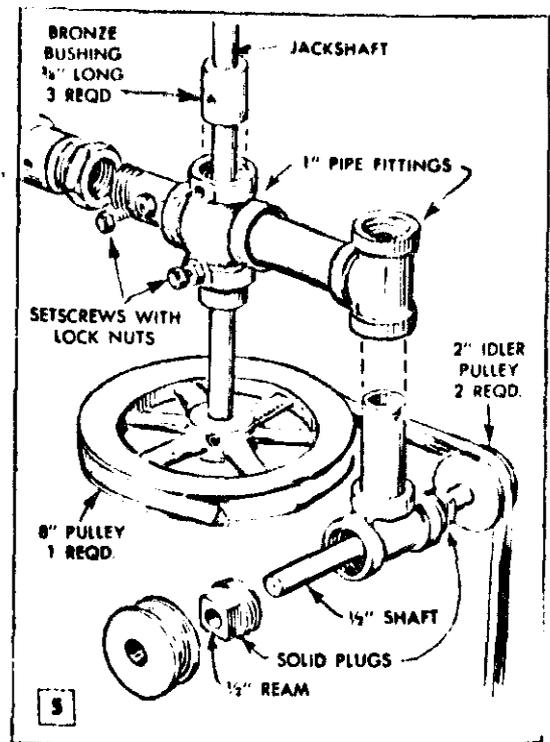
244

spindle take notched sliding keys fitted into the pulley and held in place with socket setscrews as in the lower of the two upper left-hand details in Fig. 2. Note also the detail B in Fig. 4. The keys should be drawn-filed so that they slide freely in the splines throughout the full length. Note also that the spindle assembly includes the yoke bearing, or coupling, Fig. 3, and the upper-center detail in Fig. 2.

### Jackshaft Assembly

The jackshaft, Figs. 2 and 5, is fitted with self-aligning bushings spot-drilled as indicated in Fig. 3 to take the pointed ends of setscrews held in position with locknuts. The idler shaft turns in bushings made by drilling solid pipe plugs and turning them into a pipe tee. The idler pulleys turn freely on the shaft and are held by washers and cotter pins. The lowering yoke, Fig. 3, pivots on the top end of the jackshaft frame. Location of the slots in the yoke arm must be determined at the time of assembly. The yoke pins, Fig. 3 and detail A in Fig. 4, should be a drive fit.

Note that before the lowering arm is placed in final position the hold-down, which consists of a short length of pipe and an elbow, must be made and placed in position. This part bears against the top of the spindle pulley and is shown in place in the right-hand detail in Fig. 1, also in Fig. 3. Assembling this part in position and adding the lowering wheel, or spider, completes the job. ★ ★ ★



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How to Mill on a Drill Press  
Popular Mechanics No. X422A

by: Kenneth Littlefield

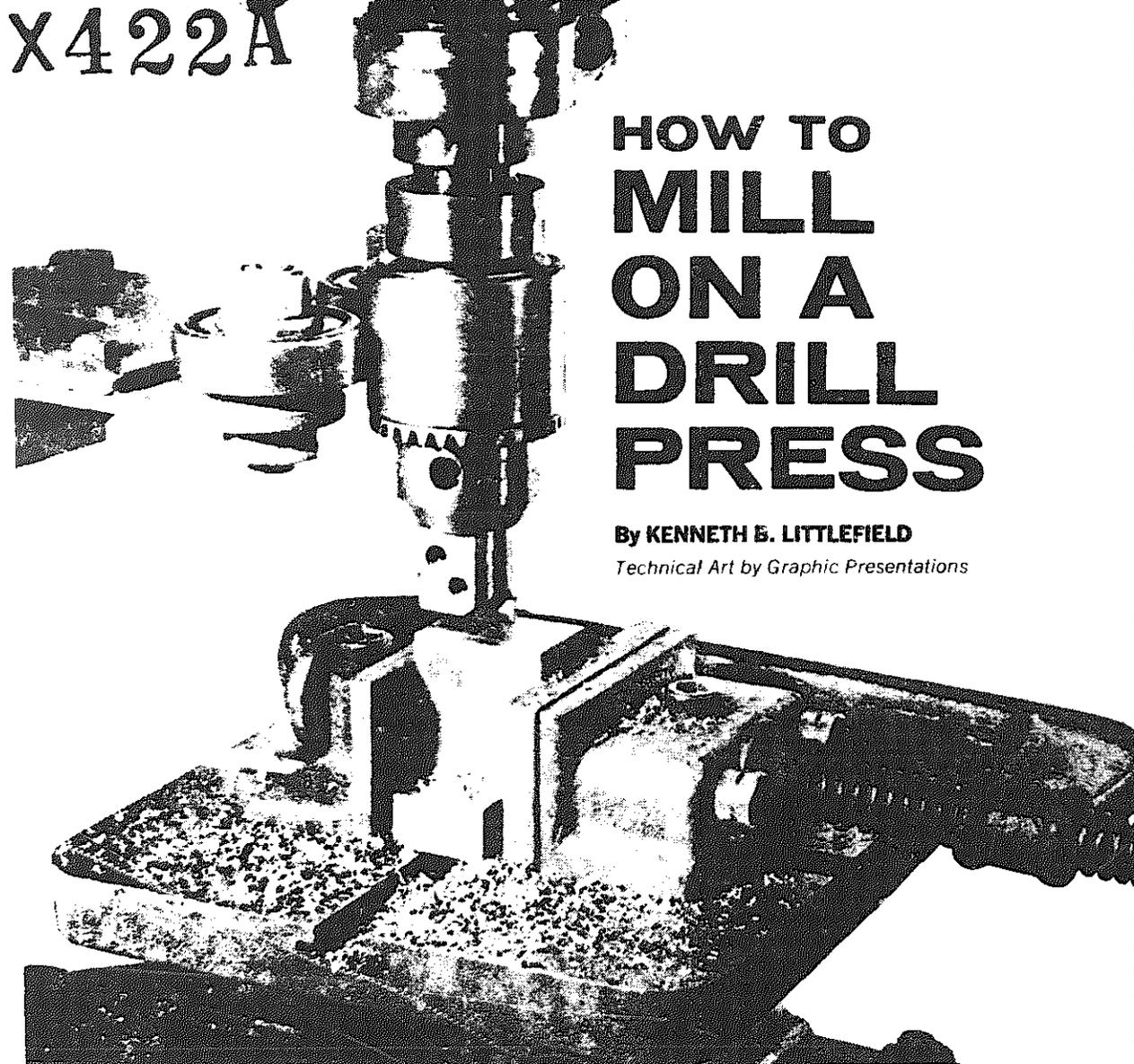
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X422A

# HOW TO MILL ON A DRILL PRESS

By **KENNETH B. LITTLEFIELD**

*Technical Art by Graphic Presentations*

**These simple cutting attachments will make it possible for you to mill metals, such as aluminum, cast iron and steel, on your drill press**

**C**OMBINE ANY MILLING VISE with the cutters and spindle support attachment shown here and you can convert your drill press into an excellent light-duty milling machine.

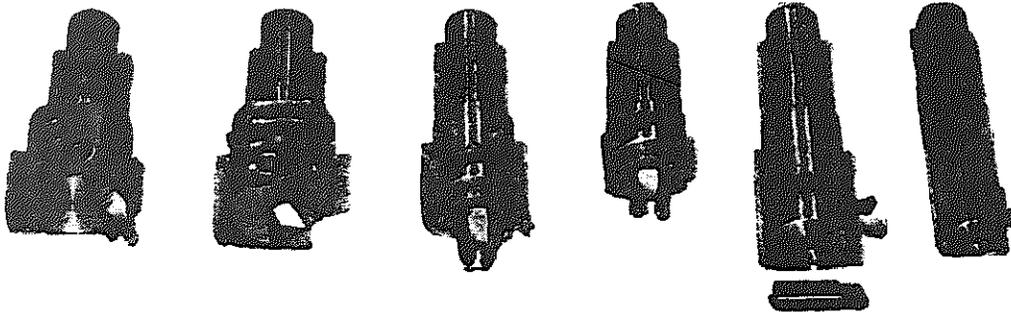
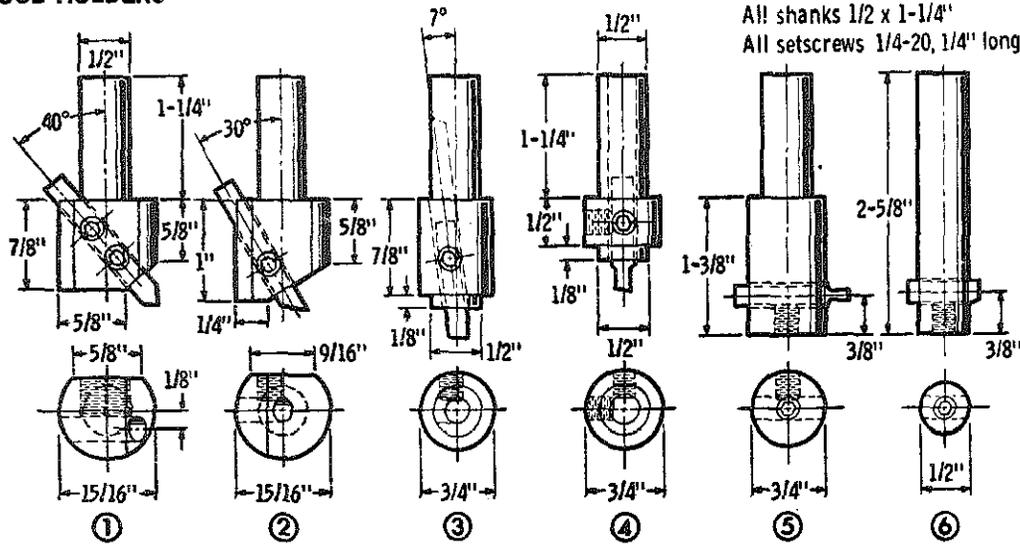
Use of fly cutters instead of multi-tooth commercial milling cutters makes drill-press milling practical for the home-workshop craftsman. These fly cutters are

inexpensive  $\frac{3}{16}$ -in.-sq. lathe tool bits fitted in vertically mounted toolholders. You can keep them sharp without special grinding equipment and can change cutting angles readily to suit the metal being milled.

