CNC PEN MAKING ON THE ROTARY INDEXER

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In Creating Wrapped Seamless Designs (https://forum.vectric.com/viewtopic.php?f=5&t=41759) we discussed how to create such designs to use on the rotary indexer or to wrap around boxes. Here we get into the step by step details of using that type of design or your design to actually carve a writing pen on the rotary. If you have experience making pens using a lathe then you are 80% there.

Below I will give some detail as to the tools, jigs, and hardware that we typically use in CNC pen making. Because I do not know what equipment you have in your shop I will try to give alternative ways of accomplishing each step so you can make some even if you don't have certain pieces of equipment. I will also reference where I purchase pen hardware, lathe/rotary accessories, and other things. I am not recommending any particular vendor as there are many trustworthy vendors that cater to the pen making hobby but I will tell you what I bought and where and the cost.

There are some commandments to be obeyed if you want to do quality work:

THE TWELVE COMMANDMENTS OF MAKING PENS AND CARVING THEM

1. THOU SHALL know the tube diameters of the hardware you are going to use and have a drill bit long enough to drill straight through at exactly that diameter.
2. THOU SHALL drill a hole all the way through your blank in one setting. Thou shall NOT drill half way and flip the material to finish drilling the hole. This leads to your blank being condemned to the eternal fire of your woodstove.
3. THOU SHALL start your drilling in the marked center of the blank and use a slow pecking technique to drill all the way through. Thou shall NOT get too upset if the exit hole is not in the center of the blank. Wood grain is not known to follow the straight and narrow path.
4. THOU SHALL measure the distance from the side of the exit hole to the shortest side of the material. Most of the time the blank will be usable as the diameter of the pen barrel being created is less than the width of the blank so there is tolerance for the hole coming through skewed.
5. THOU SHALL square the ends of the blanks to be perpendicular to the hole – not the sides of the material.
6. THOU SHALL mount and secure the blank to your indexer using a pen mandrel that grips the material through the center hole. Thou shall NOT use chucks that grip material on the outside.
7. THOU SHALL use the tail stock of your indexer to keep the pen mandrel in line and provide a centered turning point. Thou shall NOT use the tail stock to put pressure on the mandrel as it shall become bent and cause bad words to be spoken.
8. THOU SHALL center your cutting bits directly over the center line of the pen mandrel.
9. THOU SHALL use only light and slow cutting so as to not put undue pressure on the pen mandrel to get out of line and sin.
10. THOU SHALL only use a maximum depth when V carving so as NOT to penetrate the walls of your pen barrel.
11. THOU SHALL completely do all carving and finishing BEFORE installing any hardware on a permanent basis.
12. THOU SHALL put together the pen hardware in a specific order unless you want to end up throwing it away (it is metal so it doesn't burn!).

The two major challenges to CNC pen making are drilling an accurate hole through the blank and mounting that blank on an indexer in such a way that the center line of the blank's <u>hole</u> is perfectly in line with the center line of the indexer rotary <u>axis</u>.

Now we will provide interpretations and detail for each commandment so you can become a saint of carved pen making.

PEN HARDWARE

1. ***THOU SHALL know the tube diameters of the hardware you are going to use and have a drill bit long enough to drill straight through at exactly that diameter.***

You will need to purchase the mechanical & metal pieces (pen kits) that make up the heart of a pen. The pen is built around its hardware and you should have it on hand to refer to before you can do the other steps as you must know specifications of the kit you are going to use. I usually purchase my pen hardware from Penn State Industries (Pennstateind.com) and I usually get the most inexpensive hardware available which is their Funline Slimline kits. If you are just beginning in pen making, keep your costs low as you will "ruin" some kits when learning. Currently each of those pen kits are about $3.00 each with a minimum of 5 kits per order plus S&H. (You can often find coupons for free shipping and discounts). Recently a large 30 kit variety pak (#PKSLFUN99) includes 5 sets each of 6 different hardware colors for less than $50 which brings your cost to less than $2.00 per kit. (All of their pictures show finished product but you are only getting the hardware - not the turning blanks which are sold separately). **Before you order anything read through this whole document as there are other parts (such as drill bits, mandrels, barrel trimmers, extra tubes, and other equipment you may need to add to your order if you don't already have what you need)**.

