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The host of PBS' the Woodwright's Shop builds a foot-powered lathe and jigsaw. By using recycled lumber he helps the environment, adds some 'new' equipment to his shop and impresses his daughter.

at the Loft

It all began when I went to pick up my daughter Rachell at the end of her freshman year at college. We had just finished loading her belongings when I spotted a pile of pine 4 x 4s and such in a nearby dumpster.

"What's all that wood?" I asked her.

"They're old lofts from people's dorm rooms, Dad, they're trash now in the dumpster please-let's-go!" she said, sinking a little in her seat. Her friends and classmates were all around, and I suddenly realized that this was a perfect opportunity to demonstrate my concern for the environment.

Wouldn't she be proud!

"Let's go take a look. They even have a bunch of carriage bolts with them! I could make a treadle lathe from all this!"

"It's trash-in-a-dumpster, Dad, let's-go-now. Please!" she said, pulling a sweatshirt over her face and sinking even lower. I guess the sun was bothering her.

"Come on! Let's show everyone how we don't let wood go to waste!" I said as I climbed up into the dumpster and began pulling old pizza boxes off the timbers. What a treasure! And best of all,

by Roy Underhill

Roy Underhill is the host of the television series, "The Woodwright's Shop," now celebrating his twentieth year of subversive woodworking on public TV. He is the author of five books on traditional woodworking, and for ten years he was master housewright at Colonial Williamsburg.

He travels extensively, teaching and studying the technology of the pre-industrial era.

SCHEDULE OF MATERIALS • FOOT POWERED LATHE

No.	Ltr.	Item	Dimensions T W L	Material
2	A	Legs	3 1/2" x 3 1/2" x 30 1/2"*	Pine
1	B	Foot	1 1/2" x 3 1/2" x 29 1/2"	Pine
2	C	Feet	3 1/2" x 3 1/2" x 29 1/2"	Pine
2	D	Stretchers	1 1/2" x 3 1/2" x 40"	Pine
2	E	Lathe bed rails	1 1/2" x 3 1/2" x 40"	Pine
2	F	Braces	1 1/2" x 3 1/2" x 34 1/8"*	Pine
1	G	Headstock rear	1 1/2" x 3 1/2" x 36"*	Pine
1	H	Headstock front	1 1/2" x 3 1/2" x 11 1/2"	Pine
1	I	Headstock pulley	2 3/8" dia. x 3"	Pine
1	J	Tailstock	3 1/2" x 3 1/2" x 12"	Pine
1	K	Tailstock wedge	7/8" x 1 1/8" x 6"	Pine
1	L	Tool rest	3/4" x 3 3/8" x 6"	Pine
1	M	Tool rest base	3/4" x 4" x 8"	Pine
1	N	Guide block	2 1/2" x 2 1/2" x 3 1/4"	Pine
1	O	Locking panel	3/4" x 2 1/2" x 5 1/2"	Pine
6	P	Flywheel	3/4" x 7 1/2" x 22 1/2"	Pine
3	Q	Flywheel	1 1/2" x 7 1/2" x 22 1/2"	Pine
1	R	Tie rod	3/4" x 1 1/2" x 13"	Pine
1	S	Treadle	3/4" x 3 1/2" x 29"	Pine
1	T	Connecting spacer	3/4" x 1 1/2" x 1 1/2"	Pine

*Length includes tenons.

Jigsaw

1	U	Table	3/4" x 9" x 23"	Pine
1	V	Front brace	1 1/2" x 2" x 11 1/2"	Pine
1	W	Back brace	1 1/2" x 2 1/4" x 18"	Pine
1	X	Bottom rail	1 1/2" x 3" x 22"	Pine
2	Y	Arms	1/2" x 2" x 22"	Oak
1	Z	Armature link	3/4" x 1 1/4" x 4 1/4"	Pine
1	AA	Index block	3/4" x 2 1/2" x 2 1/2"	Pine
1	BB	Locking panel	3/4" x 2 1/2" x 5 1/2"	Pine