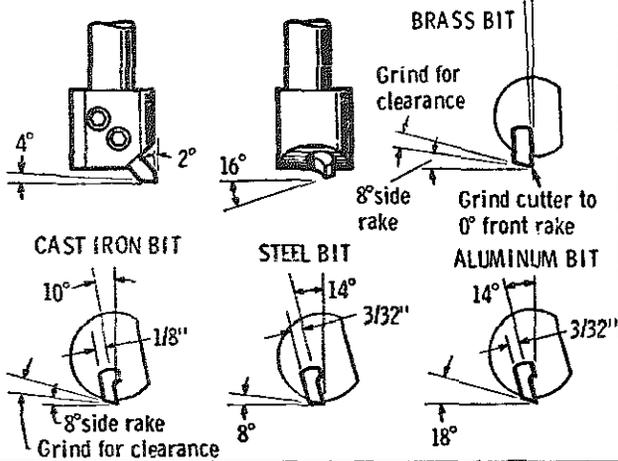
However, these fly cutters *must never be used without the spindle support attachment*. If the workpiece is advanced too

**TOOL HOLDERS**

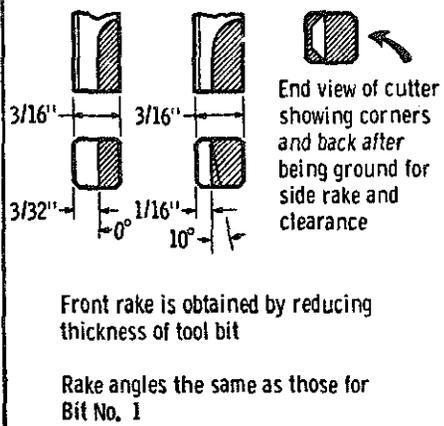
Drill all tool holes 1/4"  
 All shanks 1/2 x 1-1/4"  
 All setscrews 1/4-20, 1/4" long



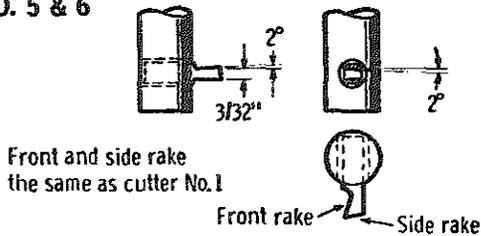
**BITS FOR TOOL HOLDER NO. 1**



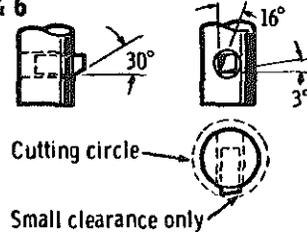
**BITS FOR HOLDERS NO. 2, 3 & 4**



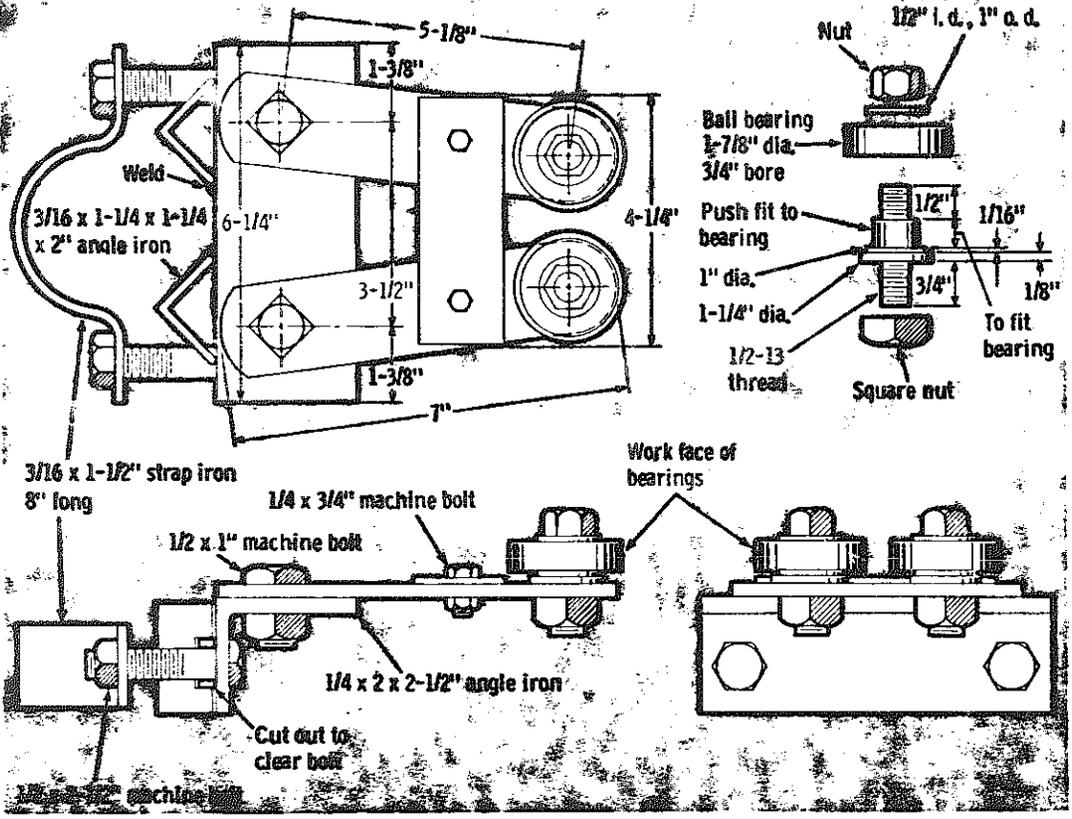
**KEYWAY CUTTER FOR TOOL HOLDERS NO. 5 & 6**



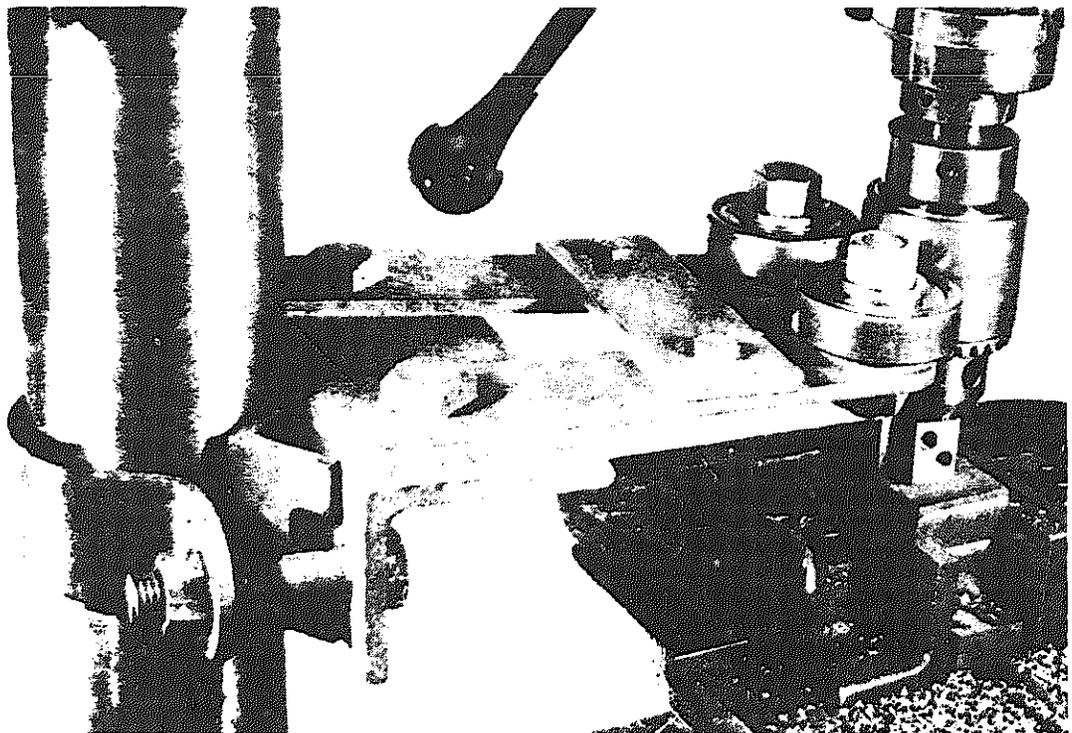
**BORING BAR FOR TOOL HOLDERS NO. 5 & 6**



**SPINDLE SUPPORT ATTACHMENT**

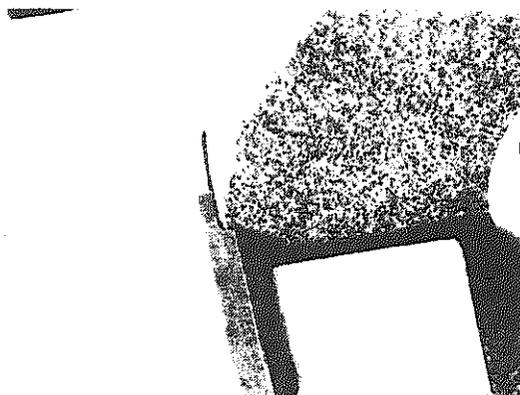


SPINDLE SUPPORT is easy to make of common workshop materials. Thicker, but not lighter, metal can be used FITTED ON DRILL-PRESS COLUMN, spindle support will prevent deep bites of bit from bending chuck spindle

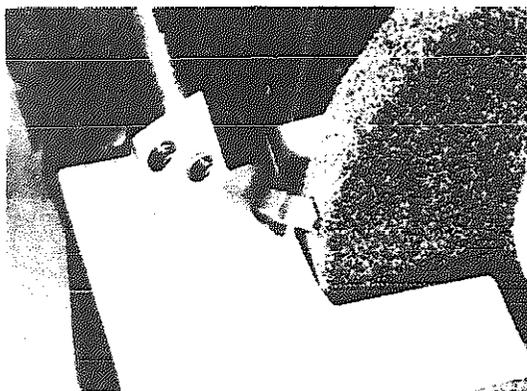




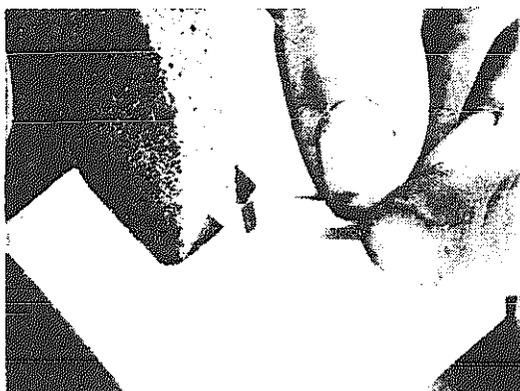
**EASY WAY TO CUT BLANK TOOL BIT** to the desired length is with a  $\frac{1}{8}$ -in.-thick abrasive cutoff wheel



**NEXT REDUCE THE THICKNESS** of the blank bit on a bench grinder. Dip in water to avoid overheating



**PLACE THE BIT IN ITS HOLDER** and continue to grind it to approximately the correct size and shape



**CAREFULLY FINISH GRINDING** the fly-cutter bit by adjusting the grinder's toolrest to the required angle

rapidly, or it slips in the vise, the cutter will strike powerfully against the work. The spindle support absorbs the force of this blow, so no damage will result. Without it, the drill-press spindle would probably bend and be permanently damaged.

The spindle support shown is for a drill press with a  $2\frac{3}{4}$ -in.-diameter column. Exact size of the two ball bearings isn't really important. Heavier steel can be substituted for that in the drawing; lighter metal definitely should not be used.

To set up the attachment, clamp the base to the drill-press column and attach both arms and bearings to the base. Swing them in until the bearings press firmly against the side of the drill-press chuck, then bolt the cross brace in position.

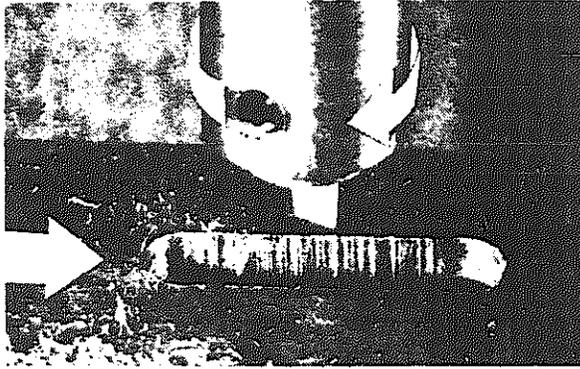
Turn the toolholders from mild steel and cut flats on two faces of the holders to facilitate boring holes for the cutter bits and setscrews. Later, corners of the tool bits must be beveled slightly to fit the  $\frac{1}{4}$ -in. holes in the holders. The No. 1 toolholder is bored offcenter to simplify

grinding the rake angle of the bit; that is, a front rake of up to  $14^\circ$  can be obtained simply by reducing the thickness of the bit. Except for the keyway cutter, a front rake is obtained similarly in the other cutters by reducing the tool bit thickness. A rake of about  $10^\circ$  can be had without weakening the tool bit. The keyway cutter is ground like a lathe tool.