As you can see from the picture above a Funline kit contains a metal point, a shirt clip, a center band, a top plug, a transmission (these are twist pens), an ink cartridge, and 2 metal tubes. One of the benefits of these Funline kits is they use the fairly common pen hardware standard of 7mm tubes that are also often used in the more expensive hardware kits. They also use the Cross ink cartridge which is easily found.

Once you have your hardware on hand it will include drawings, steps and specifications for making that particular style of pen. We need some of that technical information but not all of it as the pens I make use the hardware but the pen's top & bottom wood barrels I make and carve are not the shape or size shown in their directions. For instance, theirs pens are 5.125" in total length – mine are closer to 6"; Their recommended turning diameters are 11/32 (.34 D) where as I use .45 to .6 D and so forth. A diameter of .34 is too small and the walls too thin for good carving. So I use their hardware but do not follow their blank turning specs as you will see below.

PREPARE A BLANK

2. ***THOU SHALL drill a hole all the way through your blank in one setting. Thou shall NOT drill half way and flip the material to finish drilling the hole. This leads to your blank being condemned to the eternal fire of your woodstove.***

OBJECTIVE: Wood blanks that are 3" long and .75"+ square

SIZE: I typically make my blanks ¾ X ¾ X 3" and anytime I have hardwood scraps from other projects I mill those into pen blanks. I like some tolerance at this stage and those dimensions provide that. If your material is thicker than ¾", say 1", then simply square it to that size. The larger blank actually gives you more tolerance when drilling the hole through it as that hole WILL drift off center.

WOOD: I prefer cherry if I am going to be painting part of the carving but also use walnut, white oak and maple if they are going to be left natural. All carve nicely. I have also used plum, pine, mahogany, and other exotics if I have them around but they require more cleanup after carving. Be wary of wood that has a lot of "character" such as red oak - the visual pattern usually conflicts and detracts from the beauty of your carving pattern. You want blanks that do not have a lot of variation of color within the blank - so don't mix heartwood with sapwood within a blank.

MACHINING: To create the blanks I have used various shop machines: a tablesaw, skillsaw, bandsaw, or mitersaw. Normally I rip the material square on my tablesaw and cut to length on the mitersaw. You could also use your CNC if you don't have a separate saw. The objective is to end up with a 3" long wood blank that is ¾" X ¾" square (or larger). You can also use dowel rod of ¾" diameter or larger.

You can create two-toned blanks by cutting 3/8" off two different woods, switching them and gluing them together before drilling. Here I am using walnut and maple. The short pieces will become 1/8" bands to visually separate the top barrel from the bottom barrel instead of using the hardware center ring which doesn't have a big enough diameter. Trim the length back to 3" if needed once the glue has dried.

DRILLING THE HOLE:

3. ***THOU SHALL start your drilling in the marked center of the blank and use a slow pecking technique to drill all the way through. Thou shall NOT get too upset if the exit hole is not in the center of the blank. Wood grain is not known to follow the straight and narrow path.***

OBJECTIVE: A 7MM hole all the way through the blank

As the blanks are 3” long and the hole through it needs to be 7mm diameter (.2756”) for our chosen hardware, this is best done on a drill press with more than 3 inches of travel. It doesn’t work to drill half way down the blank and then flip it to finish the hole - it must be one continuous drill. A 7mm bit that will drill 3” deep is long and narrow and thus flexible. It tends to “wander” and follow the grain instead of staying centered. As long as the material around the exit hole is of a certain dimension all is well.


