Machining The Clapper Pin and Hole, Version 2

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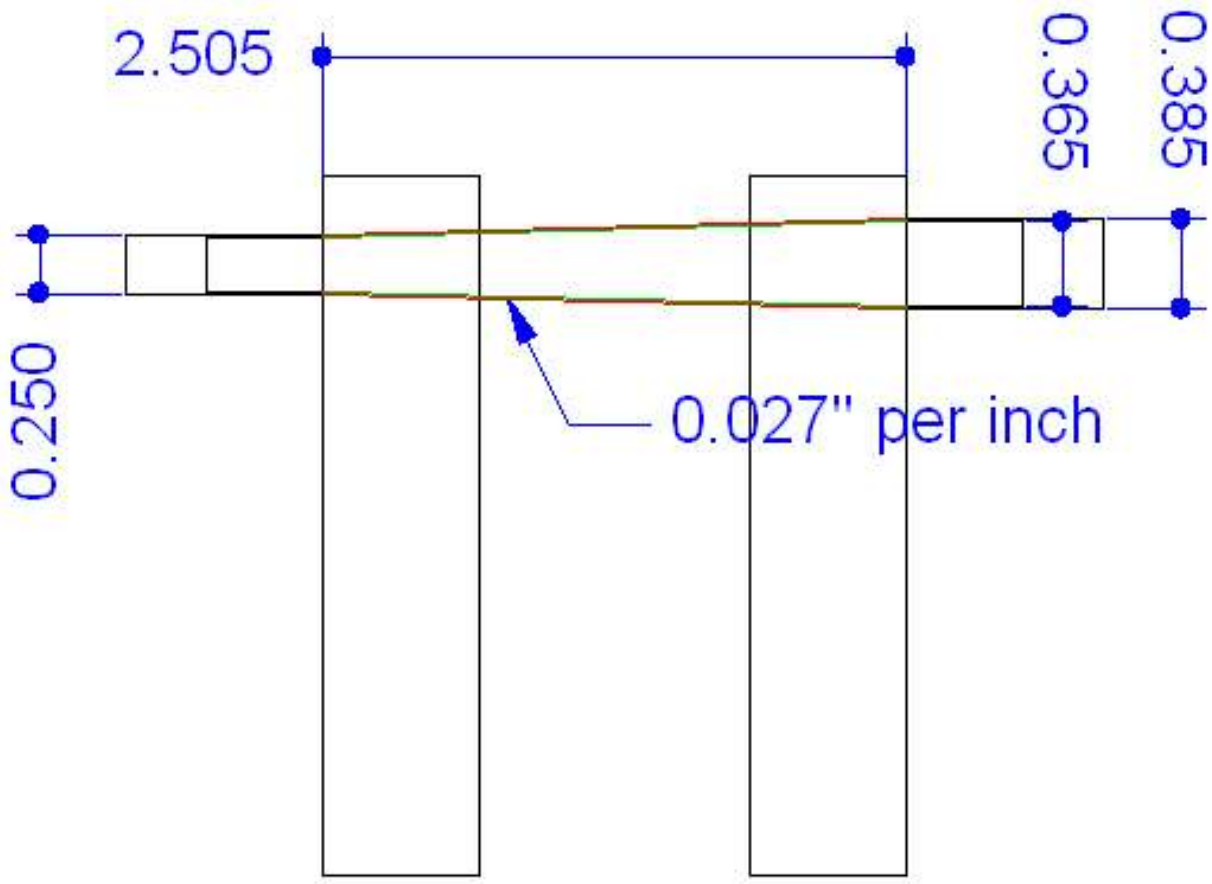
Since I do metal working as a hobby, I am more interested in "the journey" than the "destination." In this case, it means that I prefer to try my hand at making and installing a tapered clapper pin rather than just use a piece of straight drill rod. The journey included making a tapered D reamer, making the tapered pivot pin, step drilling the hole, and then using my tapered D reamer to cut a nice, smooth taper.

No one is more surprised than me. On my second try I was able to make a serviceable reamer and then use it to cut the tapered hole.