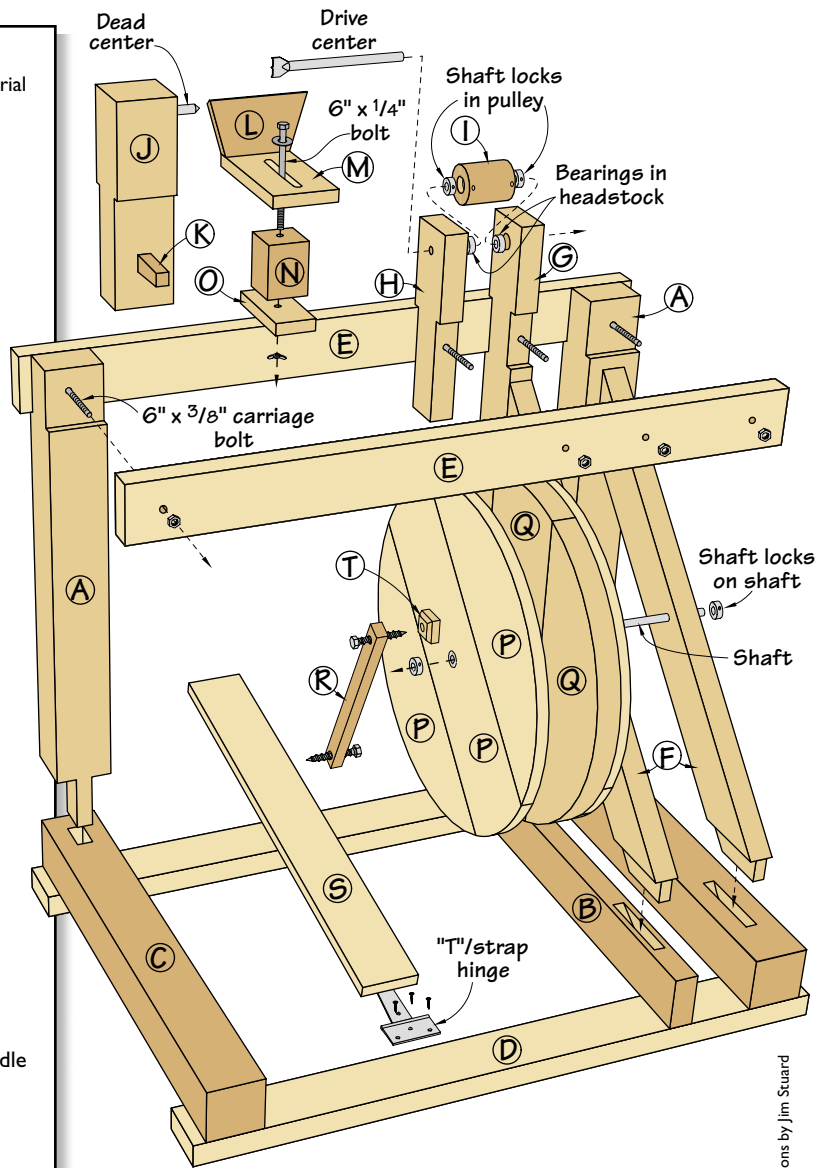
Hardware

Lathe

- 4- 1/2" stop collars
- 4- 1/2" thrust bearings
- 1- 1/2" fender washer
- 1- 1/2" x 36" steel rod (axle, drive & dead center, crank)
- 6- #12 x 4" wood screws for attaching stretchers to feet
- 4- 6" x 3/8" carriage bolts, nuts and washers
- 2- 3" x 3/8" carriage bolts connect tie rod, wheel and treadle
- 1- 3" "T" hinge for treadle

Jigsaw

- 2- 3 1/2" x 3/4" eye dia. x 3/16" thread, eye bolts
- 1- 3/16" thread x 2 1/8" turnbuckle
- 2- 1/2" bronze sleeve bearing (sawn into two 1/2" lengths)
- 2- 1 1/2" lengths of 1/2" shaft
- 2- Coping saw ends
- 1- 6" x 1/4" bolt, wing nut and washers for mounting saw.
- 1- 3 1/2" mending plate
- 1 1/2" thrust bearing



Illustrations by Jim Suard

when I had finished loading the timbers, I looked at Rachell and saw that her pride in her old man had moved her to tears! Sometimes even I do things right.