A 7MM drill

Here is my right angle holding jig that is mounted on my drill press table with a blank clamped in:


Mark the center point on the top of the blank. Use a right angle holding jig (parallel to the drill bit) to clamp your blank vertical in position on the drill press table and position the drill over the center point. Make sure it is clamped securely as there is both side pressure and up pressure when drilling. I then use a pecking style to slowly drill through the blank and excavate the cutting waste. I typically drill about ½” per peck at 1040 rpm. <u>It is more important that the hole be straight through than the hole be centered in the material because of the way the hardware is engineered!</u>

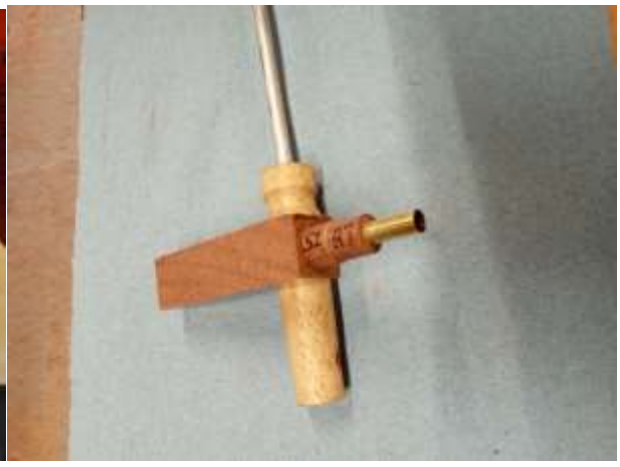
If you don't have a shop drill press you might can get by with something like this; just make sure it has enough travel to handle a 3" blank length plus the length of your bit. This gadget is available on TEMU for less than $25.

4. ***THOU SHALL measure the distance from the side of the exit hole to the shortest side of the material. Most of the time the blank will be usable as the diameter of the pen barrel being created is less than the width of the blank so there is tolerance for the hole coming through skewed.***

OBJECTIVE: Have enough material around the exit hole to get a usable blank

There is some tolerance to the bit "wandering" by using ¾ (.75" D) X ¾ stock (or larger) as you need less than .56" D for your final dimension. I like my pen top barrel to be about .52"D - .56" D and 2.5" in length. I like the bottom barrel to be slightly less in the .47" to .5" diameter range but longer at 2.625". This creates a balanced look. The hardware has some flexibility in terms of final length.

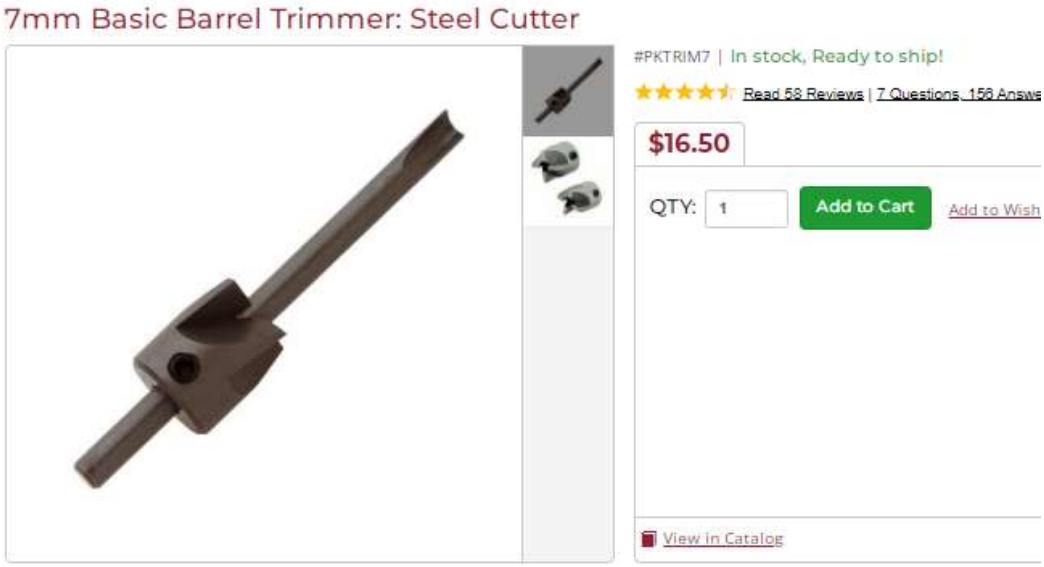
I measure the wall thickness at the exit hole with a jig to quickly test suitability- If I have at least .47" then that drilled blank is good for the bottom barrel. If I have at least .52" then the blank can be used for the top barrel. With a drill press setup and strong clamping I typically have only about 10% waste (where the exit hole skews too much for use).