A Bit of Math First



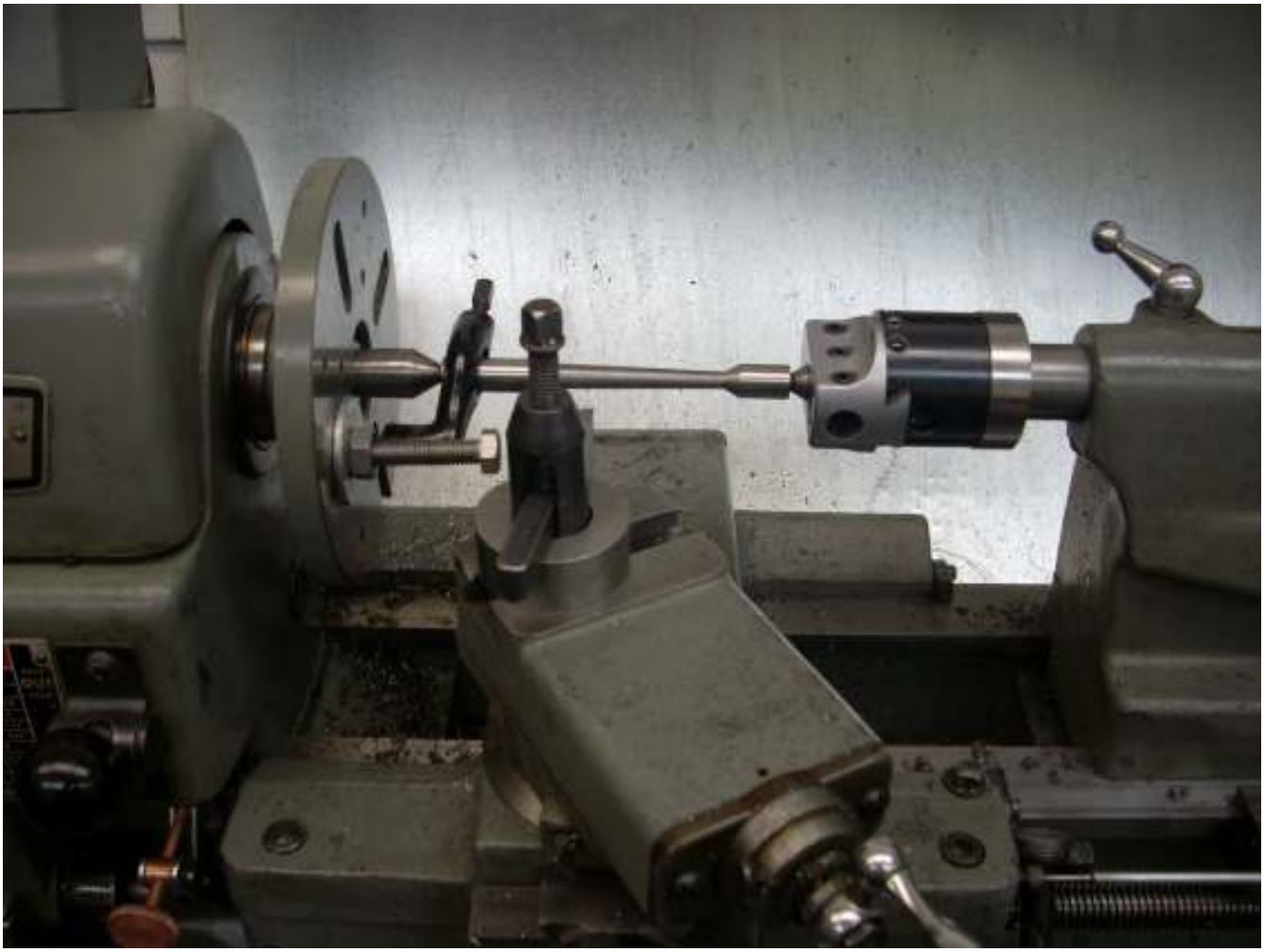
My first step was to figure out what taper was needed. I measured the clapper box and then arbitrarily decided I wanted one end of the taper to be 0.375” in diameter[1] and the other 0.250”. The distance between the supports is 2.505” as shown. This turns out to be a nice round 0.025” per inch for the taper. But wait, that is not what is shown in the figure! Very good if you caught this discrepancy. Due to a shift in my dead center taper attachment, the taper changed to 0.027”. I wanted to keep the small end 0.250” in case I decided to thread the straight part later. This means that the larger part had to be larger. It really does not matter since I made the D reamer and pin to match. I just pity the poor sole that someday inherits this shaper and decides to replace the pivot pin with one from a catalog.

Notice that one taper outline is in red and the other is green. The green outline is 0.010” smaller than the red one and was

1 The 0.375” diameter was not entirely arbitrary. If the taper could not be cut, I could drill and ream the hole for a 3/8” piece of CRS.

my attempt at defining the volume that I planned to step drill. In the end I found it far easier to just use an equation as will be explained later.

