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Building Arrow Shafts
by:
Master Rumil Fletcher

Building Arrow Shafts

While most archers have the equipment to assemble arrows out of pre-made components, few have gone the extra mile to construct those basic components. In pursuit of historical accuracy, stronger arrows, or a desire to build more attractive arrows, some archers would like to cut their own arrow shafts. But most are reluctant to do so because of the apparent difficulty in producing a good, straight, smooth shaft. Cutting your own is not as difficult as you might think. The key is to first construct a jig that gives you the control you need. Without an arrow making jig, cutting shafts can be a frustrating enterprise; one that will usually produce badly shaped, oblong, or oval cross sections instead of round arrows.

We will discuss here two kinds of jigs. The first is for the purist who wishes to build his arrows using period techniques. This method is slow and can be tedious. But it provides you with a sense of accomplishment that can only be achieved from hand-crafted workmanship. This method also allows for more flexibility, as you can cut them to any diameter, or taper them, or even make them thicker in the center of the shaft's length.

The second kind of jig is for those who lack the patience to hand craft individual arrows, or who wish to construct dozens or hundreds of shafts for distribution. It introduces the use of a plunge router to do the cutting instead of a hand plane. This method will produce quality, consistently machined arrow shafts in mere seconds, compared to the many minutes it takes to hand plane a shaft.

I will not presume to tell you which method is right for you. But I can assure you that I have used both to make arrow shafts, and both methods do work. I have also included sections on safely cutting arrow blanks for use in both jigs, and a section on selection of woods.

Rumil Fletcher

Bibliography

Jay Massey, *The Traditional Bowyer's Bible Volume One*, 1992, Bois d'Arc Press, Azle, Texas, USA, p. 299-314.

Jay Massey, *The Traditional Bowyer's Bible Volume Two*, 1994, Bois d'Arc Press, Azle, Texas, USA, p. 227-229.

Patrick Spielman, *The New Router Handbook*, 1993, Sterling Publishing Co., Inc. New York, USA, p. 201-203.

Roger W. Cliffe, *Table Saw Techniques, Revised Edition*, 1997, Strong Publishing Company, New York, U.S.A.

Aidan Walker, *The Encyclopedia of Wood*, 1989, Quarto Publishing Inc., London, England p. 82, 97, 98, 115, 117, 122, 130, 138.

Cutting Arrow Shafts the Period Way

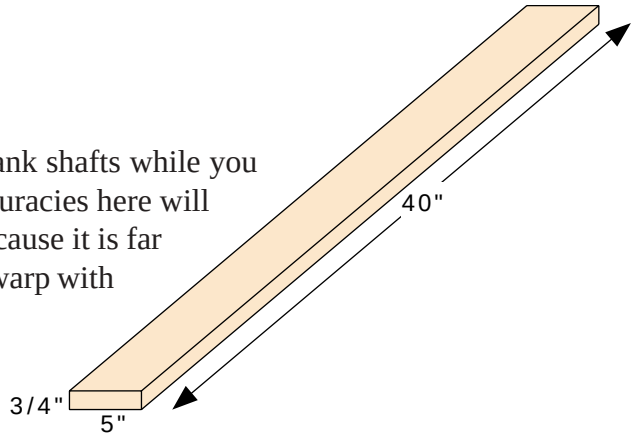
Tools and Materials Required

- A table saw with a sharp blade
- A hand drill
- Drill bits 5/16", 11/32", and 23/64" diameters (For the test template. If you have a hole gauge, you do not need these.)
- A hand plane with 2" wide blade (If you have a planner of another width, you may use it if you adjust the dimensions below to match it.)
- 2 or more clamps
- MDF (Medium Density Fiberboard) 3/4" x 5 1/2" x 40"
- MDF 3" x 5" x 3/4" (To build the test gauge.)

Warning: Construction of this jig involves the use of power tools, which can be dangerous. If you are unfamiliar with the use of power tools, get some competent help to show you how to use them safely.

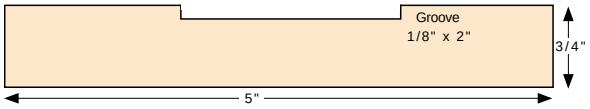
Building the Jig

The hardest part of this process is building a jig to hold the blank shafts while you cut them. Attention must be paid to this, as mistakes and inaccuracies here will translate into deformed shafts later. MDF is used for the jig because it is far more stable than wood. Wood will expand, contract, and even warp with changes in humidity. MDF is far less likely to do so.



1. With your table saw, cut the MDF to size. Make sure the sides are perfectly straight and parallel. This is critical. Next cut off two strips from this board down its length. They should be about 1/4" thick x 3/4" wide x 40" long, leaving you with a board 5" wide. These two strips will be used later as rails for the hand plane.