If the wall thickness is going to be a little under what you want you can sometimes trim the 3” length back to the final length by cutting off the bottom where the exit hole is and then measure the wall thickness again. Since the hole is at an angle coming through you might gain some wall thickness.

5. ***THOU SHALL square the ends of the blanks to be perpendicular to the hole – not the sides of the material.***

Once you have a useable blank with a center hole you need to square the ends of the blank so they are perpendicular to the hole instead of the sides of the blank. You can do this with a special drill tool called a Barrel Trimmer made for that purpose. This insures maximum area to grip the blank in the pen mandrel so it does not slip. Later you will use that tool to square the ends again when you cut the length to size.



SHAPING

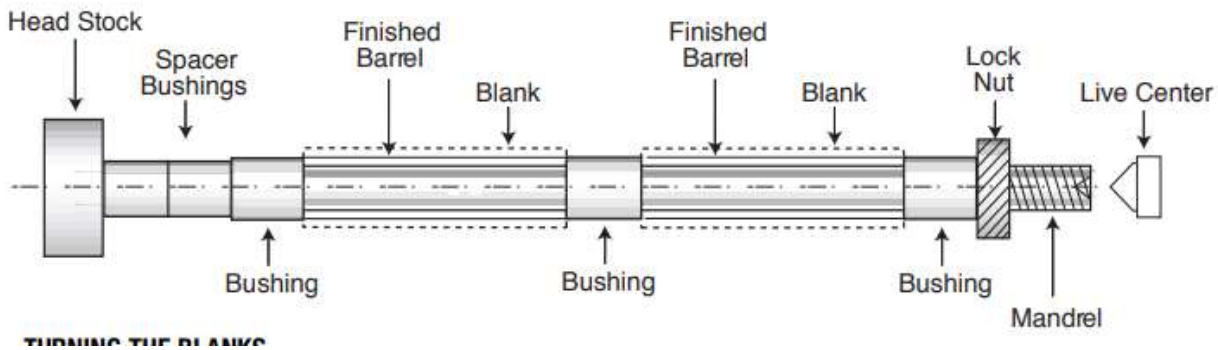
6. ***THOU SHALL mount and secure the blank to your indexer using a pen mandrel that grips the material through the center hole. Thou shall NOT use chucks that grip material on the outside.***

OBJECTIVE: A rounded blank of wanted diameter with sides <u>parallel</u> to the 7mm hole you drilled.

The blank with the 7mm hole and ends squared to the hole must now be rounded into a cylinder shape. You can do this on your CNC indexer <u>or</u> on a lathe if you have a duplicator attachment or other jigging. We need to make sure the final wood blank is a turned cylinder with parallel sides to the hole, is the same diameter at both ends, and the hole is exactly centered within. **<u>It will not work if you attach the pen blanks using a clamping type headstock tooling that surrounds the outside of the material (such as used in bowl or spindle turning) as the hole you drilled will not be exactly centered</u>**.

To do this you must use a <u>pen mandrel</u> which is a threaded rod or split system with hardware that mounts to your indexer or lathe headstock and is supported on the other end by the live center tailstock. The purpose of the threaded rod mandrel is to mount the material through the hole and secure it with a lock nut instead of it being clamped by the outside of the material. Do not use the tailstock to put pressure – only to provide a pivot point. The pen mandrel insures the shaping and carving of your material is centered around the hole.

Diagram A - Turning The Blanks



Look at this website (https://www.pennstateind.com/store/pen-mandrels.html) and you will see a number of different mandrels available which fit different brands of lathes - one of which will probably fit your indexer. There are two types. Shown above is the threaded rod which uses a lock nut to put pressure on the blank to secure it (bushings sold separately). There is also a split type where the tailstock <u>is used</u> to put pressure on the blank but it require you replace the tailstock. I have both types, the rod type on the indexer and the split type on my lathe. Both work well.

Many indexer headstocks are setup the same way as mini-lathes and you should be able to get a mandrel for yours. One common headstock connection is a male 1" X 8 tpi thread at the headstock (I think the Shark uses this type) and so you would need #PKM-BL mandrel set. In any case make sure the mandrel you purchase will fit your indexer headstock and tailstock! Check with tech support for your indexer or the mandrel supplier if you are not sure which type of mandrel to get.