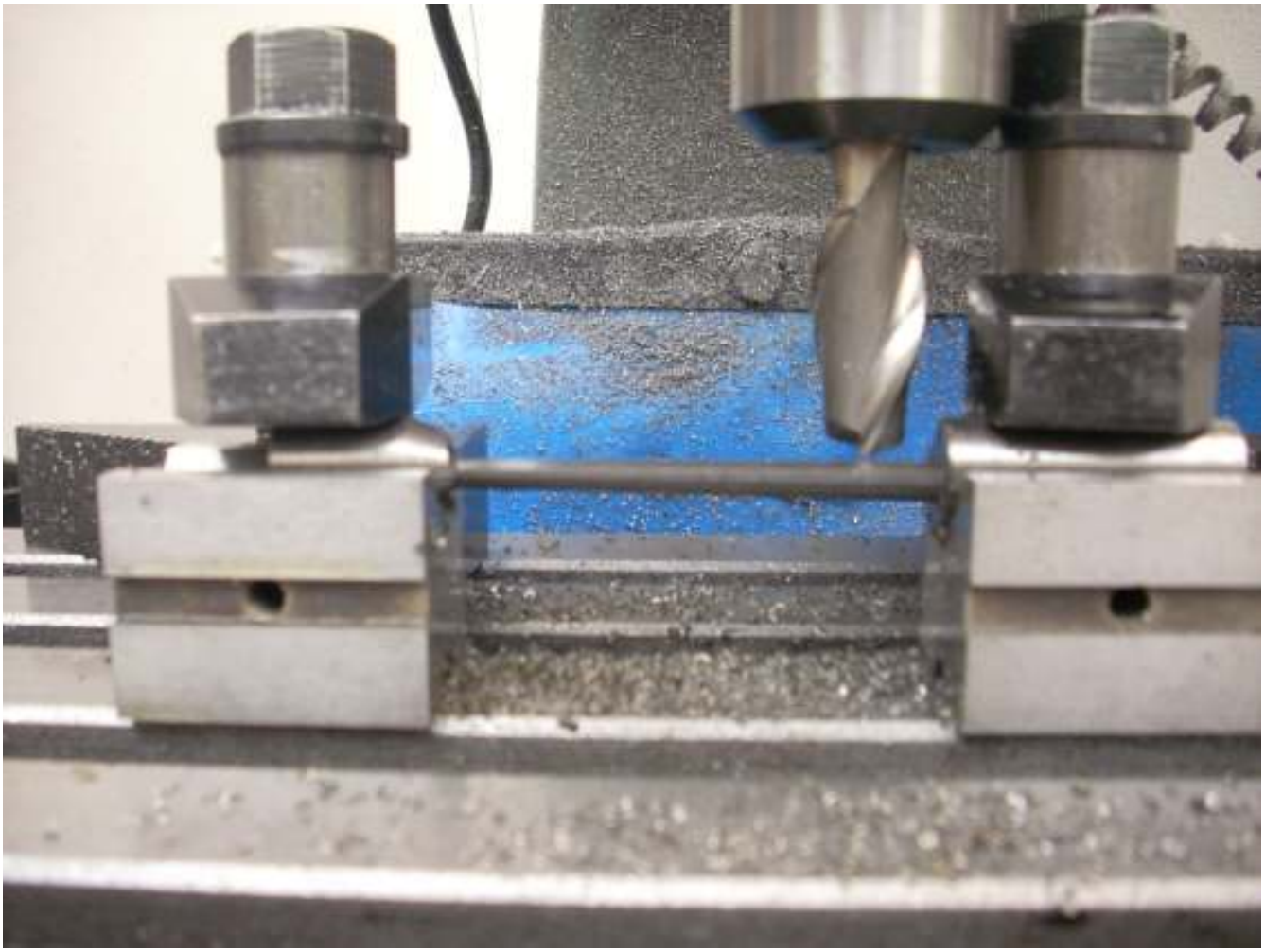
The D Reamer



Many years ago I made an adapter that permits me to mount my boring head in my tailstock. A dead center is set where the boring bar can go and I have a nice way to dial in a taper without disturbing my tailstock alignment. The only problem with this arrangement is that the boring head is not pinned in place. After initial alignment I bumped the head when there was nothing pushing on it at the dead center. The head shifted slightly but then seemed to go back in place. Well, it almost did. After making the tapered pin out of CRS, I discovered that the taper was 0.027” per inch instead of 0.025” per inch. Not to worry. I just have to stay with the new taper value. The CRS taper would at least be a means of testing my reamed hole and it turned out to work fine as the pivot pin.

I started with 0.500” CRS and turned the taper in the middle. This left some uncut stock on the ends which is very handy as you will see later.

My First Try at a D Reamer



Although I used water hardened drill rod, it didn't cut much different than my CRS. After turning the taper, I moved the part to my mill and put it up on precision V blocks. I knew the diameter was 0.500” so milled down 0.250” to get my D cross section. Because there was uncut stock at each end, it was easy to fixture.

Heat Treating

I asked a lot of people for advice on how to make this D reamer. One expert said to not hold the torch on the part too long or it would warp. Another suggested mounting it in a drill press and run the part at 200 RPM while heating and quenching it. Both ideas made a lot of sense to me so I did both. The only problem was that I really didn't know how long to hold the torch on the part. Oh well, that never stopped me before.

I turned on my drill press and slowly brought the reamer up to the color of “cooked carrots” as suggested by another expert. When it looked about right I raised the yogurt cup full of water up onto the reamer to quench. Another expert suggested I temper the reamer at 350° F for a few hours but I was in too much of a hurry to try my new toy.

The D reamer is ready to go. To its left is the CRS pin waiting to have the end cut off.

I stoned the flat to sharpen it but did not grind any relief behind the cutting edge since another expert said this was not necessary.

Testing the D Reamer

I was excited to try out my new D reamer but after all the work I have in my clapper box and clapper, now is not the time to risk them. Instead I started by making a tapered hole in an ingot.

The first step was to figure out which drills will be needed to rough out the hole and what depth they must go in. I have a selection of fractional, letter, and numbered drills. It is hard for me to drill to an exact depth even with my DRO so I decided to leave about 0.01” for the reamer. A little algebra was handy here:

$$r = 0.183” - (0.027 \times \text{depth})$$

where r is the radius of the drill and the depth is the distance the drill must go down into the part as measured from the drill's lip. A little more rearrangement gave me

$$\text{depth} = (\text{drill diameter} – 0.366”)/0.054”$$

Starting with a “T” letter drill with a diameter of 0.358”, I calculated a depth of -0.148”. I line up the lip of the drill at the surface of the hole, set my DRO's Z axis to 0, and feed down until I read -0.148”. It is only difficult because I chose to use every available drill which turned out to be 22 drills. It is easy

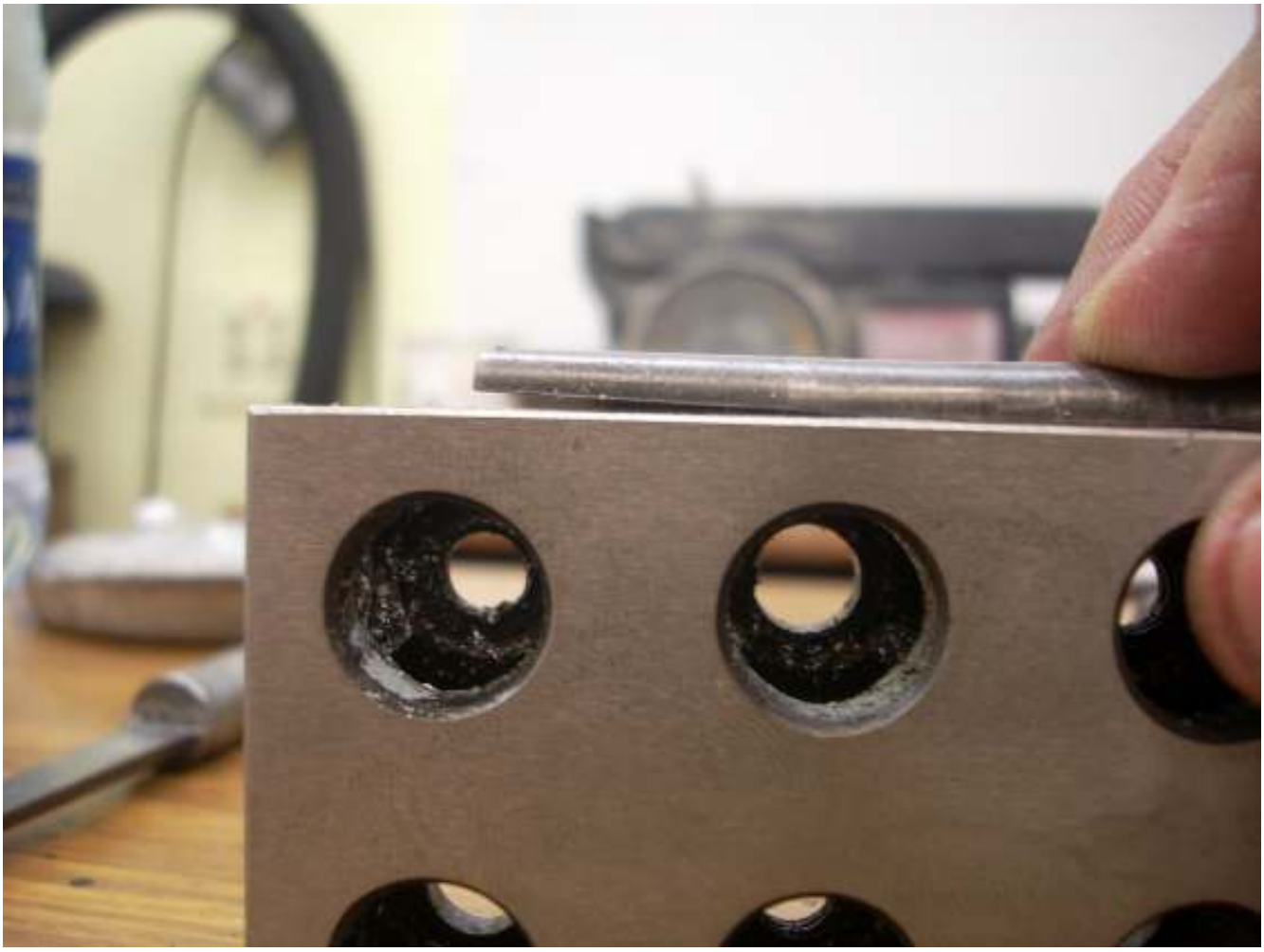
for my mind to wander as I go sailing past the correct depth. I did screw up a few times but that 0.01” allowance saved me.