The Frame and the Flywheel

The salvaged timber was perfect for my new treadle lathe design. This new lathe would be much simpler than my old one, using an "inboard" flywheel with the connecting rod attached to its face, rather than

The frame is the easiest part of the machine. Essentially the frame is three L-shaped frames, two 2x4 base plates and two 2x4 braces. The two outside frames are made from two 4x4 posts, and one 2x4 with tenons at both ends. The top of the upright 4x4 is rabbeted on both sides to form an open bridge joint with the top braces. The flywheel frame is made of 2x4s.

to a crankshaft that was difficult to make and hard to repair. It would also have a jigsaw attachment and, most important, would be a woodworking tool that kids could make for themselves.

As I was to be the primary kid using this lathe, it had to come apart and pack up small enough for easy travel. The frame of my lathe is only 40" long for two reasons. First, these lengths are easier to pack when traveling, second, the scavenged 2 x 4s were 80" long. You can certainly make it as tall and as long as you want, the only essential is a clear path for the drive belt between the flywheel and the driven pulley. I also used mortise-and-tenon joints to connect the three L-shaped frames and their braces so I could quickly knock them apart. They could just as easily be con-





I trimmed the center of the flywheel sandwich to a close octagon, then attached one side and continued to shape the two pieces. I then attached the other side and worked the whole flywheel to its ultimate round shape.



Being a firm believer in handy scraps, I was able to use two fall-off piece to help me square up the shaft to the wheel, then mark the bearing location on the wheel.

as you can get, that gives you the diameter of the wheel, and the lengths you'll need for the nine boards of the sandwich.

The flywheel has to be heavy so it will store energy, and balanced so it won't shake the lathe about as it spins. A 3"-thick solid disc of even the lightest pine will be heavy enough, so put your energy into getting the wheel balanced. If you have any boards that are heavier than the others, try to distribute them in the sandwich to create an even balance around the center. Pay attention at this point and you won't have to attach any weights later on.

Start with the three 2 x 8s that will be the filling of your board sandwich, sawing them to length and then assembling them side by side into a 22½" square. Find the center of the square by connecting opposite corners with intersecting diagonal lines and then draw the largest circle you can fit in the square using trammel points or a stick with holes in it. I used a

nected with screws or bolts and attached permanently.

In the past, I have made lathe flywheels

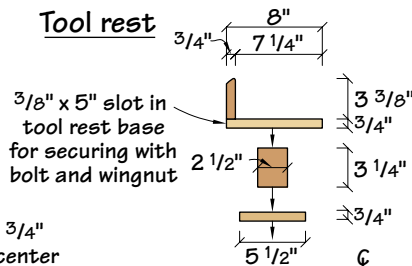
like wagon wheels, with hubs, spokes, fellows and such. Although they look nice, they work no better than this sandwiched disc made from 1 x 8 and 2 x 8 pine. Since a finished "eight-inch" board is 7½" wide, three of them laid side by side will give you a 22½"-wide total. Because this is as wide

SUPPLIES

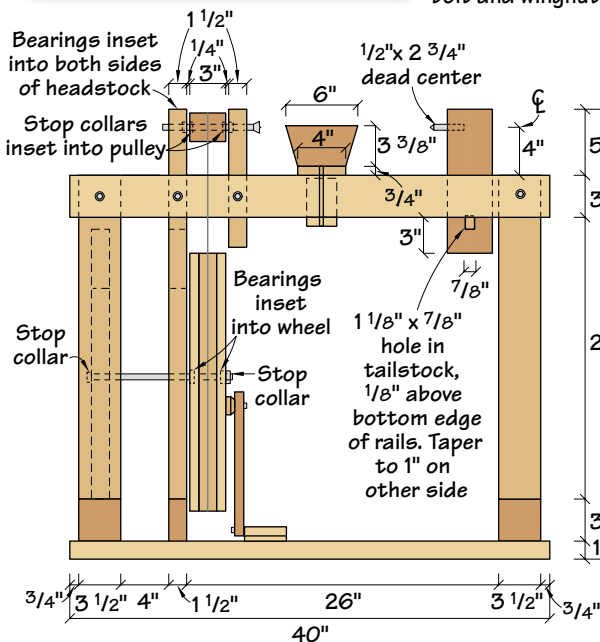
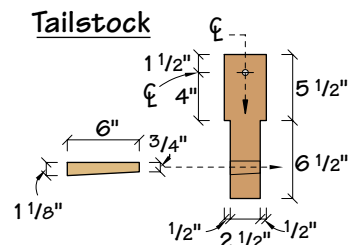
Bearing Distributors Inc.
513-761-0866
5 • Heim sealed bearings, item # RF8-18-12PP, \$8.50 each.