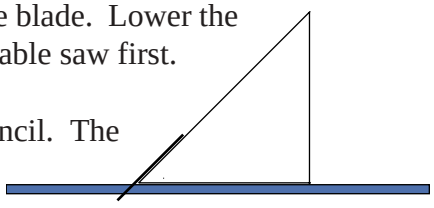
2. Cut a groove down the length of the jig, centered. It should be 1/8" deep x 2" wide. Set the fence on your table saw to cut one side of the groove, then move it 2" over to cut the other side. Remove the material between the two cuts by making successive cuts, moving your fence over 1/16" for each cut.



Cutting the Grooves

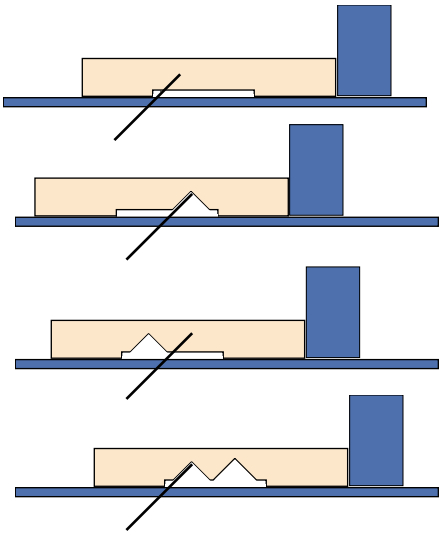
Next, you will cut two "V" grooves inside the shallow groove. This will provide a place for the arrow blanks to rest while you cut them. I strongly suggest using a couple of scrap piece of MDF a couple of feet long to test your cuts on before you cut the real thing. If you are off by a fraction of an inch, it could ruin your jig. Most authorities suggest using a single "V" groove to hold the arrow blanks. This design uses two grooves of different depths for two reasons. 1) With a single groove, a 3/8" blank is too large to fit under the planer in a groove that is also small enough to allow cutting a 5/16" shaft. Trust me on this; I did the math. 2) By using two grooves of different depths, you can rapidly switch the depth of cuts by switching grooves without having to adjust the plane's blade depth.

3. Angle the blade on your table saw to exactly 45 degrees. To do this, raise the saw blade all the way up. Angle it until it is about 45 degrees. Then use a carpenter's "speed square" to measure it for accuracy. Adjust the blade until it just barely touches the square at both the bottom and top of the blade. Lower the blade. When working closely with the saw blade like this, always unplug the table saw first.



4. Mark on the end of the jig where you wish to cut your V grooves with a pencil. The marks should indicate two "V"s. The depth of the "V"s from the top surface of the wood should be 35/64" (0.54") and 31/64" (0.48"). The depths of these cuts are important.

5. Turn the MDF jig upside down on the table saw and position the fence for the first cut. Raise the table saw until it matches the pencil mark. Cut all the way from one end of the jig to the other.

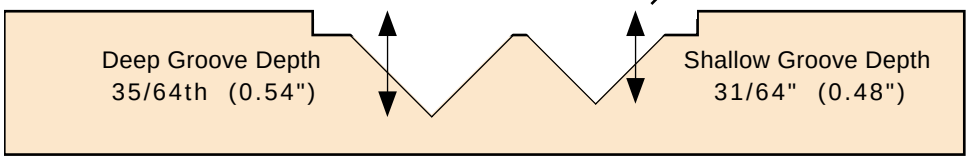


6. Flip the jig lengthwise. Move the fence so the next cut will match the tip of the first. This will result in a "V" cut into the jig that is exactly a 90 degrees angle, and offset 45 degrees from parallel with the jig surface.

7. Turn the jig around to its original position. Position the fence to match a pencil line on the second "V" cut and make the cut.

8. Flip the jig around lengthwise again. Position the fence to match the blade with the last cut, then cut all the way down the length.

9. Flip the jig upright. The cross section should now look like this.



Adding the Rails

10. To keep the blade of the plane from digging in to the sides of the jig, you will need to add a rail to each side. Place your hand plane on the jig where the blade sits in the groove. Move it to one end.

11. Position the two rails to either side of the plane where they touch without rubbing. Tack the rails down at that end.

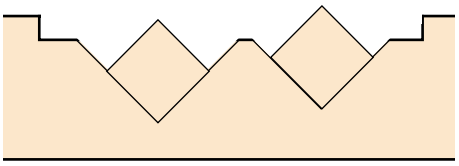
12. Move the plane down to the other end. Position the rails where they barely touch the plane. Tack the rails down here.