7. ***Thou shall NOT use the tail stock to put pressure on the rod-type mandrel as it shall become bent and cause bad words to be spoken. The rod has a small divot on the end to provide a pivot point.***

Here is my mandrel attached to my indexer (homemade). Note that the mandrels are long enough to hold both the top and bottom barrels at the same time. I only do one barrel at a time so the picture shows a scrap piece as a spacer on the right. I get more accurate results if my barrel is close to the headstock where support is strongest.

Once your stock is mounted then use an endmill and the Wrapping Gadget of the Vectric software to round your stock to the desired diameter. See the next section for the Vectric Job Setup specs I use.

8. ***THOU SHALL use only light and slow cutting so as to not put undue pressure on the pen mandrel rod which is small and long and easy to bend and the material might slip.***

At this point you have a rounded cylinder barrel mounted on your indexer; shaped to the diameter wanted; the hole exactly within the center of the material; and the sides of the material are now parallel to the hole. The next step is carving a pattern unto the barrel.

CARVING

You need to create a design to carve on your pen barrels. In doing so keep in mind the small scale you are working with. A pen barrel with a diameter of .5" and 2.5" long has a surface area of 2.5 X (.5 X Pi) which is 2.5 wide X 1.57 high. The following post might be of use:

Creating Wrapped Seamless Designs for pens in the Vectric forum post**:**

(https://forum.vectric.com/viewtopic.php?f=5&t=41774&sid=d754c1d2ad3fb84c7aec3f7245b70b68)

In addition to the above post I will try to attach 3 designs I created in dxf format for you to import and use if you wish.

9. ***THOU SHALL use only light and slow cutting so as to not put undue pressure on the pen mandrel rod which is small and long and easy to bend.***

- *THOU SHALL center your cutting bits (Y axis) directly over the center line of the pen mandrel.*
- *THOU SHALL use the **top of the material** to set Z=0.*
- *THOU SHALL set X=0 axis to the center of the barrel material.*

10. ***THOU SHALL only use a maximum depth of .08 when V carving so as NOT to penetrate the walls of your pen barrel.***

    For V carving pens I typically use a 90 degree V bit at 12000 rpm and at 40 inch/min feed rate

My **Job Setup** in the Vectric software is typically:

Job Type: Rotary

Job Size: Length 7 inches

Job Diameter: .6 inches

Z Zero Position: Cylinder Surface

XY Datum Position: center

Note that the length and diameter in the Job Setup are larger than actually used. As explained in the previous post on **Creating Wrapped Seamless Designs** the extra length is handy for maneuvering the design (which is usually oversized) into the wanted position and then "cutting" it to the desired length of the barrel being carved. Thus I can vary the length of the barrel within one job setup.

CARDINAL RULE: When trimming your Vectric design to the wanted length and height, the height **MUST BE exactly** that which is found in the Bounding Box layer created by Vectric when you finish your Job Setup if you want a seamless wrap. The length can be anything up to the length of the Bounding Box. So

If you use the .6” diameter setting above then the Y height is going to be 1.885” and your design must always keep that dimension. Your 7” X length setting can be anything up to the 7” specified.

The extra diameter in the Job Setup gives me more design room flexibility knowing that when the design is sent to the rotary post processor the rotary axis will be converted to angular dimensions and the actual diameter of the material is not critical as long as it is close to the job setup. This lets me use the same job setup for barrels that range from .45 to .7 in diameter with only a very small distortion taking place. See my forum post noted above on **Creating Wrapped Seamless Designs** for a more technical explanation as to why the Y height is critical during design but the blank diameter is not during carving.

TRIM THE CARVED BARRELS TO THE CORRECT LENGTH AND SQUARE THE ENDS OF EACH.

This is usually done with a bandsaw or fine-toothed saw in a miter box.

Once the carving is completed and the barrels trimmed to size and the ends squared, they are ready to be finished.

FINISHING THE BLANKS

11. ***THOU SHALL completely do all carving and finishing BEFORE installing any hardware on a permanent basis.***

I follow the steps below to put a finish on the carved barrels.