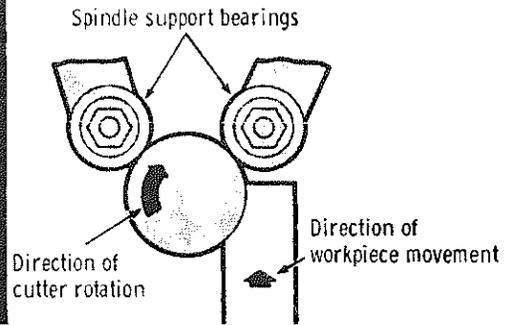
Rake and clearance angles shown in the drawings are the actual working angles of the cutters when held in the toolholders. To avoid confusion, hold the blank tool bit in its holder as you grind.

With the drill press running at its slowest speed, make a trial cut. The cutter should produce small, neatly formed chips. If not, check for sufficient side rake and regrind if necessary. If it still refuses to cut, it is because of insufficient front rake (especially when milling steel).

If the cutter seizes into the metal, accompanied by considerable vibration, reduce the side rake. With brass and to a lesser extent, gray cast iron, this effect



## METHOD OF MAKING CUTS



**TO MAKE SLOTTED CUTS**, first remove the bulk of the material with a series of drilled holes. Then fit drill press with the cutter and feed the work into the bit, in direction indicated in the drawing directly above

can also be caused by too much front rake. Bottom clearance and rake have little effect on the cutting of the bit but will affect the finish of the work.

The cutting speeds listed below are suggested only as a working basis. Too fast a speed rapidly wears away the tool's cutting edge; too slow a speed increases vibration and leaves a rough finish.

Cutter No.	1	2	3 & 4	5 & 6
Aluminum	1600	1000	2000	1000
Brass	1000	1000	1500	1000
Cast Iron	500	500	700	500
Annealed				
Alloy Steel	750	400	750	400
Mild Steel	1000	705	1000	750

The depth of cut with the large cutters should not exceed  $\frac{3}{16}$  in., while the small cutters are limited to  $\frac{1}{16}$  in.

Aluminum, brass and gray cast iron should be milled dry, as can be mild steel, but thread-cutting oil will help retain a sharp edge on the tool bit. Also use this oil when milling annealed alloy steel.

Cutters 1, 3 and 5 are sufficient for most milling jobs. No. 2 is useful for milling

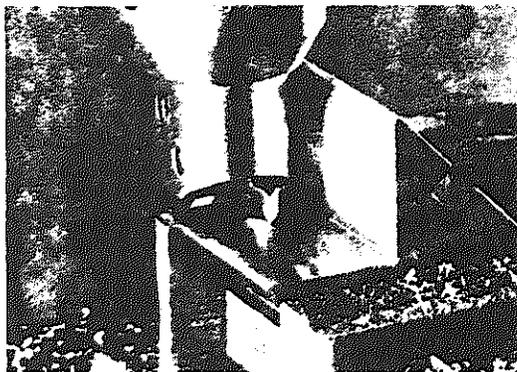
small dovetail slides but it is suitable only for light work. No. 4 is particularly useful when working with soft metals.

Cutters 5 and 6 can be used either as keyway cutters or boring bars for enlarging existing holes. In the latter case, the optimum cut is about  $\frac{1}{16}$  in., and the cutter must be fed into the work very slowly to avoid vibration. The best cutting speed will vary according to the hole diameter, but should not exceed 800 rpm for a  $\frac{5}{8}$ -in. hole or 350 rpm for a  $1\frac{1}{4}$ -in. hole. Cutting oil should be used.

There is considerable difference in the milling qualities of different metals. Even mild steel can vary so much that one piece may be milled at well over 1000 rpm, while 750 rpm may be the maximum for a different piece of the "same" metal.

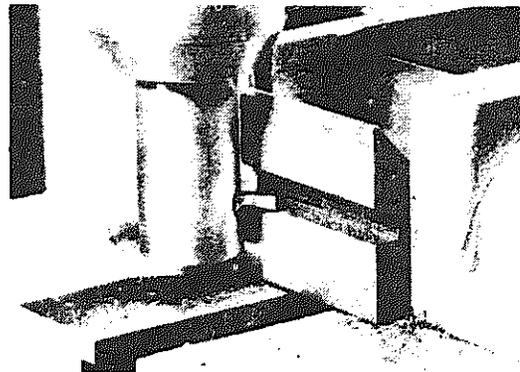
Alloy steel is very unpredictable in this respect. It's always a good idea first to make a trial cut on the piece of steel selected for a certain job. If it appears it will be difficult to mill, a different—and more easily worked—piece of steel should be substituted. ★★★

**V-BLOCKS ARE EASY TO MILL** by making successive 3  $\frac{1}{2}$ -in.-deep cuts, each approximately  $\frac{1}{4}$ -in. wide



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**SLOTS ALSO CAN BE MADE** with a number of repeat passes. Start slowly to avoid jamming bit in work



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How to Use Metal Tubing  
Popular Mechanics No. X422

by: E.R. Haan

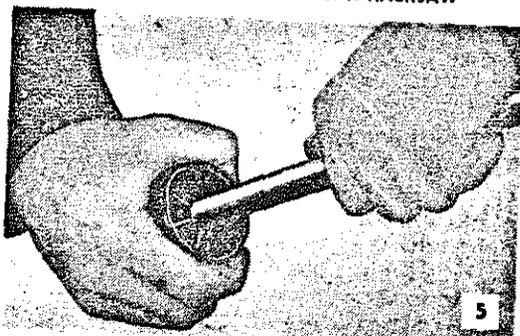
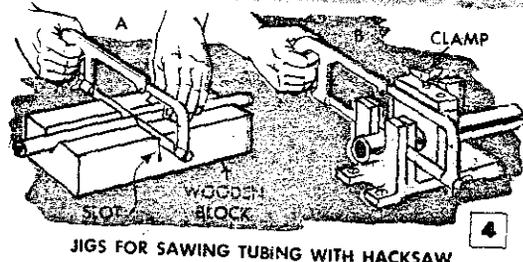
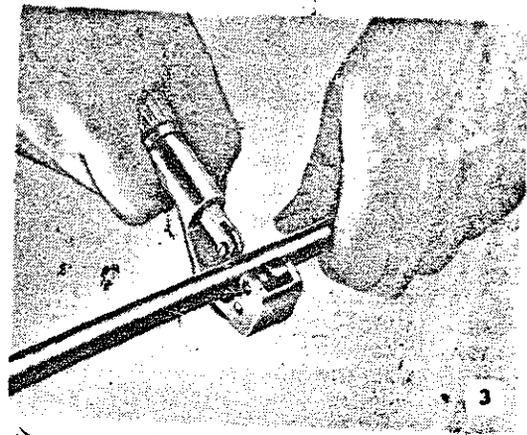
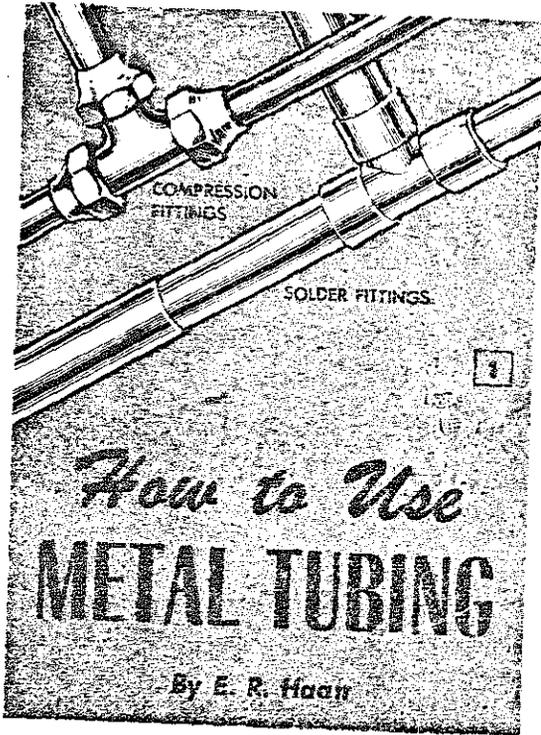
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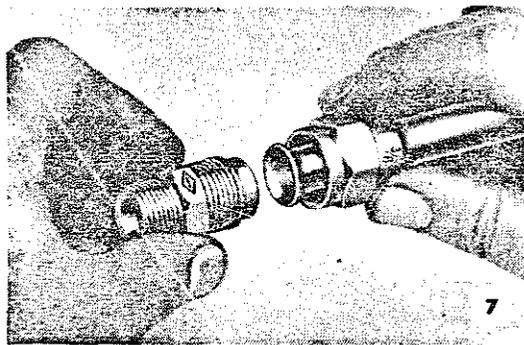
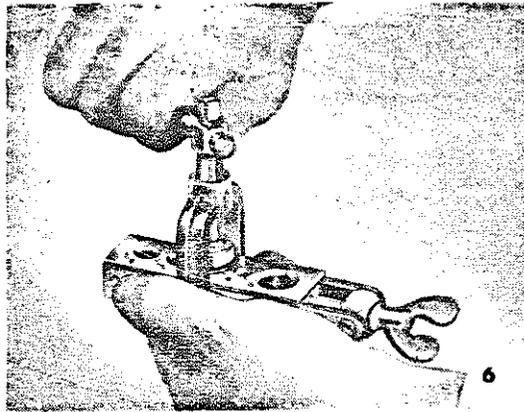
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**WHEN REPLACING WATER LINES,** extending old ones or adding new ones in your home, the job may be simplified by using soft copper or aluminum tubing. It can be run around corners, over or under obstructions and "snaked" through partitions with ease. Besides being rustproof, soft tubing expands if water freezes in it and therefore can resist several successive freezings before rupturing. Available in 60 and 100-ft. coils, tubing eliminates many pipe-cutting and threading operations and requires fewer fittings than does rigid pipe when used in continuous runs. The tubing generally used ranges from 1/4 to 2 in. in diameter, and comes in hard as well as soft varieties. The former is made in straight lengths, while the latter is obtainable in coils.

**Two assembly methods:** There are two methods of tubing assembly which differ in the kinds of fittings used, as shown in Fig. 1. Compression fittings are used with soft tubing, and solder fittings with both soft and hard tubing. The fittings include practically all the kinds used in regular pipe work plus adapters that connect tubing to threaded pipe. Copper, tinned-steel and brass tubing can be soldered readily. Aluminum tubing is assembled with compression fittings.

**Straightening coiled tubing:** To straighten coiled tubing, set the coil on edge on a flat surface and unroll it slowly while holding the straightened portion down as in Fig. 2.