The reamer worked great in the 1/2” thick cast aluminum ingot. My tapered pin was a nice snug fit.

The next test of the reamer was in some 12L14 leaded steel. This is the same material used to make my clapper.

The 12L14 is up on 3” blocks to insure enough room for the reamer.

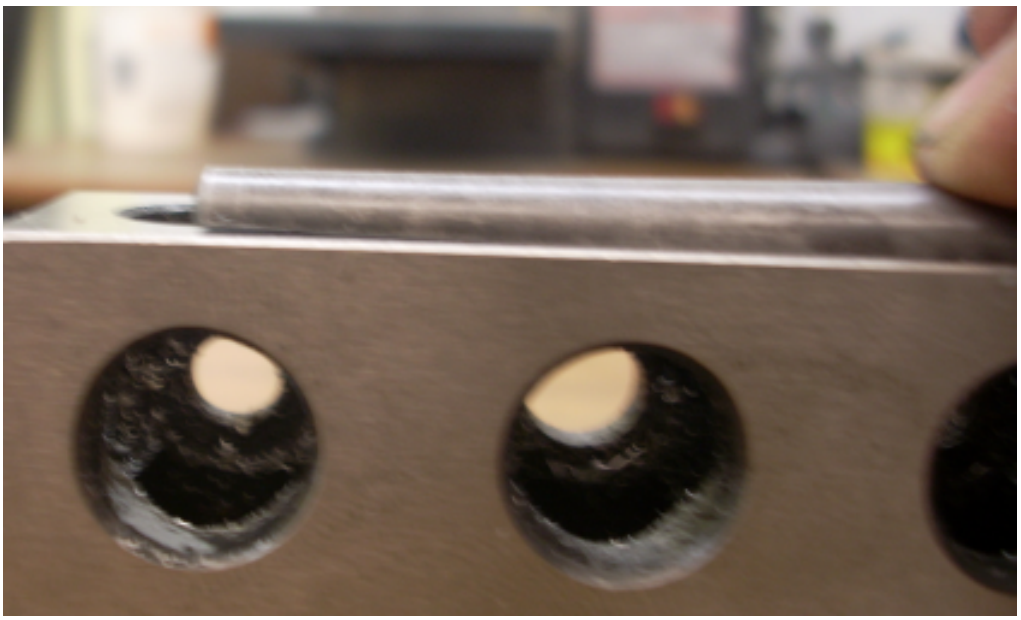
Well, this time the reamer didn't work so great. After some head scratching I noticed a few things. First of all, the center of the reamer was necked down. Can you see the shiny areas along the edge?



Then I noticed that my reamer was very badly warped, probably during heat treating[2]. No wonder it worked fine in 1/2" thick stock but poorly in the thicker 12L14. Oh well. Time to try again after taking a break. I needed some time to readjust my attitude so I didn't start to feel frustrated.

The second reamer was made the same as the first but I took a little more time to evenly heat the drill rod as it turned in the drill press.