13. Reposition the place at intervals of 8 to 12 inches over the jig. Tack the rails down at each point.

Adding the Stops

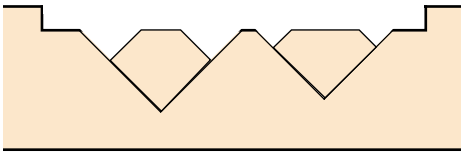
Next you need to make a stop for each groove to prevent the blanks from sliding out as you plane them.

14. Using the table saw, cut two pieces of scrap wood to 2" x 3/8" x 3/8". These shall be the stops to be inserted in one end of each groove.



15. Glue these stops into the "V" grooves at one end of the jig. It should now look like this in cross section. Allow to dry overnight.

16. Set the hand plane into the shallow groove, and plane off the top of the two inserts.

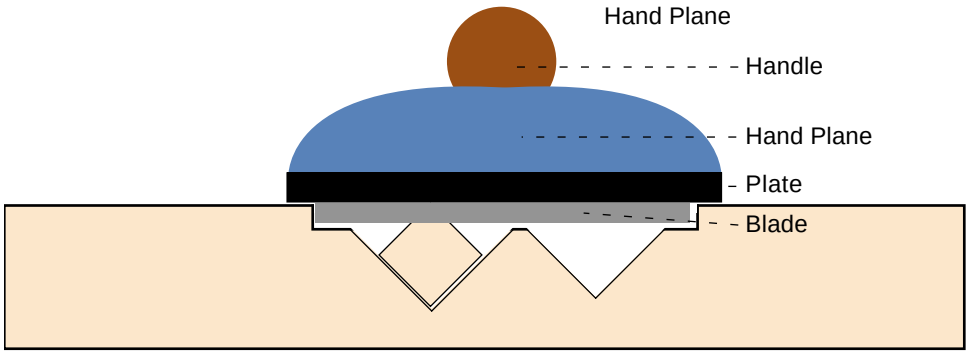


17. To fully secure the stops, hammer a short brad through the top of each stop into the jig base. Use a countersink punch or a thick nail to force the top of the brad below the surface of the wood. Failure to do so could result in the blade of the planer striking the top of the nail.

18. You need one more piece of gear to test the size of your arrow shafts. Take the 3" x 5" x 3/4" MDF or plywood and drill evenly spaced holes in it. The holes should be 5/16", 11/32", and 23/64" in diameter. Label them for size. Alternately, you could simply drill these holes into the jig itself in some unused location. The problem with this is that you have to move the jig to run the shaft through the hole. To test the arrow thickness, simply run the shaft through the hole of the desired size. You will easily be able to see where it needs to be planed off some more.

Planing the Shafts

Before you can start planing the shafts, you must first cut some blanks. See the section in this article on how to safely construct blanks.

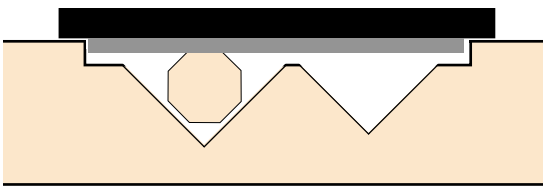


Once you have a number of blanks to work with, it is time to work the blanks into shafts. The first step is to bring the blanks down to close to the finished size. You don't wish to do it all at one time or you will get an oddly shaped shaft. In this function, you will want to tightly clamp the jig down to your workbench. You may also find it useful to use a hand clamp to hold the blank in the groove at the stop end to keep it from coming up and out of the jig. But you will only need to do that if the wood is curved or warped slightly. You would be better off if you rid your shafts of curvature before you plane them, as the planing process will remove any heat or tool marks from straightening your shafts.

Another point of considerable importance is the direction that you plane the wood. You always want to plane it in such a way that the grain, if it is not perfectly aligned with the shaft, is slanting up at the stop end of the shaft. By doing so, the planer will not tend to "dig in" to the wood. The resulting cuts will be smoother and easier to produce. This also means that you will have to switch ends of the shaft when cutting opposite sides of the shaft.

1. Place the blank into the deeper of the two V grooves. Place a clamp at the lower end and middle if you need to. Adjust the blade of your hand plane to take the corner off the blank. Be very sure after each cut to sweep any shaving out of the groove. Such material will slightly raise the shaft off the bottom of the groove, producing a slight "rise" in the shaft, which will cause the blade to take off more material than it should.

2. Run the plane down the length of the blank. Make sure you took enough of the corner off to eventually make the blank into an octagonal shaft. But do not take too much in each slice. In hardwoods in particular, it is easy for the blade to dig in and gouge the wood if your cuts are too deep.