Grainger
www.Grainger.com, or check phone book for local branch
4- Shaft collars, Item # 2X568, 1.98/pkg. of 3.

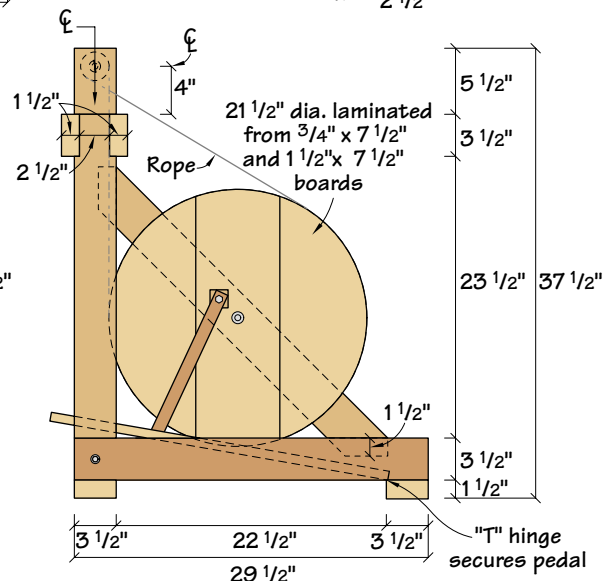
Tool rest



Tailstock



Elevation



Profile



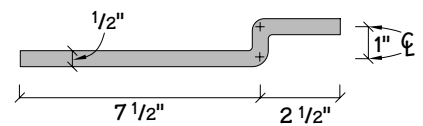
Carving the groove in the flywheel for the rope takes a little time, but the changes in end-grain direction makes carving easier than turning.



The connecting rod is attached to the treadle by a lag bolt screwed into the treadle side. The opposite end of the connecting rod rides on a $\frac{3}{8}$ " lag bolt screwed through a small block (to allow clearance over the stop collar) into the flywheel.

Jigsaw Crankshaft

Approximately 11" long jigsaw crankshaft with 1" offset to replace lathe drive center



thin-bladed turning saw to cut the circle, but you can also make a series of close cuts with a regular panel saw and then chisel and shave down to the line.

Because each of the three layers in the flywheel will be offset 60 degrees from the others, the grain on the edge of the assembled wheel is going to be headed every which way and complicate smoothing with proper edge tools. Therefore, I urge you to bring the middle layer of the sandwich true to a circle before attaching an outer layer with slathers of glue and finishing nails. You can then bring the outer layers true to the inner circle with a minimum of cursing.

Mounting and Truing

Having taken care to make a balanced wheel, you need now to hang it true on the axle. Find the center of the disc by repeatedly swinging arcs from the outside edge with the trammel or other stick you used to draw the original diameter. The center of these arcs is the center of your wheel. I used two cheap thrust ball bearings in the wheel, aligned as follows:

- Set an expansive bit so that it will

bore a snug hole for the bearing you intend to use, testing it on a scrap piece to be sure. Bore into the center mark just deep enough to inset the bearing.

- Now get a $\frac{9}{16}$ " auger and bore the rest of the way through the wheel. (As always, it's a lot easier to bore the larger diameter hole first and then center the smaller hole within it than it is to reverse the process.)