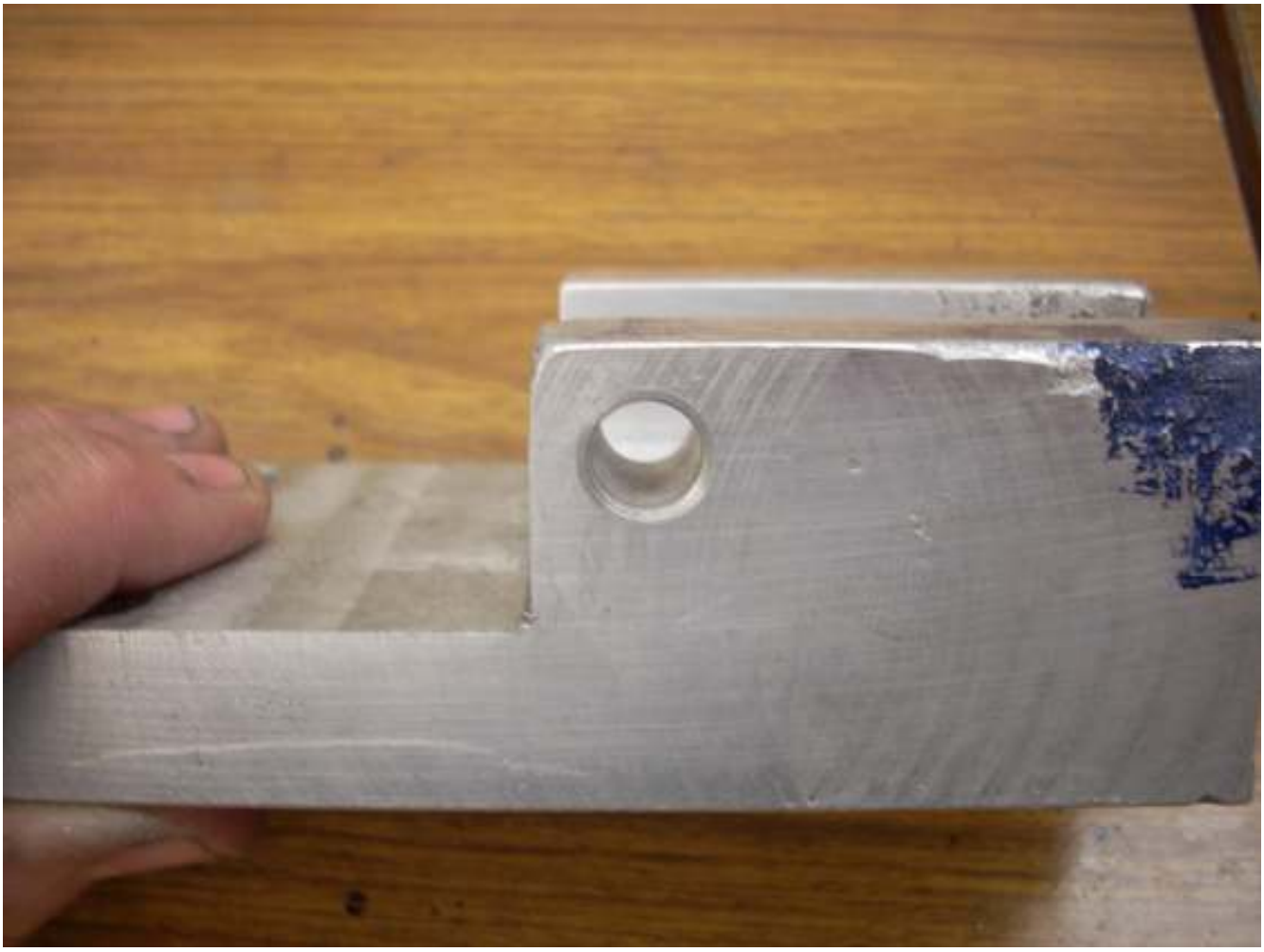
2An expert on line named "doc" gave me a few pointers for next time. "Use O-1 way more forgiving ....there will still be warpage ...much less....make it oversize & grind it out. u can anneal the rod first at 500 deg, straighten it then anneal it again. Use the oven and then cool in freezer. Repeat cycle a couple of times to take out the internal stresses...uneven heating will still cause some warp. If u can't do overall grinding after hardening , then grind out the d bit 1/2 after hardening. Alternately, "draw" metal in oven at 375. u can fudge a straight d bit that warped, by relieving beyond the cutting head."



This time I was much luckier. The reamer has much less warpage. I still have some curve but it looked good enough to risk trying it on my clapper box and clapper.

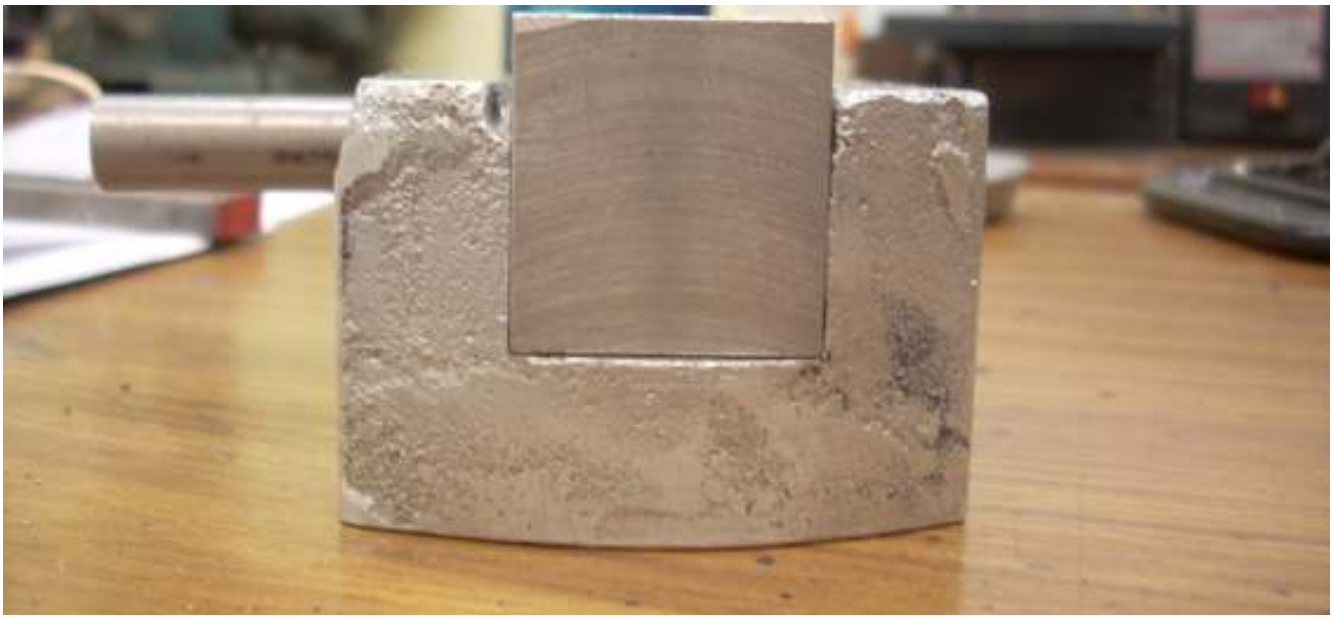
The clapper box and clapper are secured to the table. The C-clamp is holding the clapper tight to the back of the box. This will insure that the clapper is snug against the back of the box during the cutting stroke. Any play would translate into a poor finish.

The long process of step drilling with all 22 drills begins. After the drills, I put the D reamer in the drill chuck and ran it at 120 RPM. Lots of cutting fluid and cleaning of swarf every 0.1” of downfeed.