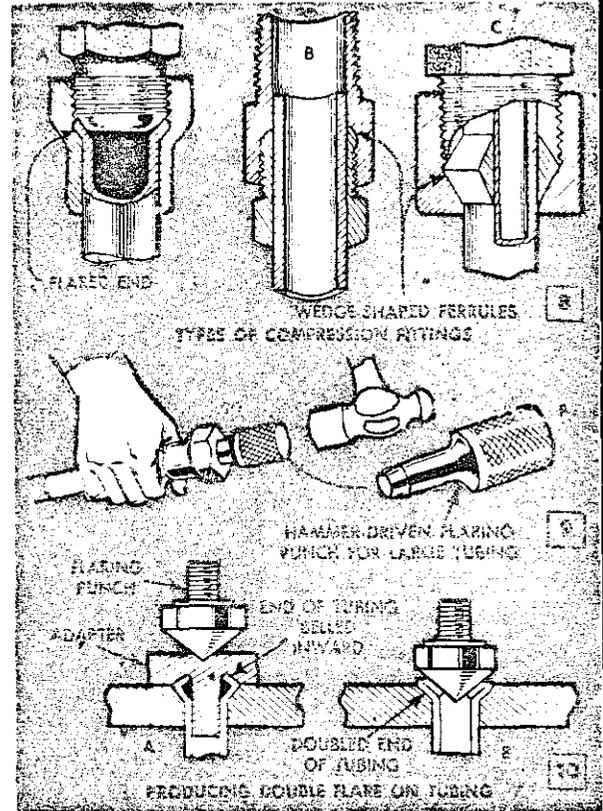


**How to cut tubing:** For either method of assembly, the ends of the tubing must be cut off absolutely square. Cutting is best done by means of a regular tube cutter, Fig. 3. Cutting also can be done with a fine-tooth hacksaw—32 teeth per in. To assure square cuts when sawing the tubing it is held in a V-block which has a cross slot to guide the saw as in detail A, Fig. 4, or in a regular tube-cutting fixture as in detail B.

A cutter forms a burr on the inside of the tube and it is necessary to remove it by reaming lightly as in Fig. 5. Hacksawing produces burrs on both inside and outside. To remove them, use a reamer on the inside and a file on the outside. When reaming or filing, always hold the open end of the tubing downward so that the chips fall away from, rather than into, the tube.

**Compression fittings:** Fig. 8 shows three types of compression fittings. The kind shown in detail A requires flaring the ends of the tubing. Those shown in details B and C require merely pushing the tube into a fitting, then tightening the latter. This compresses a wedge-shaped ferrule or sleeve firmly on the tubing wall.

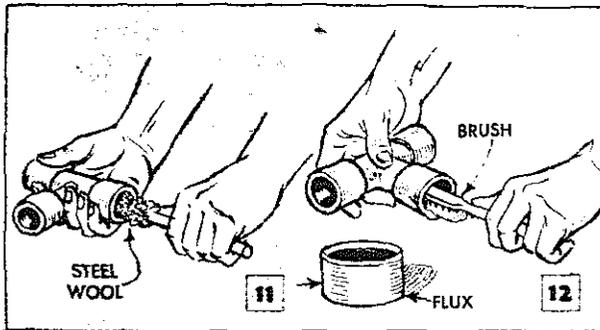
**Flaring the ends of tubing:** Flaring is done with a special tool as shown in Fig. 6. After slipping the compression nut of the fitting over the tubing, insert it in the block of the flaring tool so the end will pro-



ject from  $\frac{1}{16}$  to  $\frac{1}{8}$  in. above the block. Tighten the block to grip the tubing securely, then screw down the threaded punch. Most flaring tools accommodate tubing from  $\frac{1}{4}$  to  $\frac{5}{8}$  in. in diameter, but larger ones are available. Also, for large tubing, a hammer-driven flaring punch of proper size often is used, as shown in Fig. 9.

Double flaring, Fig. 10, is recommended for steel tubing, which is especially likely to crack when only a single flaring is used. Double flaring also is advised for copper and aluminum tubing when extra-strong joints are desired, or where they must be frequently disconnected and reconnected. The inside bend is made by using an adapter on the flare block as in detail A, Fig. 10, after which the flaring proceeds as in detail B. A little oil on the end of a flaring tool reduces friction and helps to prevent scoring the metal. Avoid using excessive pressure when flaring tubing, since pressure hardens it and makes it more likely to crack from strain or vibration. After flaring, assemble the fitting as in Fig. 7.

**Solder fittings:** With solder fittings you merely insert the tubing in a fitting and sweat-solder the two together. If there is any distortion caused by soldering heat, the tubing must be shaped to perfect roundness by means of a sizing tool, Fig. 17. The surfaces to be soldered together (the outside of the tubing and the inside



of the fitting) must be cleaned thoroughly with fine steel wool or emery cloth, rubbing the metal as in Fig. 11 until it is bright. Wipe the tubing clean, then apply a thin film of soldering flux, Fig. 12. Push the tubing into the fitting as far as it will go, then rotate it a few times to assure even distribution of the flux.

**Preheating and soldering:** Preheating the joint comes next, using any suitable kind of torch. Play the flame over the fitting, not concentrating it too long at any one point. As most torches produce a flame that has a temperature considerably higher than the melting point of copper (1900 deg. F.), care must be taken to prevent burning a hole.

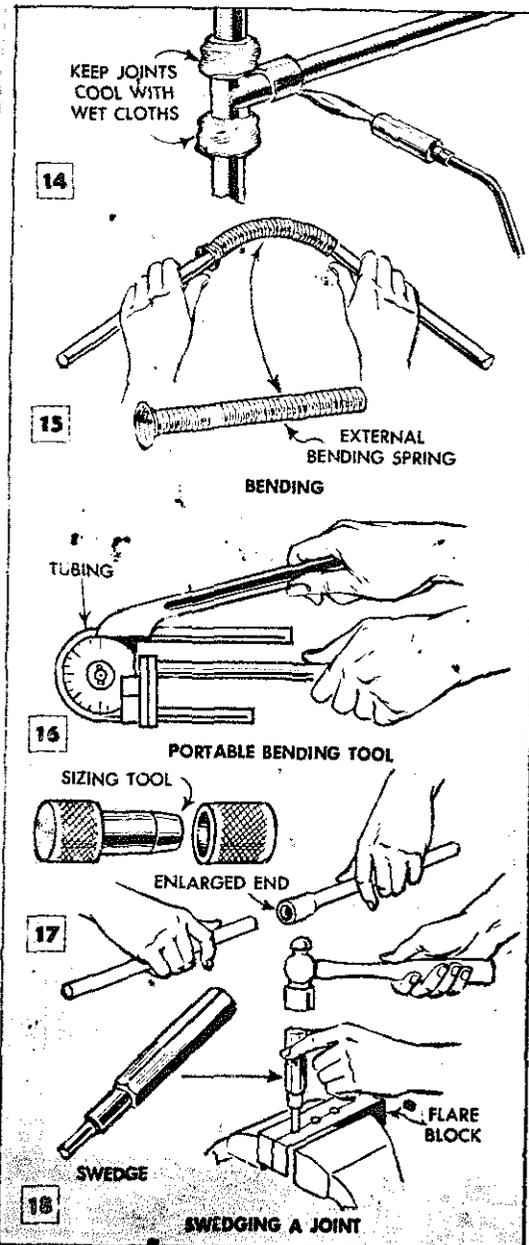
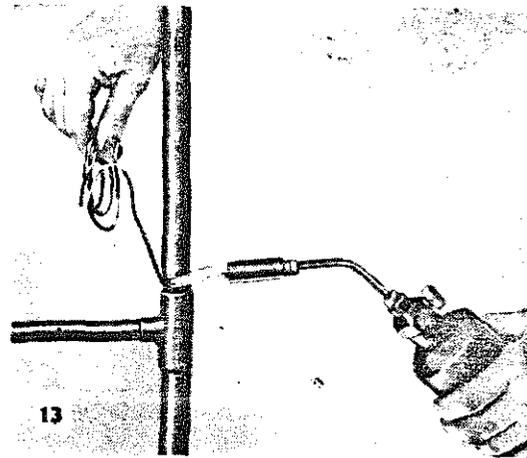
While heating, touch the end of a piece of wire solder to the edge of the fitting occasionally—outside the flame—to check for correct soldering temperature. This is reached when the solder liquefies immediately when touched to the fitting. Do not heat the metal above this temperature.

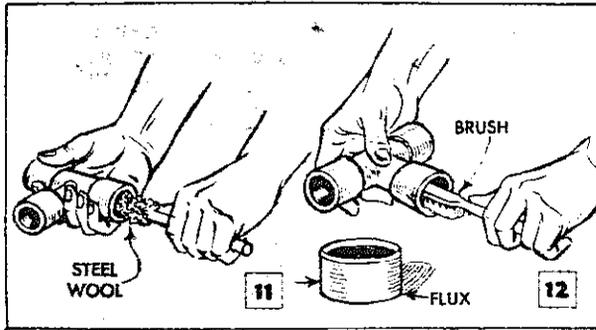
Next, feed the solder along the edge of the fitting, Fig. 13, while keeping the fitting hot. The solder is drawn between the contacting surfaces by capillary attraction no matter at what angle the fitting is held. Generally, the correct amount of  $\frac{1}{8}$ -in. wire solder to use per joint is a length equal to the diameter of the tubing.

Avoid getting solder all over the work. You can wipe off excess solder while it is still liquid with a moistened cloth but do not remove the bead from the chamfered ends of the fitting. Avoid movement of the tube or fitting until after the solder has "set" or hardened, since any disturbance before this time weakens the joint. To protect wood or other combustible material in the vicinity of the flame when soldering a joint, use a sheet of asbestos board or asbestos paper.

Whenever soldering tubing into a fitting which has other outlets already soldered into it, prevent the latter from melting loose by wrapping wet cloths around the joints to be protected as in Fig. 14.

**Solder to use:** Ordinary "soft" solder is





of the fitting) must be cleaned thoroughly with fine steel wool or emery cloth, rubbing the metal as in Fig. 11 until it is bright. Wipe the tubing clean, then apply a thin film of soldering flux, Fig. 12. Push the tubing into the fitting as far as it will go, then rotate it a few times to assure even distribution of the flux.

**Preheating and soldering:** Preheating the joint comes next, using any suitable kind of torch. Play the flame over the fitting, not concentrating it too long at any one point. As most torches produce a flame that has a temperature considerably higher than the melting point of copper (1900 deg. F.), care must be taken to prevent burning a hole.