The object now is to inset the second bearing on the opposite face so that the wheel will not wobble on the shaft. Easy:

- Insert the first bearing in its socket and slide a length of the $\frac{1}{2}$ " shafting through it.

- Lay the wheel with this first bearing-side down. Slip the second bearing over the shaft so it slides down onto the upper face.

- Because the $\frac{9}{16}$ " hole extending through the wheel is larger than the shaft, you have enough play to push the shaft into a precisely square relationship with the face of the wheel. Check all around the axle shaft with several squares at once, and when you have it just right, carefully trace around the second bearing.

- Remove the bearing and the shaft and carve out the socket for the bearing with gouges and chisels. Even if you find you are a little out of square, you can correct the matter with shims and screws around the sides of the bearing.

With the wheel now running on its shaft, you can further balance and true it by holding the shaft in a vise and spinning the wheel. It doesn't need to spin like the wheel on a racing bike, just so it doesn't wobble and shake more than you do. I used the two teeth of a mortising gauge to lay out the $\frac{3}{8}$ " groove for the drive cord that goes all the way around the wheel. In theory, you could turn this groove into the periphery of the wheel as it spins, but considering the grain changes, you're better off carving.

The final finagling with the wheel involves mounting it squarely on the back braces of the lathe. Again, the fastest way to get it square is to bore the first hole through the innermost brace, set the long shaft into this hole, mount the wheel and then push and pull the shaft until the wheel is hanging with equal clearance all around. When the shaft is in the right position,

The two ends of the rope belt are butt-spliced by sewing back and forth between the two pieces. It only takes a minute or two with an upholstery needle. With time and use the rope will stretch and you'll need to cut and re-splice the rope.



smack the end with a hammer to leave a mark on the inside face of the second, outer brace to show where you need to bore the second hole. Finally, put a big fender washer between the wheel and the frame and stop collars on the ends of the shaft.

Of course the wheel doesn't do much without the treadle and connecting rod. The treadle simply attaches to the frame with a T-hinge at the back, and the connecting rod rides on a lag bolt set into its side, with the opposite end attached to the flywheel. Adjusting the attachment points of the tie rod to the flywheel and the treadle will partially determine the "mechanical advantage" (how high you have to lift your foot) of the lathe. A 6" motion at the end of the treadle seems about right for most work.

Headstock and Drive Center

The headstock consists of two extensions of the frame holding bearings. These bearings can be bronze or ball, but at least the left one must be a thrust bearing, meaning it is designed to take pressure along the length of the shaft as well as easing the shaft's rotation. You follow pretty much the same procedure used to align the bearings in the flywheel to make sure the bearings in the headstock are properly lined up.

Unlike the flywheel, the driven pulley needs to attach firmly to its shaft, as well as being readily removable. The stop collars inset into both ends of the pulley meet both of these needs; their greater diameter makes a firm connection to the wood of the pulley, and their set screws (reached through holes drilled through the pulley) allow you to remove and change the shaft as needed.

The wooden part of the driven pulley begins as a 3" section of pine 4 x 4. Find

the center of one end and bore a precise inset for a stop collar into the end grain. Now set a $\frac{9}{16}$ " auger in the center of this hole and bore through to the other end, stopping just as the end of the lead screw peeks out. Using this point to center the auger, bore the inset for the second stop collar into the far end.

The pulley is still just a square block at this point — not much good. Put the stop collars in place and mount the block between the headstock bearings. Hold a pencil in place on the end grain to draw a $2\frac{3}{4}$ "-diameter circle on each end. You can then remove the block and chisel down to these lines — assured that you have roughed in a pulley precisely concentric to the shaft. (It's kind of like shooting arrows at the side of the barn and then painting the targets around them — perfect every time.)