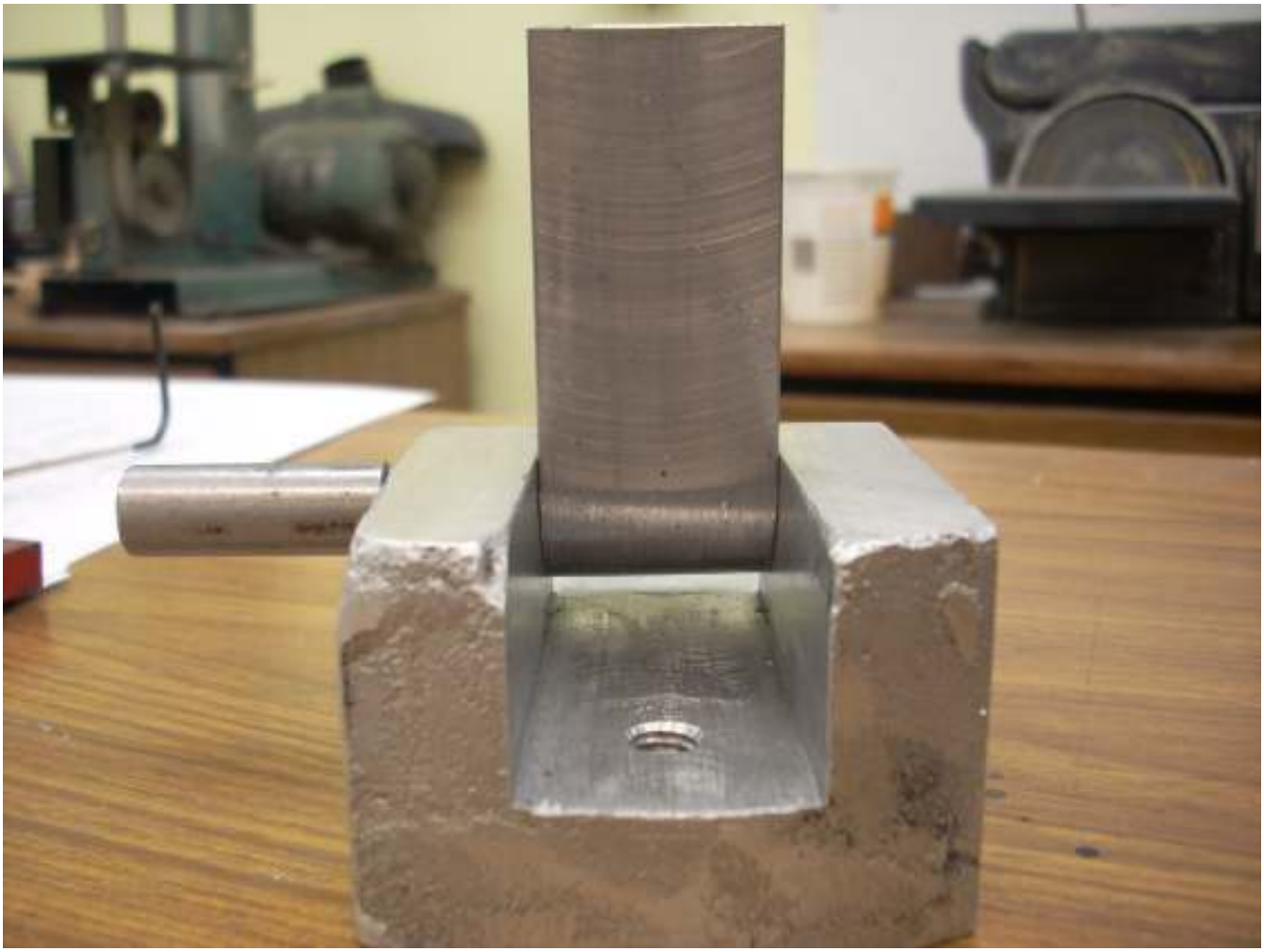


I couldn't believe my eyes! The hole is actually reamed nice and smooth. The chamfer was added after reaming.

The clapper block came out nice and smooth too. The gunge you see came off of my fingers. The sides of this clapper were lapped nice and smooth.



The pin is a snug fit in the clapper box and a sliding fit in the clapper. Dumb luck! Since the pin was cut with the clapper clamped to the clapper box, there is a close fit between the two as can be seen above.



The clapper easily swings up. It flops back down with a slight push. All that is left here is to trim off the excess pivot pin.

OOPS!

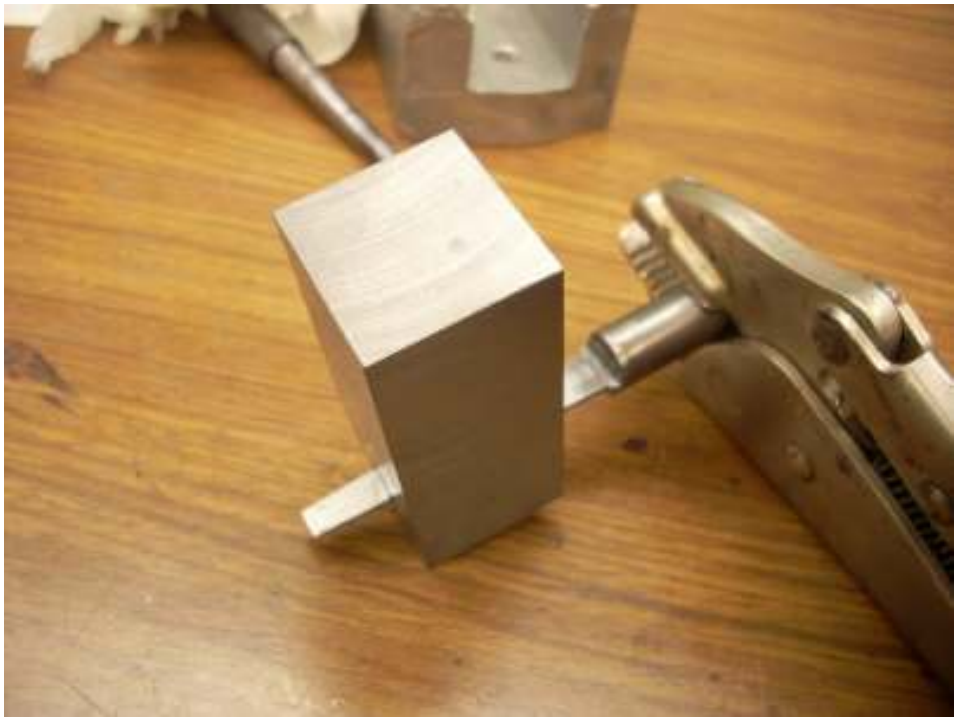
As you can see in this picture, the pin is not seated all the way in. I didn't notice this until after publishing version 1 of this article. I was doing the final fit of my tapered pin yesterday and noticed that it would not go in the last 1/8". At a taper of 0.027” per inch, this means there is a gap of 0.027/8 = 0.003” which is enough play to probably cause chatter.