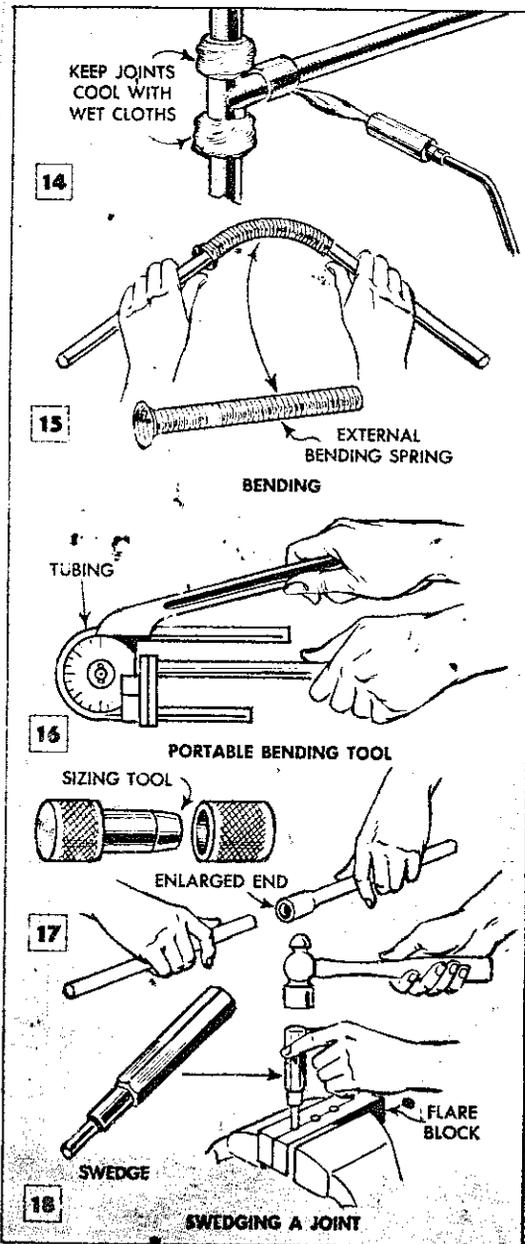
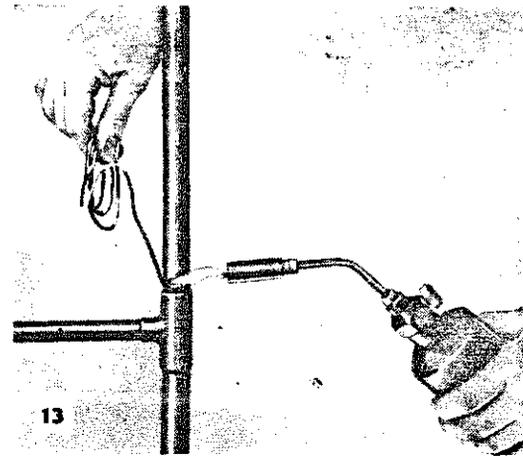
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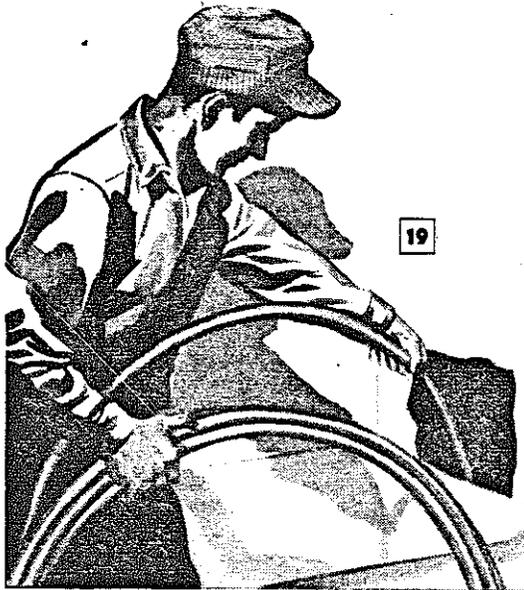
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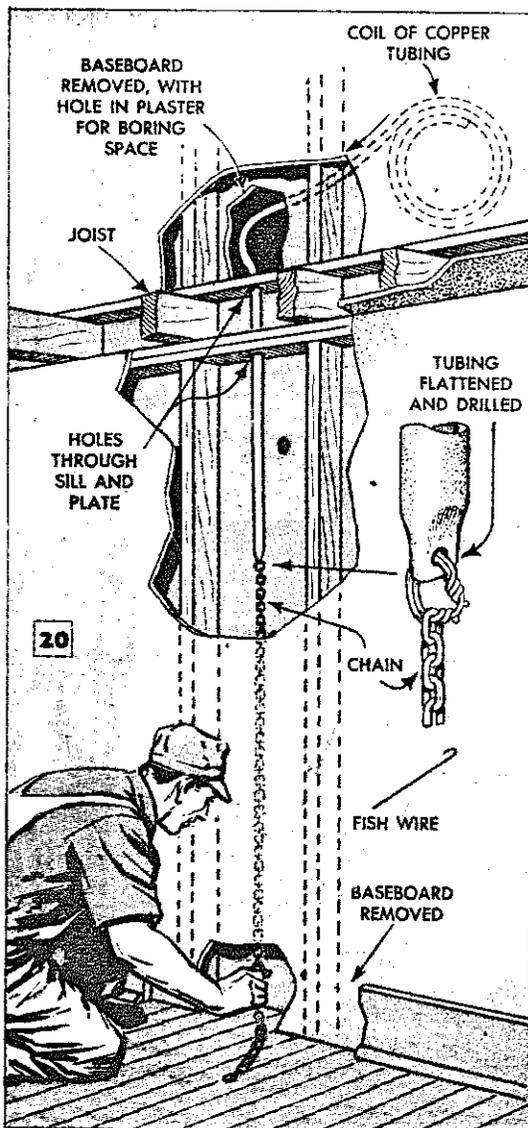
Whenever soldering tubing into a fitting which has other outlets already soldered into it, prevent the latter from melting loose by wrapping wet cloths around the joints to be protected as in Fig. 14.

**Solder to use:** Ordinary "soft" solder is





19



20

satisfactory where joints are not subjected to much strain or vibration and are not heated to temperatures above 250 deg. F. For producing stronger joints, use "hard" or brazing solder which flows at temperatures of 1300 and 1400 deg. F.

**How to bend tubing:** You can bend soft copper tubing by hand as in Fig. 15, using spring-steel bending coils. Bending coils come in various sizes, for either inside or outside application. For accurate, small-radius bends, use a bending fixture, Fig. 16.

When copper tubing is bent or otherwise worked, it becomes hard and brittle. Therefore, before rebending copper tubing, anneal it by heating to a dull cherry-red color, then quench it in water. Aluminum is annealed in the same manner.

**Swaged joints:** Lengths of tubing can be spliced together by swedging, thus eliminating the need for a coupling. A swedging tool of the proper size, Fig. 18, increases the diameter of tubing a short distance from its end so it can be fitted over the end of another length. The joint is finished and soldered in the manner already described.

**"Snaking" tubing through partitions:** Copper tubing usually can be snaked through partitions as shown in Figs. 19 and 20. Two workers are required for this job. Holes are bored through the top and sole plates of the partition, a length of chain is lowered from the upper to the lower opening and it is pulled through the lower opening by means of a piece of wire with a hook bent in the end. This arrangement permits the worker below to pull the tubing through the partition by pulling on the chain while the worker above feeds the tubing into the partition. If any cross-pieces or fire stops are encountered, it is necessary to open the wall at this point and notch the obstruction.

Horizontal lengths of tubing must be supported adequately with suitable hangers to prevent sagging at any point. The hard variety of tubing generally is used for long horizontal lengths.

**Buried copper tubing:** Copper tubing buried underground should never be run through cinder fill, especially where the ground is wet. The sulphur in the cinders attacks copper. Where such a condition exists, damage to the tubing can be prevented by wrapping it with canvas liberally coated with an asphalt compound such as roofing cement or roofing paint. The covered pipe then is surrounded for a distance of 1 ft. with a layer of sand mixed with lime or broken plaster in equal proportions. Compression fittings are preferred for underground work and should be tack-soldered for added security against loosening. ★ ★ ★

X 1988 C

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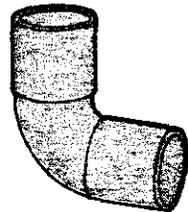
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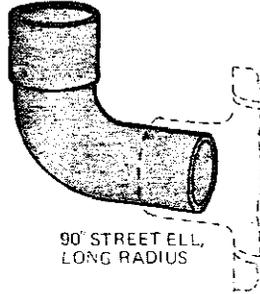
# How to work with copper piping

X198C

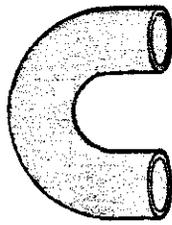
## TYPICAL PRESSURE FITTINGS



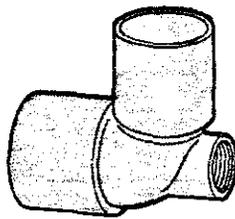
90° ELL. CLOSE ROUGH



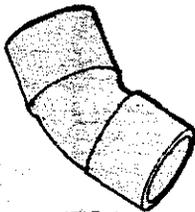
90° STREET ELL. LONG RADIUS



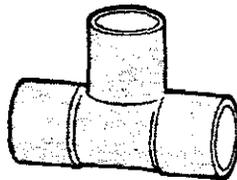
RETURN BEND



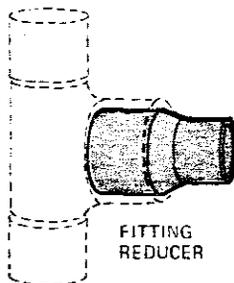
BASEBOARD TEE



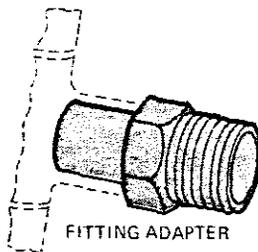
45° ELL



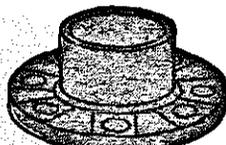
TEE



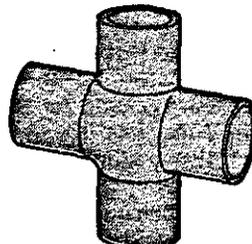
FITTING REDUCER



FITTING ADAPTER



COMPANION FLANGE NO. 125 STANDARD

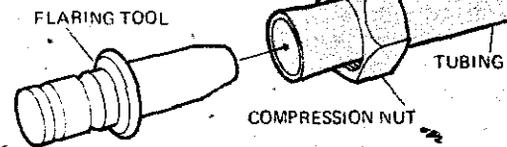


CROSS

Copper piping is light and extremely durable, requires no threading of the ends to join it, comes in varying diameters, wall thicknesses and degrees of hardness, and is suitable for both hot and cold-water systems. To join copper piping, there are many types of fittings to cover every part of the plumbing layout. A number of common fittings are shown at the left.

Copper pipe can be joined using either soldered (also called capillary or "sweat" joints) or screwed (compression fitting) joints. Compression joints are of two types. With the first, called a "bead" fitting, the tubing is pushed into the fitting, a bead of jointing paste is applied around the tubing in front of a compression nut, and the compression nut is tightened onto the fitting. The result is a watertight fit. The second type is called a "flare" fitting because the end of the tubing is funnel-shaped with a special flaring tool (below). This shaped end receives the male end of the fitting; the compression nut is then tightened to finish the connection.

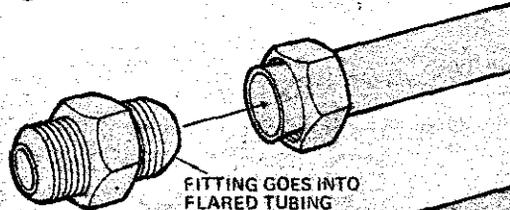
## FLARED JOINTS



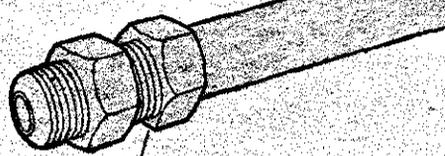
FLARING TOOL

TUBING

COMPRESSION NUT



FITTING GOES INTO FLARED TUBING



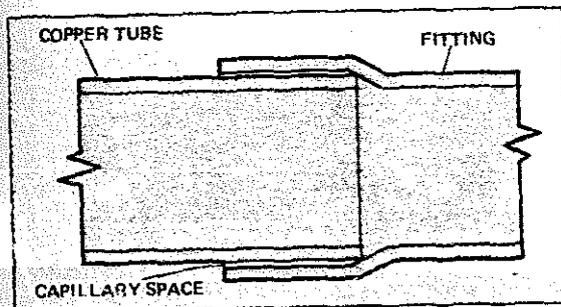
NUT IS TURNED ONTO FITTING TO CREATE A WATERTIGHT JOINT

## Types of copper piping

Type	Temper
K	Hard (rigid) or soft (flexible)
L	Hard or soft
M	Hard only

To be sure the type of copper piping that you use for a specific application complies with local plumbing code, always check with your local building department. In general, Type L can be used below ground, Type M above ground. For a superior installation, use Type K below ground and Type L above ground.