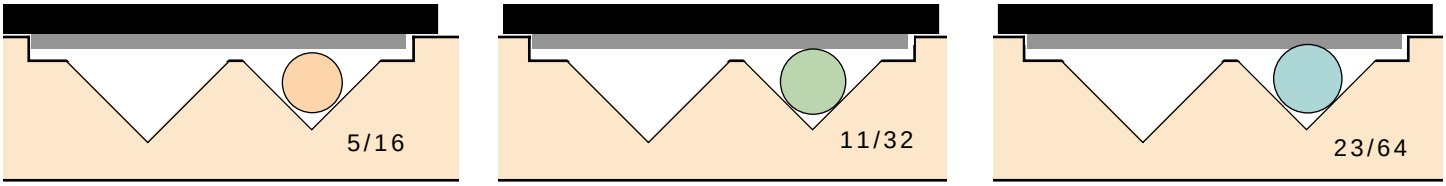
3. Rotate the blank 90 degrees. Run the plane down the shaft again.

4. Rotate it again and plane.

5. Rotate a fourth time and plane. Your blank will now have eight sides, but four of them will be longer than the other four. Move the shaft to the shallower of the two grooves and repeat steps 1 through 4. This will take a little more off.

6. Examine the end of the shaft to see if it needs more material removed. If it does, adjust the blade of the planer

to cut a bit deeper, then move the shaft back to the deeper groove and repeat steps 1 through 5. Repeat this as required until all eight sides are fairly equal in length.



Final Shaping

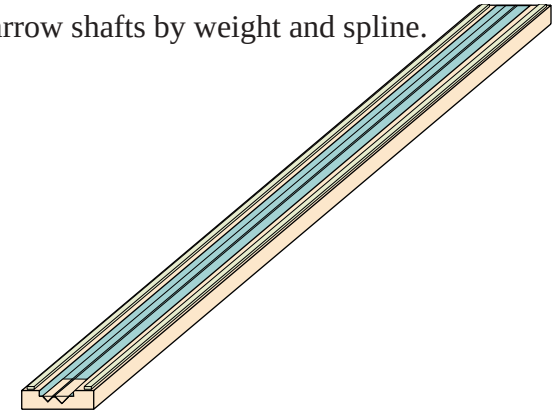
7. To turn the eight sides blanks into a round shaft requires patience. Place the shaft in either of the grooves and adjust the blade until it just barely touches the wood. Take off a tiny portion of the shaft.

8. Rotate the shaft as required, examining the ends after each cut to see where material needs to be removed. Be sure to place that part at top so it can be planed off. You may find is useful to switch back and forth between the two "V" grooves when planing. Doing so seems to make it a bit easier. Above are some scale illustrations to demonstrate how the blades will be set in comparison to the shafts and grooves. In each drawing, the blade is set the same. But note the differences in the shafts compared to the blade.

9. Continue planing the shaft down to size until it can fit through the desired sizing hole in your gauge.

10. Once you have produced a shaft that is more or less round, you can finish it by using sandpaper. Grip the shaft with one hand. Wrap a square of sandpaper around the shaft. Hold onto the excess part of the sandpaper with your other hand, not the part that is actually in contact with the shaft. Sand the entire length vigorously. Remember to rotate the shaft as you work so the sanding will affect all parts of the shaft equally. As with all sanding operations, start with a course grain such as 60 grit, and work successively through lighter grades such as 80, 100, 120, 180, and 320. Finish with steel wool. The more grades of sandpaper you use, the less time it will take to sand overall.

11. If you have a splining jig and scale, you can further match your arrow shafts by weight and spline.



An illustration of the completed jig.

Cutting Arrow Shafts the Industrial Way

Warning: Construction and use of this jig involves the use of power tools, which can be dangerous. If you are unfamiliar with the use of power tools, get some competent help to show you how to use them safely.

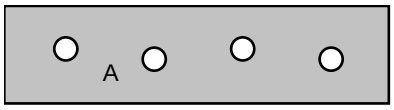
Tools Required to Build the Jig
- A table saw
- A drill press
- A hand drill
- Drill bits of 1/8", 11/32", 23/64" and 1/2" diameter
- Various clamps

Tools Required to Cut Blanks and Operate the Jig
- A table saw
- A hand drill, variable speed preferred
- 3/8" socket and drill adapter.
- A plunge router
- A round nosed router bit.