1. I first use a brass brush to clean out the carving.

2. I then do a light sanding to remove most fuzzies left over.
3. I put on 1 coat of wax free shellac (spray or can) and let it dry – usually less than 1 hour.
4. Then repeat steps 1 and 2 and also use a carving knife or razor cutter to do a final cleaning.
5. Then I spray on 1 coat of gloss varnish and let dry overnight.

6. IF I want to leave everything natural then 2 more coats of gloss spray varnish - let dry; lightly sand (240+ grit) and then a final coat (or 2) of spray varnish in whatever final sheen I want (satin, semi-gloss, or gloss). Using gloss as the first coats and then changing the final sheen leaves a look with more depth and clarity.

7. IF I want the background of the carving to be painted or stained I do a 2nd coat of gloss varnish and let dry overnight. I then cover the carving with the background coloring and carefully wipe off the top surface to expose the natural wood. Have plenty of folded shop towels on hand and work quickly so as not to let the surface coloring dry up before being wiped away. If using oil-based coloring I dampen the towels with mineral spirits and keep lightly wiping the surface until I get what I want. If using a water-based finish, slightly dampen your towels with water. I normally use Varathane Black Cherry stain for this process if I carve cherry wood and I get a beautiful antique look with high contrast. Let dry overnight.

8. IF I want to paint the foreground of the carving, (with or without the background treatment in #7), I paint with paint pens and let dry overnight. I am not an artist – I find colored pictures on the internet and follow that! Then I finish off with spray varnish with the same procedure as in #6. The nice thing about water or oil-based paint pens is you can paint over the varnish surface and it tends not to leave streaks. They also are good about covering one color with another if you change your mind about what you did. DO NOT us colored permanent markers as the spray varnish coat “melts” some of those alcohol based colors and you have a mess.

This is the “drying rack” I made of ¼” dowels. Note the tape wrapped around the bottom of each dowel to keep the blanks up in the air so puddling does not occur. When spraying I hold the carved blank with the metal brush handle and twirl it. I enlarge the metal handle slightly using a nail set so the fit is snug. I use the brush end if using canned finishes. These are cheap Harbor Freight acid brushes which are very useful. This is another reason I don’t install the brass tubes yet as the brush handles and the ¼” dowel drying rods fit nicely in the 7 MM drilled barrel holes and make finishing much easier.



INSTALLING HARDWARE

12 THOU SHALL put together the pen hardware in a specific order unless you want to end up throwing it away (it is metal so it doesn’t burn!).

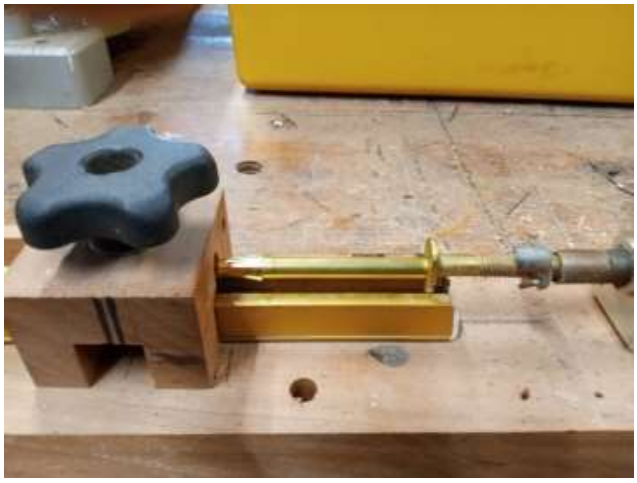
Contrary to the instructions sent with the pen hardware, I do not glue the brass tubing into the pen blanks until the blanks are carved and finished. I do use brass tubes as spacers within the blanks when mounting on the pen mandrels. I bought an extra set of 7 mm brass tubes to use for this purpose as they become part of my mandrel setups. It is because my carved blanks are a different length than the instructions that I do it this way. Also because I pre-finish the carvings I don’t want the finishes clogging up the tubes if they were pre-installed.

Here is the jig I made to put together the hardware.

Pen vendors sell this type of tool and there are numerous YouTube videos on how to make your own or use other shop tools such as a drillpress to press the pen hardware components into place.