## Capillary or 'sweat' joints



Properly prepared, a sweated joint will provide many years of troublefree (nonleaking) service. Although your joint may leak the first couple of times you attempt to sweat pipe, you'll soon be sweating copper pipe just like a pro by getting a little practice under your belt and by following the rules outlined on these pages.

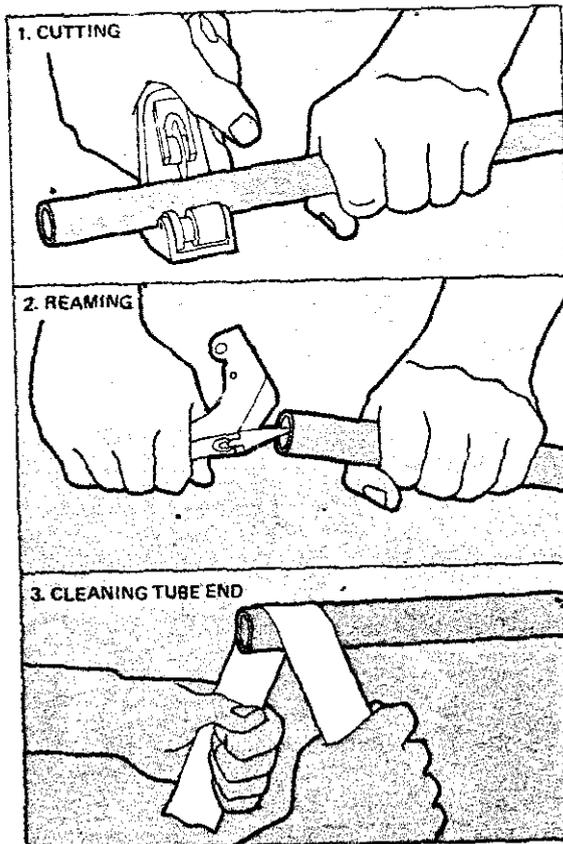
To understand the principles of sweating pipe, you should understand how capillary action works. When the end of a copper pipe is inserted as far as possible into a fitting, a small amount of space will remain between the inside wall of the fitting and the outside wall of the pipe. When the fitting is heated with a propane torch and solder is applied around the pipe at the outer edges of the fitting, the solder will be drawn into this space by capillary action, bonding the pipe and fitting together securely. Such action will be the result regardless of whether the piping will be running horizontally or vertically.

If you're repairing or adding to an existing copper piping system, remember that all parts to be joined first must be completely dry. After the soldering is done and the joint cooled to room temperature, test the work for possible leaks.

## Equipment needed

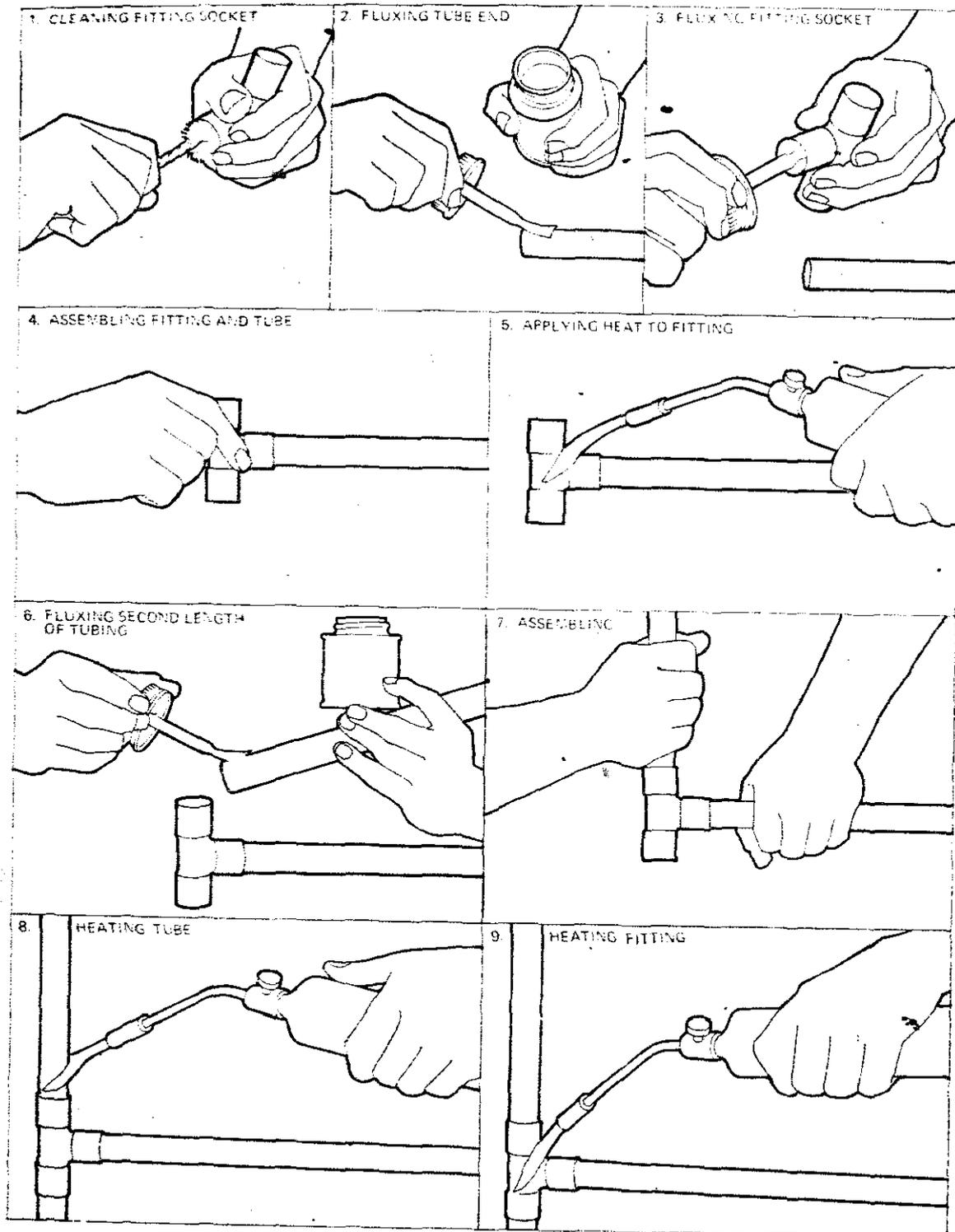
Propane torch	Tubing cutter
Hacksaw	with reamer
Smooth file	Sandpaper or fine steel wool
Tubing bender (also known as a "hickey")	Solder
	Flux

## Cutting and cleaning

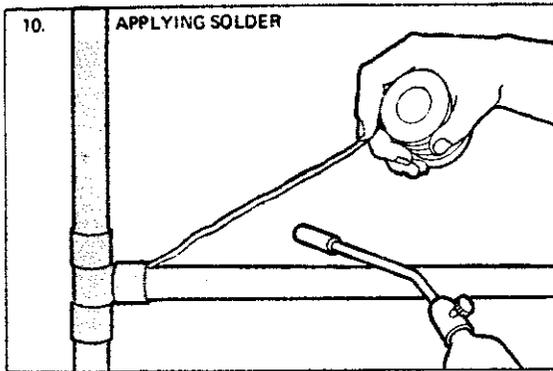


Cut pipe to length using a tubing-cutter (1) or a fine hacksaw blade. Make sure the cut is square and the pipe remains round and true. Cutting with a hacksaw blade leaves rough edges on the inside and outside of the pipe, while a tubing cutter leaves rough edges on the inside of the pipe. Remove burrs on the outside of the pipe with a smooth file or sandpaper and on inside of the pipe with a reamer (2) or rattail file. Clean the end of pipe with steel wool or a strip of sandpaper (3).

## Ten steps for assembling copper piping



Clean the inside of the fitting with a wire brush. A thorough cleaning is absolutely necessary because a "sweat" joint relies on capillary action and any dirt, grease, or surface oxidation on the pipe or the fitting will hinder the joining action. Because the pipe should fit tightly into the fitting, do not remove too much metal when sanding or the capillary space will be enlarged and the joint weakened.



### Assembling copper system

After you have thoroughly cleaned the inside of the fitting socket (Step 1, left), apply a thin coat of flux to the end of the pipe (Step 2) and the inside of the fitting (Step 3) with a small, clean brush. Then push the tubing tightly into the fitting (Step 4) and twist the pieces slightly in order to distribute the flux evenly. Wipe off any excess flux that remains and apply heat with a propane torch to the fitting (Step 5).

In the same manner, apply flux to the second length of tubing (Step 6), insert in the fitting (Step 7) and apply a flame to both the tubing (Step 8) and fitting (Step 9). Melt the solder from a spool of soldering wire around the tubing-fitting joint (Step 10, above).

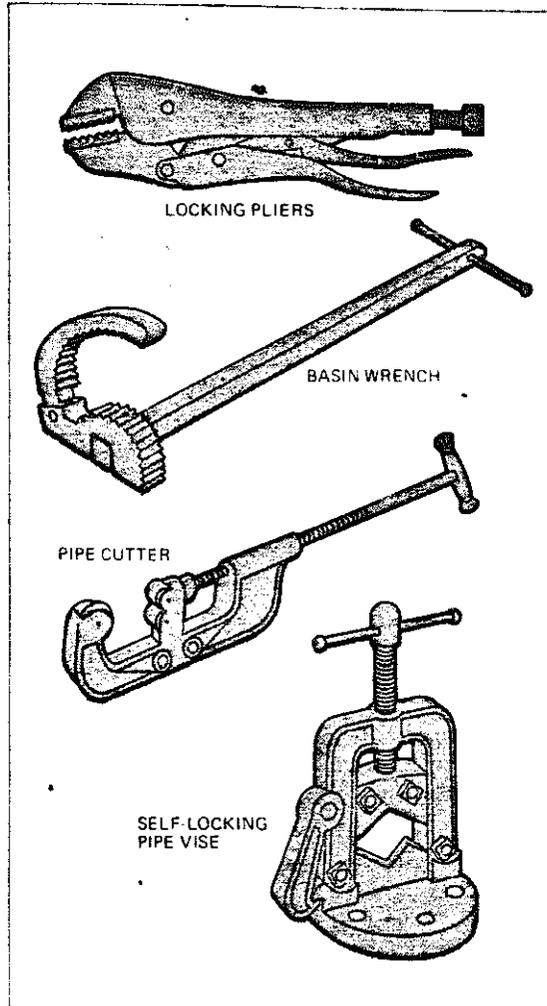
Flux for soldering is mildly corrosive. It contains zinc and ammonium chlorides in a petroleum base, and is used as a protective coating on the metal and as an agent to help the solder flow. Always stir flux before you use it.

The cardinal rule in choosing a solder is to buy a quality solder. Most solders for household plumbing jobs are composed of 50 percent tin and 50 percent lead. If the joint requires a solder of greater strength, use one comprising 95 percent tin and 5 percent antimony.

Do not clean, flux and assemble more copper piping than you can solder in about two hours.

### Soldering tips

Remember to align joints with adequate support before soldering, and to place no strain on them. When soldering, use torch with sweeping motion—tubing and fitting should be at same temperature for best flow of solder into joint. If solder forms lumps, joint is not hot enough. If there is no question that the joint is hot enough but solder still does not flow freely, overheating resulting in burned flux is likely, and the joint must be started again from Step 1. As soon as solder has set, use a wet brush or rag to crack and remove flux (remove it from inside of pipes by flushing with water); remove all flux before pressure-testing the joint—if necessary use a wire brush. If you have to redo a joint, reflux the entire joint area before applying heat to unsolder.