Jig Materials List	Part Name
(1) steel plate with 4 pre-bored holes.	A
(3) MDF 2" x 6" x 3/4"	B, C, D
(1) MDF 1" x 6" x 3/4"	E
(1) MDF 5" x 8" x 3/4"	F
(3) deck screws 3"	G
(6) deck screws 1 1/2"	H

Building the Jig

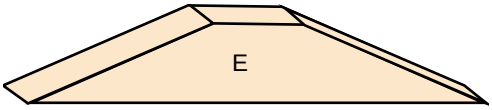
The exit hole for the arrow shaft is critical. It must maintain its size and shape even after repeated uses. With any kind of soft material such as wood, the exit hole will be rapidly worn away with use. A steel plate will be much more durable in this regard. The difficulty, of course, is how to drill a hole in a 1/8" thick steel plate with home workshop tools. The answer is to let the manufacturer do most of the work. You can, at most hardware stores, purchase steel connectors plates with 1/4" holes already drilled in them. They come in various sizes, are inexpensive, and look like the illustration at right. With most of the hole already drilled out, a quality set of metal cutting drill bits will have no trouble cutting out the remainder, as long as the plate is made of regular steel instead of stainless, tempered, or high carbon hardened steel.



I have indicated MDF (Medium Density Fiberboard) should be used for the wood parts. You may substitute 3/4" thick plywood if you like. Plywood is stronger but more expensive than MDF. You must not use a wood board, as it is dimensionally unstable. MDF and plywood will both keep the same shape and size you machined into them, regardless of changes in the humidity. A wood board will change shape slightly, which will adversely impact the precision production of arrows. For this kind of project, I prefer MDF to plywood because it has no grain to influence the position of the drilled holes when using smaller drill bits.

1. Using your table saw, cut out the MDF parts (B through (F).

2. Using your table saw and an angle jig, cut two 20 degree angles into MDF part (E), as shown, to make a triangle.



3. Trim off the top of the triangle. Trim enough to allow room for

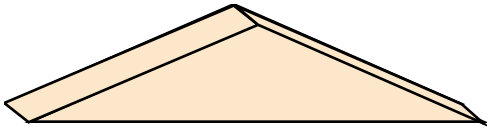
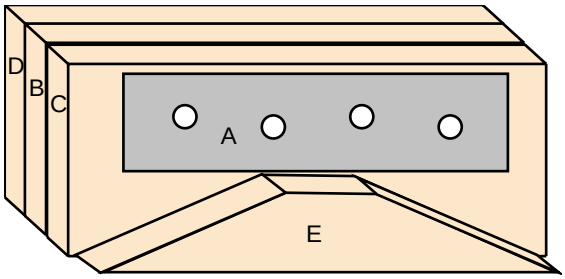
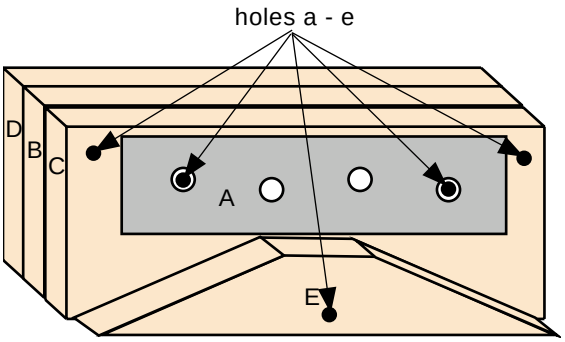


plate (A) to sit above it, with a little extra room as shown. This part will fit beneath the router bit. The slope will encourage the wood shavings to migrate down and out of the jig instead of clogging it up.

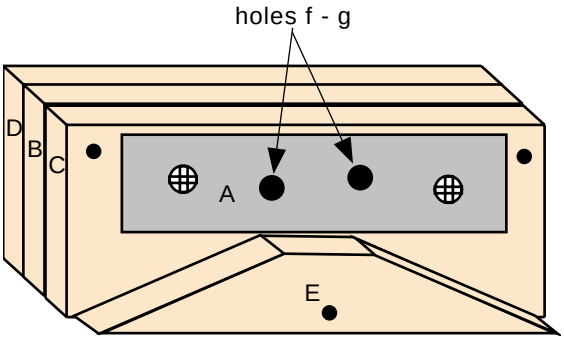


4. Stack parts (D), (B), (C), (E) in that order from back to front.

5. Place steel plate A on the stack as shown and clamp the entire stack together. Be sure to leave room around the clamps for the drill press to drill holes at the indicated locations.



6. Using your drill press and a 1/8 drill bit, drill pilot holes at the points marked (a), (b), (c), (d), and (e). It is important that you use a drill press instead of a hand drill because the MDF part (D) will be moved to the front and its holes must line up perfectly with the others. The outer holes (a), (d), and (e) must go all the way through the stack. Inner holes (b) and (c) need only go through parts (B) and (C), although it won't hurt if they go all the way through part (D).

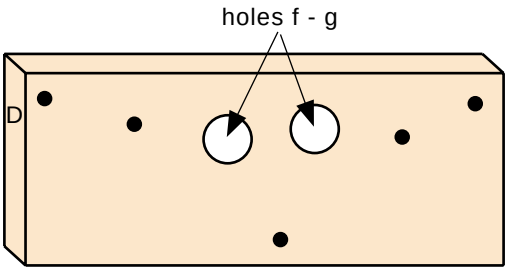


7. Insert 2 of the 1 1/2" deck screws (H) into the inner holes (b) and (c) and tighten fully. This will hold parts (B), (C), and (A) together.