Before I did any damage, I blued the pin and wrung it in the hole.

There was one very small high spot on the pin so I put it in my drill press and lightly polished the pin with an emery cloth. Still no luck. The pin still would not go in all the way.

Duh, turned out the minimum diameter of the pin was larger than the minimum diameter of the hole! A quick pass with a 1/4" drill and the pin went in all the way.

Sure glad I didn't go crazy on the pin or hole before figuring this out. With the pin seated, the clapper and box both grabbed the pin.



It was then a simple matter to use the reamer to gently remove a tiny amount from just the clapper's hole.

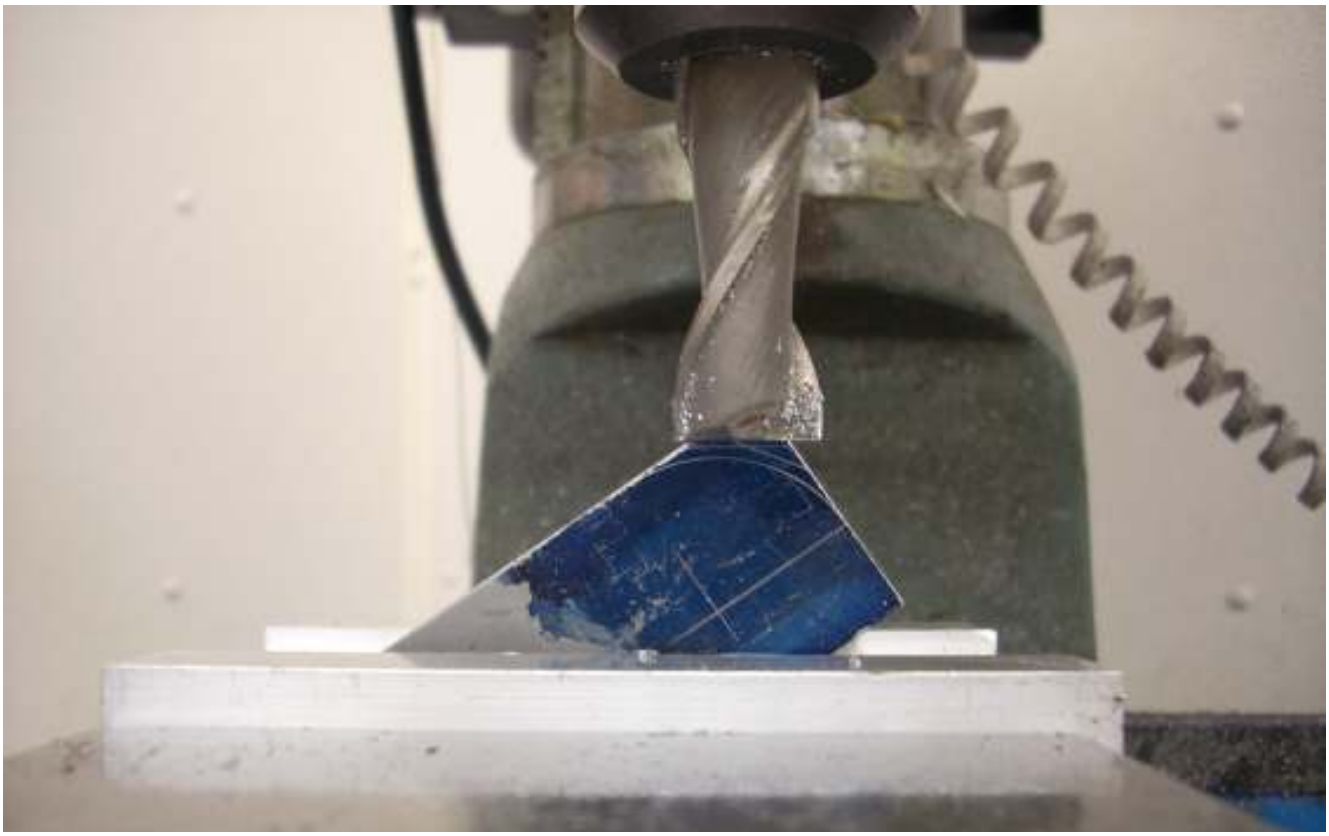
The straight part of the pin was cut off on the bandsaw and the end cleaned up with a file. Now I am really done with the tapered pin and hole.

If the pin moves when the shaper is operating, I can add a flat to the pin and a set screw on the box.