### Toolbox additions

If you plan on doing most of your own plumbing jobs, the four tools shown above can be valuable additions to your toolbox. The two pictured at the top are available at most hardware stores, while you may have to visit a plumbers' supply house to find the lower two.

Vise-grip pliers, with serrated jaws and locking nut, are especially useful when working with small-diameter pipes. A basin wrench, whose gripping head is adjustable, will save you many bumps and knocks on head and hands when you are installing a basin where there is little room for swinging ordinary wrenches.

A pipe cutter, which is faster and more accurate than a hacksaw when cutting iron or galvanized pipe, is operated simply by starting the cutter over the pipe, and, as it is revolved, tightening the handle gradually to deepen the cut. Thread-cutting oil should be applied to both the cutter and the pipe.

A self-locking pipe vise has V-shaped jaws that grip the pipe from both top and bottom. It eliminates the need for a helper to hold the pipe while you do the cutting. ★ ★ ★

X420A

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A project of Volunteers in Asia

Try Your Hand at Metal Spinning  
Popular Mechanics No. X420A

by: Sam Brown

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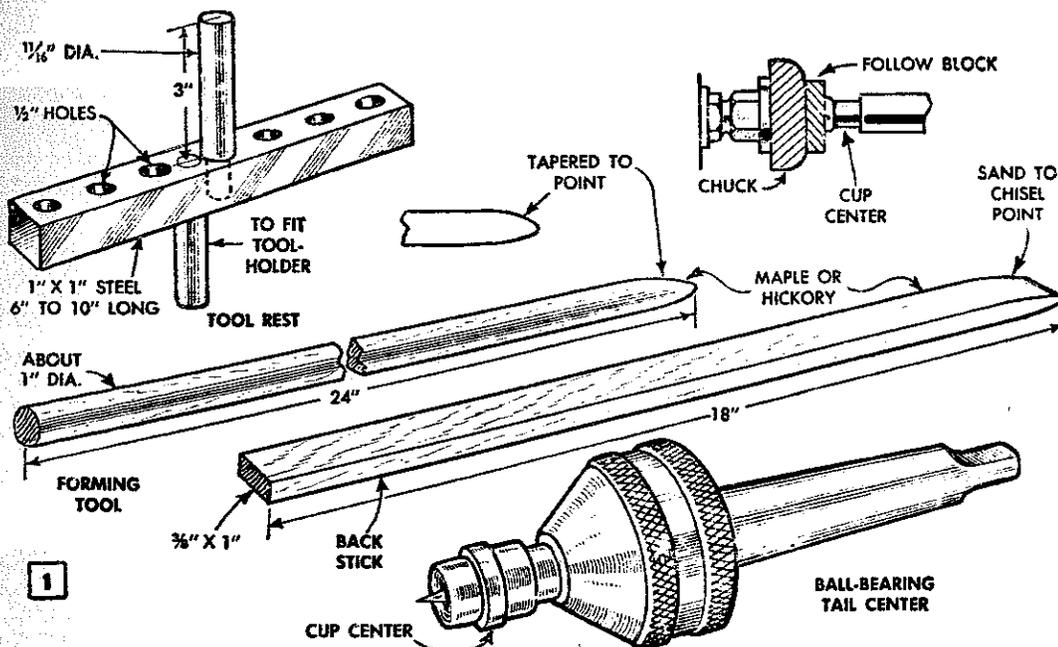
## Shop Notes

### TRY YOUR HAND AT METAL SPINNING

By Sam Brown

**I**F YOU BEGIN with soft aluminum and work it over a simple form you can spin a bowl in less than five minutes after the job is set up. Aluminum spins very easily and does not tend to score or buckle under the forming tools. It need not be annealed during ordinary spinning procedure as it will take medium-radius bends. It stretches to form tapers without cracking, and offers no undue resistance to flaring, beading and hemming. Pewter has similar characteristics but is rather expensive. For average work pewter is the easiest of all metals to spin. Copper and brass have much higher resistance to spinning and require frequent annealing.

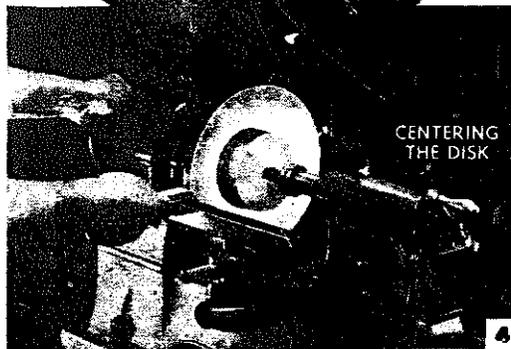
**Equipment:** For spinning simple projects in aluminum and soft copper, all the special equipment needed is shown in Fig. 1. Wooden forming tools generally are used on these metals. For more advanced work you would need a complete set of special spinning tools, but these are not necessary for the projects detailed. In addition to the



METALS	THICKNESS	ANNEAL	LUBRICANT	REMARKS
Aluminum	16 to 22-gauge. 18-ga. suitable for most work	650°—just chars pine shavings. Water or air cool	Any kind of lubricant can be used:  BEESWAX BURNISHING SOAP TALLOW TALLOW CANDLE CUP GREASE LAUNDRY SOAP	Low cost. Easy to spin. Annealing not needed for average work. Use ALCOA 25-O or equal (pure, soft aluminum)
Pewter	14 to 20-gauge. 18-gauge is most popular	No annealing required		Easiest metal to spin, machine and solder. Costs several times as much as aluminum—too much to be practical.
Copper	20 to 26-gauge. 23-ga. suitable for most work	1000°—black-red. Quench in water or air cool		Rich golden-red color often desirable. Resists spinning, hence thinner metal specified. Requires frequent annealing
Brass	Same as copper	Same as copper, except air cooling may be preferable	A dry lubricant, such as beeswax, is recom- mended	In general, same as copper, with in- creased tendency to crack and buckle. Requires very frequent annealing



3



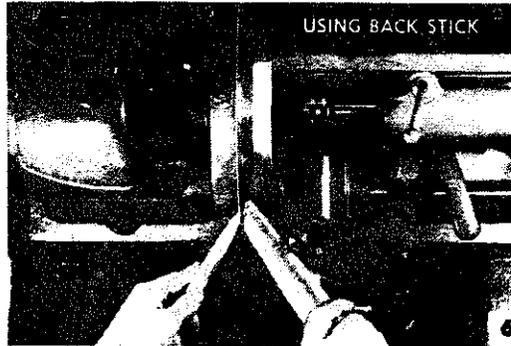
CENTERING THE DISK

4



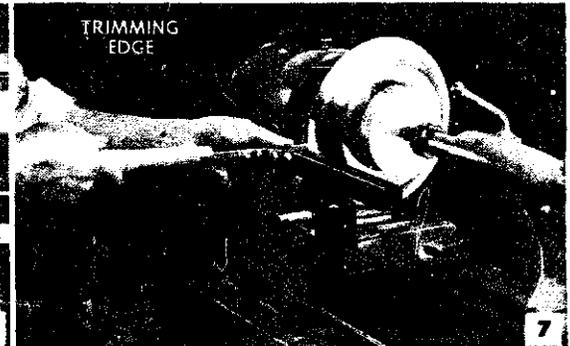
CATCHING THE FOOT

5



USING BACK STICK

6

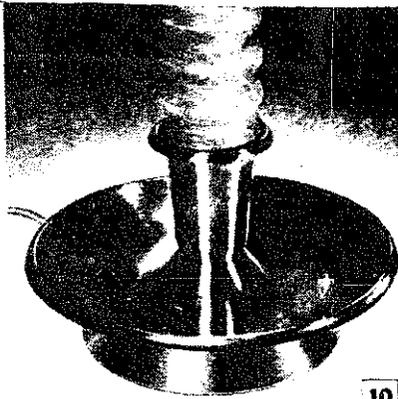
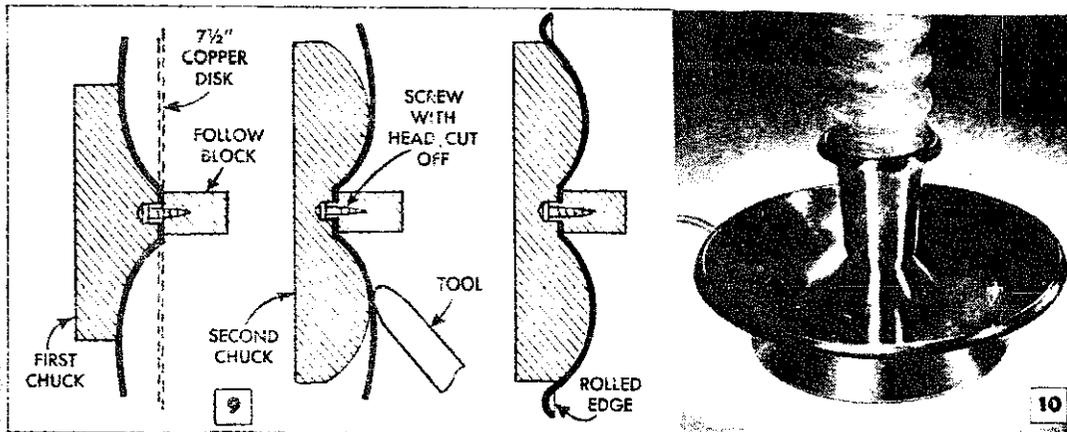
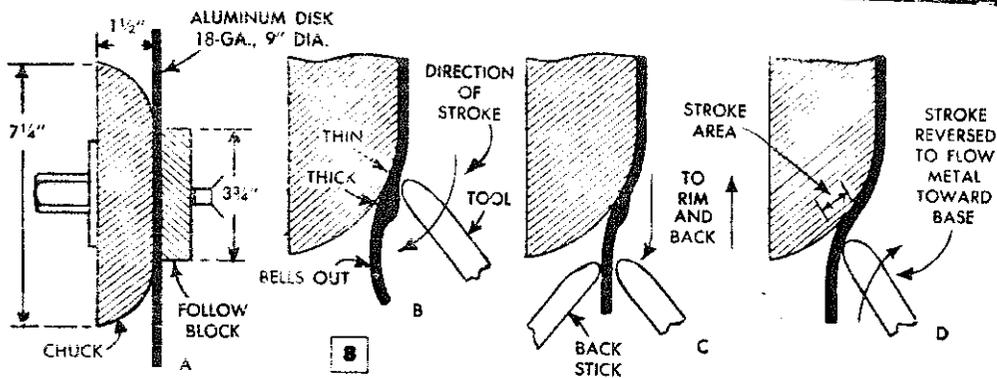