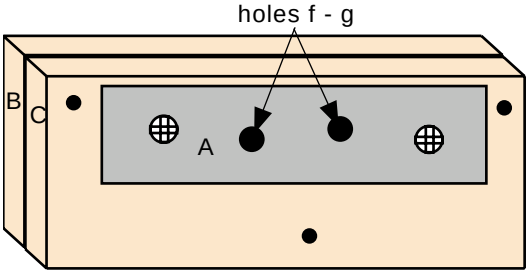
8. Again using the drill press, attach the 1/4" drill bit and drill holes at points (f) and (g) in parts (D), (B), and (C). These holes will be the same size or a little smaller than the holes in the metal plate (A).

9. Unclamp the stack, and remove parts (D) and (E).

10. Insert the 1/2" drill bit into the drill press and, in MDF part (D) only, expand holes (f) and (g) to 1/2" diameter. Do not expand these holes in any parts except part (D). These holes will be the "in" ports for the jig, and will just accept the 3/8" square arrow shaft blanks.



Note: This jig allows the production of two sizes of arrow shafts, 11/32" and 23/64". These correspond in the industry to medium and large arrow shafts. If you wish your jig to instead make small and medium shafts, use a 5/6" drill bit for the small shafts, and a 11/32" drill bit for the medium shafts. Otherwise, follow the directions below.

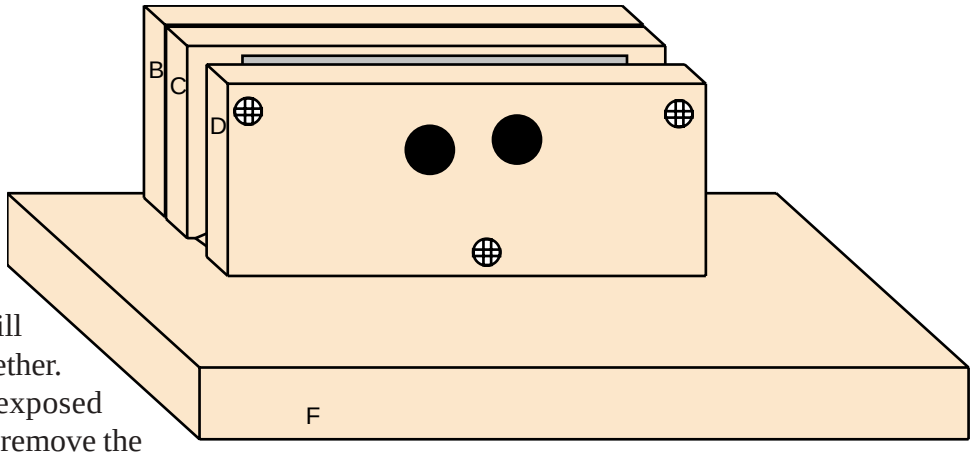


11. In stack (B), (C), (A) which is now screwed together, use the drill press to expand hole (f) from 1/4" to 11/32". This hole is larger than the hole in the steel plate, so the drill will ream out part of the steel as well as the wood. Because of this, it is important to have the assembly firmly clamped down. Failure to do so could result in the whole thing getting slung around in a circle if the bit catches the steel, which could result in personal injury to you.

12. Repeat this procedure in the stack using the 23/64" drill bit to enlarge hole (g). These holes (f) and (g), will be the exit holes for the arrow. They must maintain their size and shape consistently or the whole thing will fail. This is why using a steel plate is so important. If you used MDF or plywood to guide the exit hole, it would rapidly wear out and enlarge, making the entire jig useless.

13. Assemble stack (B), (C), (A), (E), (D) in that order, from back to front.

14. Use a bit of scrap 3/4" thick MDF to insert between parts (C) and (D), above part (A). The purpose of this is to keep the plates (C) and (D) spaced correctly apart while you screw them together.



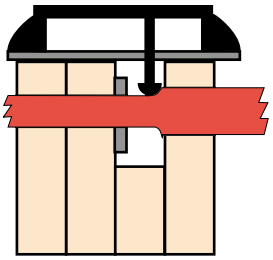
15. Install some 3" deck screws in the holes at (a), (d), and (e). This will permanently hold the entire stack together. At (a) and (d), the screw will be exposed between parts (C) and (D). You may remove the scrap bit of MDF now.

16. Turn the jig upside down and clamp MDF part (F) to the bottom of the stack. Position the back of the stack along one long edge of (F).