The roughed-in pulley is about to become your first turning job. Of course this means you need a belt to connect the flywheel to the pulley, and short of a proper bit of round leather belting (such as used on old sewing machines) you can get by with $\frac{1}{4}$ " cotton cord, joined with a square knot for the time being. Simply wrap the

rope around, pull it semi-snug and tie it off. Start treading and the roughed in pulley will spin so that you can turn it down to the finished size, using your regular turning gouges and an improvised tool rest. Once you get a smooth place turned, stop and move the rope into that spot, retying the knot tighter if necessary. Finally, turn a groove in the middle of the pulley for the belt to ride in. As with any lathe, the smaller the diameter of the driven pulley, the higher the speed and the lower the torque. You can, of course, just treadle faster or slower, and you can easily turn at over 1,000 rpm.

One peculiarity of this design is the crossed drive cord which creates the additional peculiarity of the flywheel going in the opposite direction as the driven pulley. The point of this crossing is to increase the contact surface between the belt and the small pulley. Without the crossed belt,



To sharpen the dead center for the tail stock, I slipped the bar into the drive pulley and tightened it down with the stop collars. Then it was a simple matter of turning the lathe and using a file to form the point. Note the crossed drive cord on the pulley which increases the contact on the pulley, keeping it from slipping during use.



The drive center is shown here being formed, with the jigsaw crankshaft lying next to it. After rough shaping, the center is filed and ultimately takes on its spade-bit shape. The center is then mounted in the drive pulley by tightening the stop collars.



or the addition of an idler pulley, the driven pulley would be constantly slipping. You can further reduce slipping by making the rope sticky with just about anything containing sugar. I use maple syrup with great success.

When the pulley is turned as smooth as you need, finish it by first drilling the holes through its sides to give access to the set screws in the stop collars. After the holes are done and tested, run some glue around the seats for the stop collars and, with the shaft in place, set the stop collars back in for the final time. You can continue with the knot in the rope to let it stretch and until you get an idea of how much tension it needs. Eventually, though, you'll want to butt-splice the rope.

Tailstock and Dead Center

Now for the second piece of turning — the dead center for the tail stock. The dead center is just a short length of the 1/2" shafting with the business end sharpened to a precise conical point. The angle of the cone is not critical, but its concentricity is. If the point is the least bit lopsided or

rough, it will quickly enlarge its contact point with the wood being turned and will be a constant source of trouble. So, although you can quickly rough in the point by freehand filing, the final shaping needs to come from mounting it in the driven pulley, (before you cut it into the 3" length that you need), tightening the stop collars and bringing the end true with your file held against the spinning point. After

this, you'll be able to tell folks how your treadle lathe works for turning metal as well.

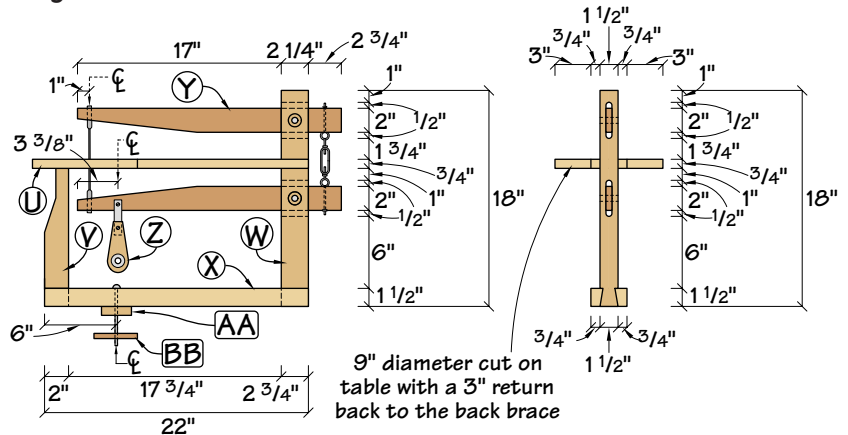
Would that the drive center was as easy. The drive center needs to grip the end of the wood being turned, and has somewhat the shape of a spade bit. Having anvils and forge about, it was quickest for me to simply heat, hammer and file the end of the shaft into shape. This may be the most awkward part of the lathe for you (kid or not) to make. Although you can cold hammer the drive center into shape, you will need a good red heat to make the sharply bent crankshaft for the jigsaw attachment. Minimally, you can do the job yourself with a torch, a hammer, a vise and something to use for an anvil. The path of wisdom, however, may be to support your local blacksmith.