TRIMMING EDGE

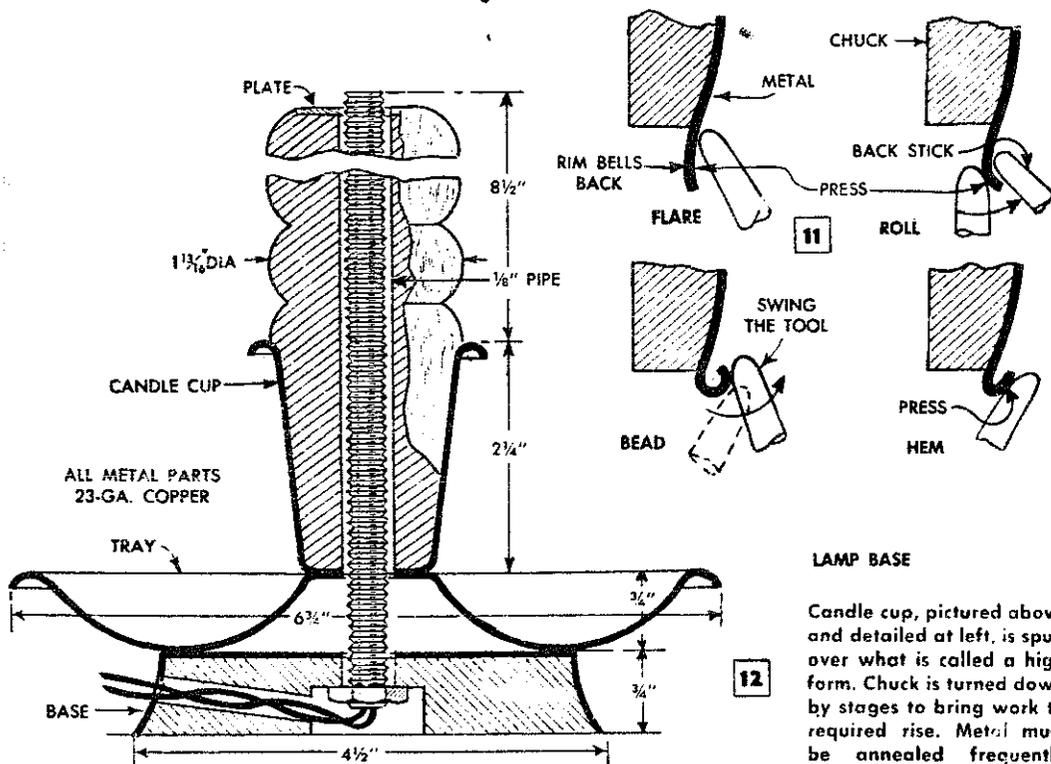
7

items shown you will need beeswax for lubricating the metal and glazing the hardwood chuck over which the metal is formed. Lathe headstock bearings should be in good condition as they must take fairly heavy thrust. If you plan several projects it will pay to purchase the ball-bearing tail center, Fig. 1. The ball-bearing center turns with the work and does not require frequent lubrication to prevent heating as does the nonrotating cup center. However, the latter can be used for occasional jobs. The special tool rest can be purchased ready to use or one can be made to fit your lathe as in Fig. 1. Also, you require the hardwood chuck turned to the form of the finished project. The chuck must be turned and sanded smooth and glazed with beeswax while in the lathe.

**How spinning is done:** Figs. 4 to 7 inclusive show how to set up and spin the popcorn bowl pictured in Fig. 3. Projects such as the bowl usually are referred to as low-form types and require no reverse chucking. After the metal disk has been cut to the required size it is centered between the chuck and the follower as in Fig. 4. Adjust the lathe to give a spindle speed of about 900 r.p.m. This speed can be used for nearly all average spinning projects on a small lathe. Begin by applying pressure at the base of the chuck as in Fig. 5, keeping the point of the tool in a small area not more than 1/2 in. wide. Aluminum begins to spin over the form

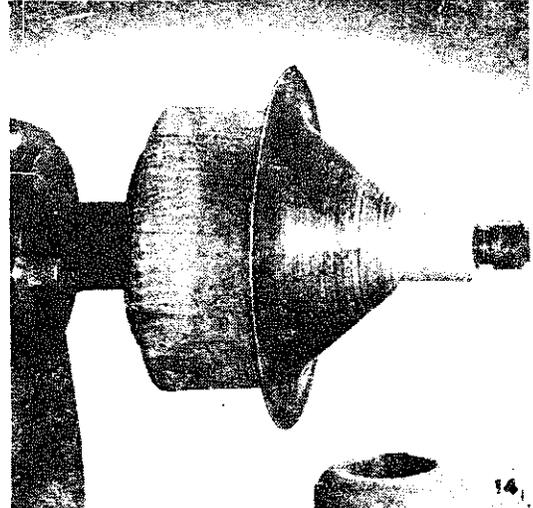
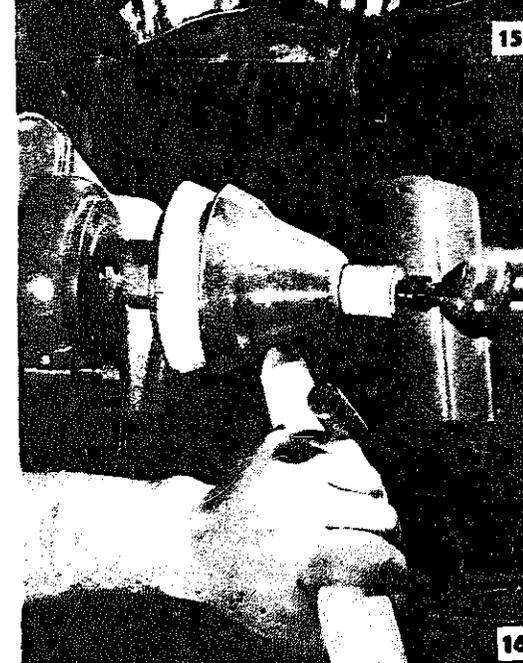
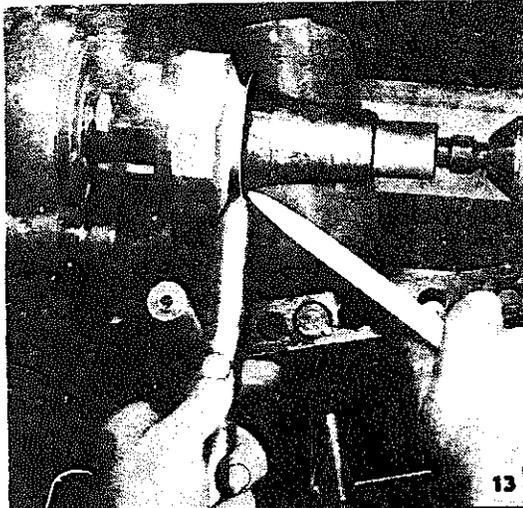


Lamp base in spun copper offers a good example of reverse chucking. Shape requires the use of a first and second chuck. Job is finished with a rolled edge or a bead as shown below. Roll is easiest



LAMP BASE

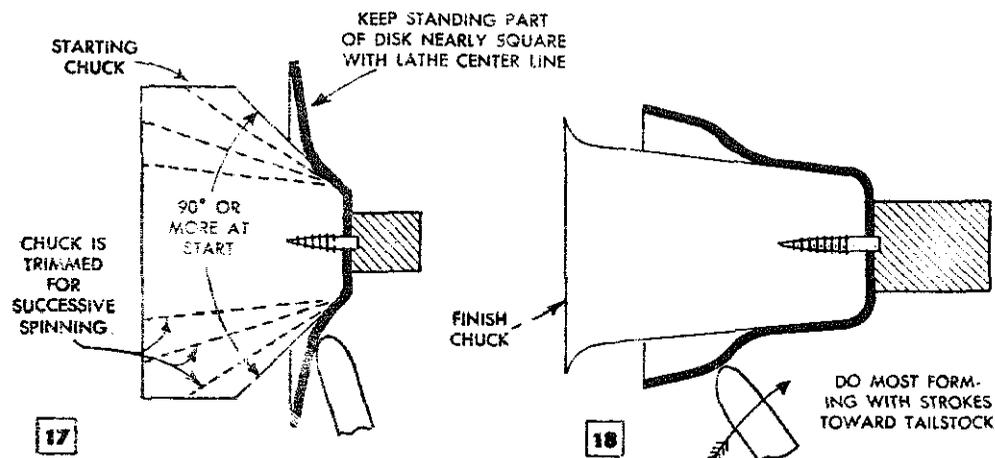
Candle cup, pictured above and detailed at left, is spun over what is called a high form. Chuck is turned down by stages to bring work to required rise. Metal must be annealed frequently



readily when pressure is applied, detail A, Fig. 8, but the rim bells back toward the tailstock as in detail B. Straighten the rim with the back stick as in Fig. 6 and the detail C, Fig. 8. When spinning the next  $\frac{1}{2}$  in. of metal onto the form, make the stroke toward the base of the chuck as in detail D, Fig. 8. From this point on the process repeats. Spin  $\frac{1}{2}$  in. of metal onto the chuck, straighten the standing edge, then continue spinning by  $\frac{1}{2}$ -in. stages until the bowl reaches its full form. As the final step trim the edge as in Fig. 7.

**Edges:** A flared edge forms naturally in the spinning process, Fig. 11, but the edge can be spun tight to the chuck and finished square if desired. The popcorn bowl, Fig. 3, has a flared edge. Applying pressure on the left side of the flare with the back stick will widen it or start a roll as in Fig. 11. This can be carried over to form a bead or pressed flat to form a hem, Fig. 11. Turning the roll over to form a bead requires considerable practice and the process is somewhat difficult to picture clearly in sequence. After the roll has been turned slightly more than that shown in the upper right-hand detail in Fig. 11, it is helpful to file a half-round notch in the end of the forming tool and use this to turn the bead to the full form.

**Copper lamp base:** This project, Figs. 9, 10 and 12 involves reverse chucking of the base and high spinning over a long form to shape the candle cup. Both parts of the base are of copper which must be annealed while spinning. These requirements put the job up in the professional class. Note the spinning characteristics of copper in Fig. 2. The tray requires reverse chucking detailed in the three steps in Fig. 9. With the experience acquired in spinning the popcorn bowl, you won't have any trouble with the lamp base and reverse chucking



the tray will require a little more time, but high-spinning the candle cup takes more skill.

**High forms:** Figs. 13 to 19 inclusive picture the procedure in spinning the candle cup on a high form. It will be noted that the rise of the curved portion of the cup is considerably greater than one third its diameter. This classifies the job as high-form spinning and means that it must begin on a starter chuck as in Fig. 17 and finish as in Fig. 18. In this case the chuck is trimmed for the successive spinning stages. The included angle of the chuck should be at least 90 deg. at the start. Some shapes will require a starting chuck of 120-deg. included angle. Each time the chuck is trimmed it is necessary to spin the metal down to the chuck throughout the full length, as otherwise you may experience trouble with cracking. Fig. 14 shows the first stage nearly complete; Fig. 16 pictures an intermediate stage and Fig. 13 shows the final roll-over being made at the rim. Copper "grows," or "builds," considerably as it is spun and must be held to a uniform stretch by making most of the forming strokes toward the tailstock of the lathe. Even with this precaution it may be necessary to trim the excess metal as in Fig. 19, when the shape nears the final form. Trimming off excess metal relieves stresses to some extent and may help to prevent cracking near the rim, a common trouble when spinning over a high form. Keep the work well lubricated with beeswax as the spinning progresses.

**Annealing:** When spinning copper over any form having even a slight rise it is necessary to anneal frequently. Pressure of the forming tool crystallizes (hardens) copper quickly. In average spinning procedure the change will be noted immediately by the operator due to the sudden



Metal spun over high form tends to stretch. Edge usually must be trimmed before spinning to final shape

increased resistance of the metal. When this occurs stop and anneal. Clean off the beeswax lubricant with turpentine and place the work over a gas burner as in Fig. 15. The temperature of the metal should rise until it "blooms" into colors and then turns black. A few seconds after it blackens remove from the flame and quench in water. In some cases it is advisable to permit the work to air-cool, especially when it is in the final stages of high spinning. The black scale left on the surface will do no harm and is easily removed in the final polishing operations. A quenching solution of five-percent sulphuric acid will keep the metal clean. *Caution:* Sulphuric-acid solution must be handled with care. Do not permit it to come in contact with the skin. Dispose of all unused portions. ★ ★ ★