17. Drill four 1/8" pilot holes through (F) up into the bottom of the stack where the holes will go into the four corners of the stack in parts (B) and (D). Be careful that you do not place them in such a position that they could run into the screws running front to back through the jig at points (a) and (d).

18. Install four 3" deck screws into the pilot holes, which hold the base (F) to the stack. It should now look like the illustration above.

19. You can now mount the router to the top of the stack with screws. You will have to mark and drill a different set of mounting holes for each size of arrow. I can't give you a specific location for this, because each router is configured a little differently. The important thing is to position the router drill bit directly over the path the shaft will take as it passes through the jig. You will also want to position the router bit closer to (D) than (C) because you don't want to take a chance the router bit might hit the steel plate.



To Use the Jig to Make Arrow Shafts

Once the jig is constructed, you are ready to make some arrow shafts. Here is how it works. You attach your wood blanks to the hand drill. You feed the spinning wood blanks into the large holes on the front of the jig. The router bit is positioned perfectly to cut away any part of the blank that it can reach, while the hand drill spins the blank rapidly, ensuring that all parts of the blank go past the router bit. At right is a side view of the jig, with the router mounted on top. The wood blank is inserted spinning from the right. The router bit cuts away the wood to the proper diameter. The completed wood shaft then exits the jig on the left.

Procedure

1. Cut out some blanks on the table saw. You want each blank to be 3/8" x 3/8" x 36". Set the fence to 3/8". Run your lumber through the saw several times to get a number of blanks. Turn each piece sideways and run them through again. A 1" board from the lumber yard will actually be around 13/16" thick due to shrinkage. If the board

is sufficiently thick, you will be able to get two blanks from each strip of wood. Do not move the fence between cuts or the blanks will not be square. Cut the blanks to 36" in length. Do the same with some cheap wood such as yellow pine from some 2x4s. You will use the pine to test the depth of the router bit, and need some cheap, throw away-wood for this instead of your expensive hardwoods. Cut the pine blanks to half length. You will get twice as much use from them, and they don't need to be a yard long for running tests.

2. Insert a round nosed router bit in the router and attach the router to the top of the jig over the selected hole.

3. Lower the router bit to the correct depth. This step is absolutely critical and must be done with precision. Instructions on how to do this are at bottom.

4. Mount the blank in the 3/8" socket and attach this to the hand drill. You can get a 3/8" socket from any socket set. I have also found it useful to use a square of masking tape to hold the blank in the socket.

5. Start the router and clamp the switch "on."

6. Insert the tip of the free end of your blank into the 1/2" hole in the front of the jig.

7. Start the blank spinning by depressing the trigger of the hand drill.

8. Slowly move the spinning blank into the jig. The router will remove the outer parts of the blank, making it round. You may have some trouble getting it to hit the hole on the other side of the router bit. Just play around with it a bit, moving the drill end about until the free end enters the hole. Once it is started, it should feed easily. Move the blank slowly into the jig until the socket and drill touches the jig. You will have a short stub at the drill end which is still square. The other end will be irregular because it was inconsistently fed while you were getting started. By making the blank 36" long, you can cut two inches from each end and still get a 32" shaft.

9. Once the shaft has passed as far as it will go through the jig, turn the drill and router off. Withdraw the shaft from the jig. You may have difficulty in extracting the last couple of inches of the shaft, it is irregularly shaped from the initial part of the cutting. Since you are going to cut it off anyway, now is a good time to remove the last couple of inches with a small hand saw.

10. Once you have produced a shaft that is more or less round, you can finish it by using sandpaper. Grip the shaft with one hand. Wrap a square of sandpaper around the shaft. Hold onto the excess part of the sandpaper with your other hand, not the part that is actually in contact with the shaft. Sand the entire length vigorously. Remember to rotate the shaft as you work so the sanding will affect all parts of the shaft equally. As with all sanding operations, start with a course grain such as 60 grit, and work successively through lighter grades such as 80, 100, 120, 180, and 320. Finish with steel wool. The more grades of sandpaper you use, the less time it will take to sand overall.

11. If you have a splining jig and scale, you can further match your arrow shafts by weight and spline.

Adjusting the Router Bit Depth

This adjustment is critical. If it is set a hair too high, not enough wood will be cut away and the shaft will be too large to go through the exit hole or will burn from the friction of contact with the sides of the exit hole. If it is set too low, the shaft will not be large enough to feed consistently. The result will be a very rough shaft surface, with spiral cuts going around the shaft its entire length. To get it just right, use the pine blanks as test shafts. Initially set the depth with a known diameter shaft. Then run one of the pine blanks through to see how it goes. Make your adjustment, then try another test shaft. Repeat as often as needed. You may go through several test shafts before you get it just right. Once the depth is perfectly set, you are ready to use your hard wood blanks.