With the drive center in place, all that remains is the tool rest, which can be a full length bar resting on outriggers attached to the head and tail stocks, or a smaller L-shaped construction attached by bolt and wing nut, or both. The tailstock is attached with a wedge.

Turning

Using the lathe is just the same as with any other alcohol-powered equipment. Rough in the stock to an octagon before mounting it between the centers, being sure to rub some beeswax in the hole for the dead

Jigsaw





The bent crankshaft is attached to the jigsaw through a hanging armature link. The mount is attached to the jigsaw with a piece of steel strapping screwed into a saw kerf in the mount, and attached loosely to the lower jigsaw arm.



An L-shaped tool rest is shown here attached by bolt and wing nut to the lathe frame. The tailstock is best attached with a wedge. This is the fastest and the firmest way to move and mount the tailstock. The wedge gives just the right "pinch" to the wood being turned if you slightly cock the bottom of the tailstock towards the center before tapping the wedge home.

center. If your bearings are too cheap and have so much play in them that the work chatters when you're turning, you can compensate a bit by adjusting your cutting style to put more of a "push" from rubbing the bevel. Bronze bearings may have less play than cheap ball bearings. You can even turn the bearings slightly out of square with the shaft to tighten them up.

Still, machines tend to give you problems at places where motion changes direction, like when car engines "throw a rod," the conversion of the reciprocal motion of your foot on the treadle into the rotary motion of the flywheel is a potential trouble spot. Just as a car needs accurate timing, so too does the foot operating the lathe need timing, as a sudden stop in the foot will meet with considerable resistance from the flywheel, snapping the connection at the end of the tie rod. You will develop considerable expertise with this lathe, but it is so inviting for others to try that you will have a lot of inexperienced feet on it, they will snap the bolt, and excuse themselves by making a com-

ment about "walking and chewing gum at the same time," so keep a few spare bolts on hand.

Jigsaw

As if this treadle lathe were not cool enough, now you can make the jigsaw attachment that sits atop it. Curiously, the jigsaw is basically a way to convert the rotary motion of the flywheel and pulley back into reciprocating motion of the blade. This conversion requires that you loosen the set screws in the stop collars of the driven pulley, remove the drive center and replace it with a crankshaft. Unless you are Superman, you cannot bend these sharp angles in cold 1/2" steel shafting — you'll have to heat it with a torch and bend it in a vise.

The frame of the jigsaw is quite straightforward. I used big dovetails for the front and back posts as the best combination of strength and quick disassembly. The arms

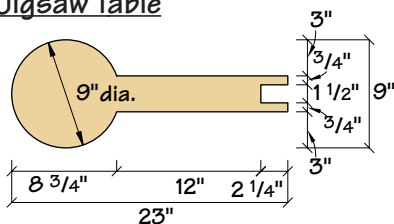
of the jigsaw are the only pieces that aren't scrap pine; they are scrap oak for strength. They have to be strong because the turnbuckle at the rear must tension the coping saw blade at the front.

I have seen many homemade jigsaws from the past century, and every one used the blade holders from an old coping saw. Often the maker would just hacksaw off the arms of the coping saw and bolt them onto the ends of the jigsaw arms. This has the advantage of allowing you to turn the blade at right angles to the arms when necessary for clearance.

It's quite a spectacle when this whole thing is going. The flywheel looks like something off of Fred Flintstone's car, the bearings are rattling, the drive rope twanging, and the jigsaw jumping as your knee goes up and down.

But there at the business end, the saw cuts along beautifully, the lathe turns like a top. Won't the kids be proud! **PW**

Jigsaw Table



The turnbuckle is right off the shelf, with the addition of a lock nut to one of its eyebolts (obviously not the one with the left hand threads). Without the lock nut, the turnbuckle will work loose in seconds. I also inset a bronze bearing (sawn into a 1/2" length) into each of the arms at their pivot points. This is not so much to reduce friction in operation as it is to keep the wood from wearing and again loosening the tension on the blade.