The movable holding block has a drill hole to hold the pen' top plug and a tapered hole within to hold the pen's metal end point. This tapered hole is made using a hole enlarger – also found at Harbor Freight. I also use this tool to make pen holder holes.

First I press the metal pen end point into the first metal tube.



Then I move the block back and press the transmission into the other end of that tube.

THIS PRESSING IS VERY CRITICAL AND MUST BE VERY ACCURATE AS THE TUBE MUST BE PRESSED INTO THE BRASS END OF THE TRANSMISSION UP TO WHERE THE LINE IS WHERE THE TWO PARTS OF THE TRANSMISSION MEET – THIS IS THE TWIST POINT.

IF YOU DON'T PRESS THE TUBE UP TO THAT LINE THEN WHEN YOU TWIST THE PEN THE INK CARTRIDGE POINT WILL NOT COME FAR ENOUGH OUT OF THE END.

IF YOU PRESS THE TUBE PAST THAT CONNECTION THEN YOU ARE CAPTURING THE PIVOT POINT AND THE TWISTING MECHANISM WON'T WORK! WORK SLOWLY. TEST SCREW IN THE INK CARTRIDGE AND TWIST THE MECHANISM WITH YOUR HAND TO MAKE SURE THE POINT GOES IN AND OUT CORRECTLY.

I insert this assembly into the bottom barrel usually with my hands. If it is a tight fit then I leave it at that. If it is too tight to insert re-drill with the 7MM drill bit. If it is a loose fit then I pull the assemble out a small distance and dab a small amount of Super Glue Gel onto the tube; smear it around so it is not a glob; and then carefully push the Tube#1 assembly into its final resting place. If a small amount of glue squeezes out where the Pen Point attaches then wipe off immediately. One option if you need to glue is wrapping the Pen Point with masking tape to protect it during this procedure. The shiny (right hand) side of the transmission should be mostly sticking out the other end of the bottom barrel. Install the Ink Cartridge and test mechanism for ease of twisting and the point going in and out correctly. Test

the Ink Cartridge to make sure the ink is flowing – there usually is a dab of shipping sealant on the very tip that needs to be pulled off with your finger nail.

Next I press the End Cap into Tube #2. Then I cut Tube #2 where 1/3 of it stays with the End Cap and 2/3 is available to put into the bottom of the Top Barrel. This cutting is necessary as the tube is not long enough to span the 2.5" length I make the Top Barrel. You will probably need to sand off burrs where you did the cut so the tube fits into your barrel correctly. Press the End Cap into the top of the Top Barrel.

Insert the 2/3 section of Tube #2 into the other end of the Top Barrel putting the cut end up toward the End Cap. Glue this tube into place by putting a dap of Super Glue Gel into that end of the Top Barrel and smearing it around using a tooth pick or other small object. Then slide Tube #2 into place making sure it goes all the way in to slightly past flush. It takes very little gel glue to stabilize the mechanism into the barrels.

Let glue set for 30 minutes then screw in the ink cartridge and then hand press the Top Barrel onto the Bottom Barrel. Test the twist to make sure that part is working.

NOTE that I do not use the hardware shirt clip or the middle metal band as they are not sized correctly for the diameters of the barrels I create.

HOPE YOU ARE SUCCESSFUL.

FEEL FREE TO ASK QUESTIONS ON THE FORUM OR PM ME.

MY NEXT POST WILL SHOW HOW I PRODUCE CARVED V-BIT FOLDED BOXES WHICH I USE AS NOTEPAD AND PEN HOLDERS AS WELL AS OTHER THINGS.

IF YOU DECIDE TO "GET IN PRODUCTION" OF PENS FOR SALE OR GIFTS I WILL BE GLAD TO SHARE MORE DETAILS AS TO MY SETUP AND JIGS AND HOW I CAN PRODUCE A PEN IN ABOUT 45 MINUTES TOTAL TIME WITH MATERIAL COST OF LESS THAN $10. CNC TOTAL CARVING TIME IS <30 MINUTES AND ABOUT 45 MINUTES OF LABOR TIME WHICH IS DONE CONCURRENTLY (NOT COUNTING OVERNITE DRYING OF FINISHES).