Other Considerations

You must be careful when feeding the blanks through the jig. If there is a little curvature in the shaft, the shaft will be deformed by centrifugal force as it spins, which will further warp the curvature it has, or even break the shaft before you finish cutting it. If this starts to happen, get a friend to put on a heavy glove and loosely hold the free end of the shaft to keep it from flopping about. It is better to go ahead and get rid of any curvature before you turn the shaft. You can also control the flopping of the out end by slowing down your hand drill. The slower it spins, the less it will flop about.

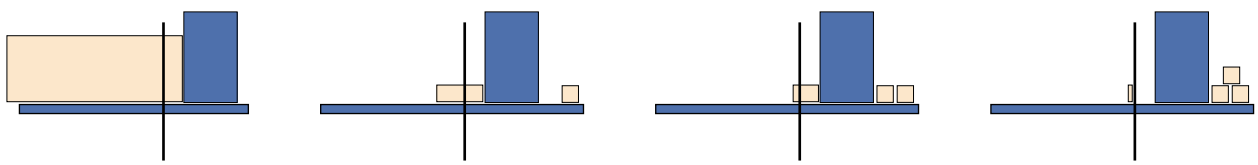
Cutting Blanks

Before you can start planing your arrows, you have to cut some blanks to fit in the jig. You will cut these to 3/8" x 3/8" x 36". You may vary the length as desired to match your draw length. But you should start with shafts that are at least four inches longer than you think you will need to allow for inaccuracies at the ends.

1. Choose a wood. See the section in this article on woods for more information.

2. Set the fence of your table saw to 3/8". Cut some slats of wood from your board.

3. Without moving the saw fence, flip each 3/8" slat onto it's side and cut them to 3/8" wide rods. You will need a feather board to keep the wood nestled firmly against the fence and to keep your fingers away from the sharp blade.



Woods

Some consideration of woods suitable for arrows is in order. So, what wood is the best? The short answer is: there is no short answer. Some people swear that Port Orford Cedar is the best and only choice for arrow shafts. Others claim that Port Orford Cedar is the worst possible wood and that some other wood is best. It ultimately comes down to personal preference. The simple fact is that most woods are usable, with varying degrees of success.

Some woods are definitely not usable. Yellow Pine, such as is found in a 2x4 from the lumber yard, is absolutely not usable. Not only is it one of the weakest woods, but it has hundreds of tiny knot holes throughout it's length. Of the dozens of test shafts I made from pine, not one had a knot-
free length long enough to use. These of course will break the first time any stress is placed on them. Wood from the cedar family tends to do better. It is a little stronger, and has its knot holes grouped together at regular intervals, making the procurement of "clear" wood of suitable length more likely.

You may choose a particular wood for non-archery reasons. For example, you may use greenheart or purpleheart woods if you happen to like those colors. Or perhaps ebony suits you because no one else could afford to build them. (At $90 to $100 per board foot for ebony, I am not kidding.) Maybe you like the grain on a particular wood. You may want to use a wood that would be used by your persona. Or perhaps you just want something stronger than cedar that is cheap and easy to work.

The Japanese used bamboo, the English used oak or ash, some Native Americans found cane useful. People the world over used whatever was available and suited them. So don't be misled into thinking only a few woods are suitable. That said, I have attached a small chart with some characteristics of various woods.

Impact Bending - This is the woods resistance to a sudden sideways load.
Stiffness - This corresponds to spine, or a general tendency to stay straight when it is shot. The stronger your bow, the more spine your arrows need.
Density - This will tell you the weight of the arrow. If you shoot a light bow, you don't want a heavy arrow or it will seriously degrade your range.
Workability - While this is not important on shafts made with the Industrial Jig, it is very important on shafts made with the Period Jig. But by itself, it does not present a complete picture. A particular wood may be easily worked with a hand drill, but may be terrible when it comes to using a plane on it. It will depend on how parallel or interlocked the grain is. The only way to find out if a particular wood planes well is to try it.
Bending - This indicates the ability of the wood to withstand bending without breaking.
Crushing Strength - Indicates the lengthwise strength. A shaft with a higher crushing strength is less likely to shatter when shot into a tree or post.

	Impact Bending	Stiffness	Density	Workability	Bending Strength	Crushing
Yellow Pine	1	1	2	2	2	3
Port Orford Cedar	1.5	2	2.5	2.5	2	3
Basswood	2	2	3	2	3	3
Red Oak	3	3	4	4	3	4
Ash	3.5	2	4	2.5	3	3.5
Purpleheart	3	4	5	4.5	4	4
Greenheart	4	5	5	5	5	5
Lignum Vitae	5	5	5	5	5	5