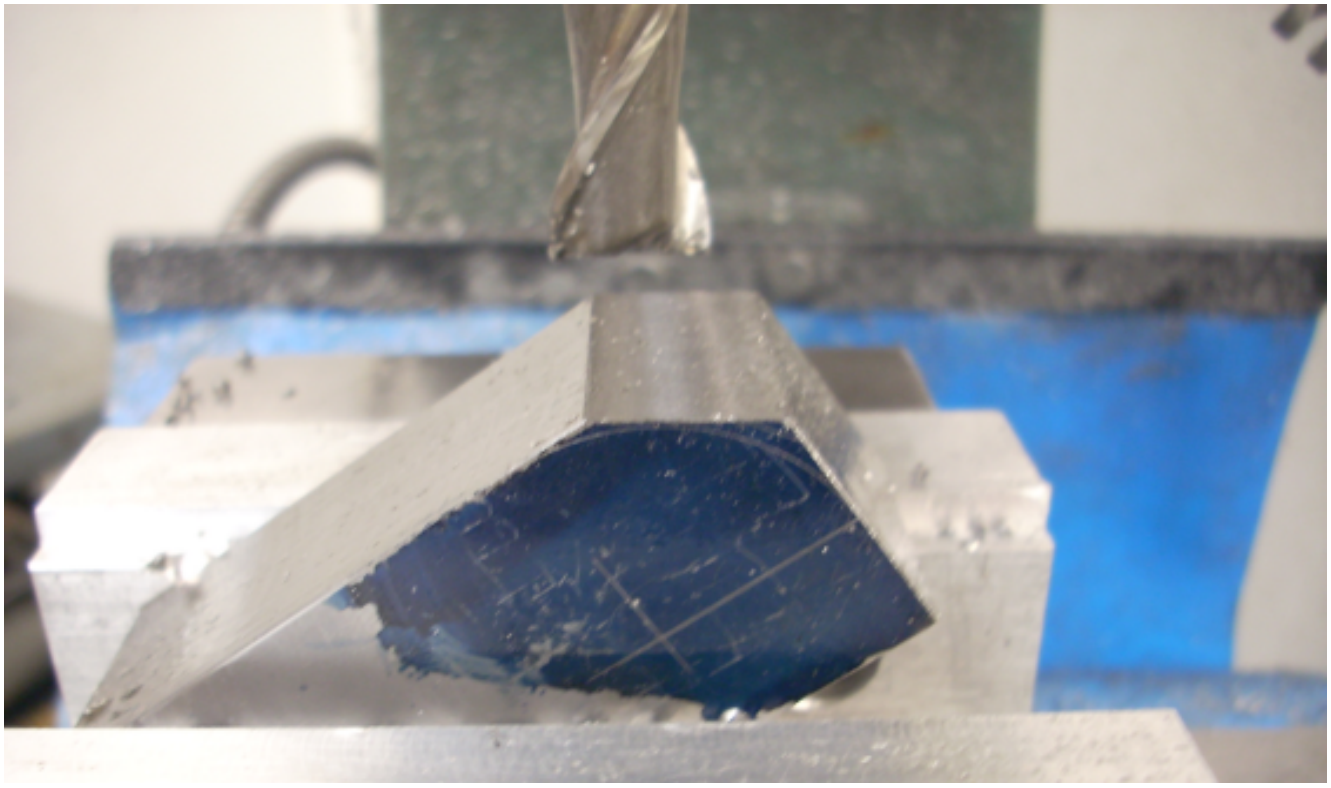
Cutting the Clapper Radius

I just realized that I forgot to mention how I cut the radius on the clapper. This radius provides relief so the clapper can swing out without hitting the back of the box.

The center of the radius was marked out on my surface plate. A divider was then used to scribe the radius.

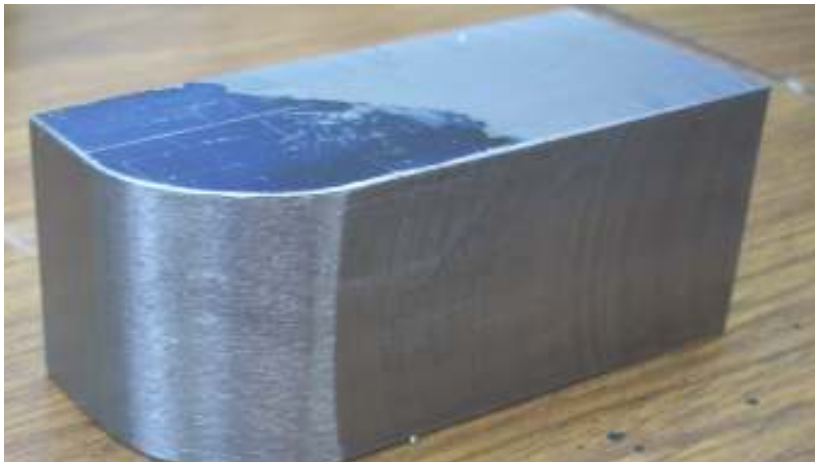


I scribed a few tangents and then used my end mill to remove most of the excess corner.

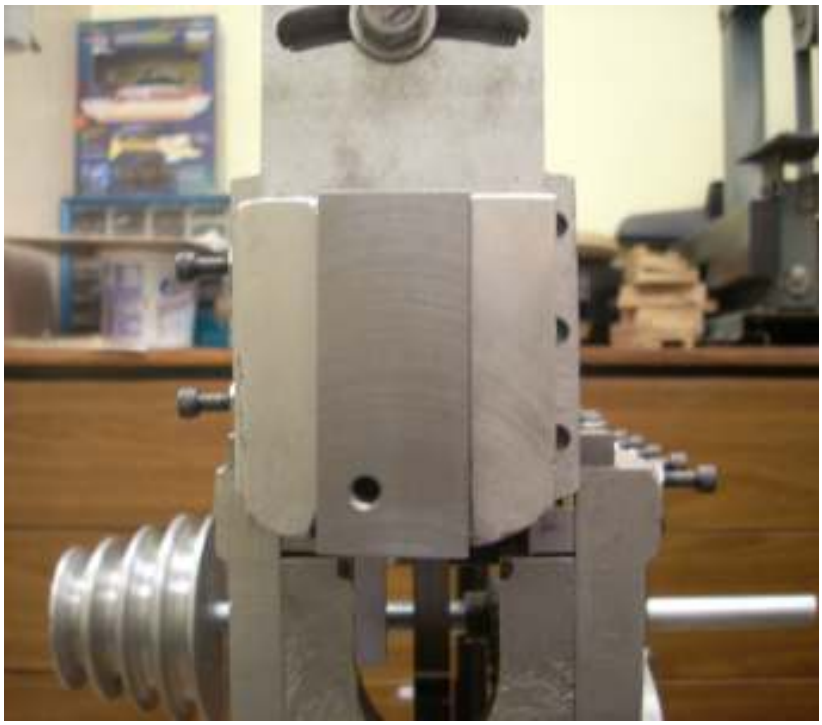


Not much metal left to be removed now.

A little time on my disk sander and I've got a half decent radius. The milled flats were square with the block so it was not hard to retain that alignment during sanding.



A little more work is needed before this clapper is done. I followed the design by Rudy Kouhoupt detailed in ***The Home Shop Machinist***, January/February 1998.



His design places the cutter on the center line of the pivot pin in order to minimize chatter.

The hole in the front of the clapper contains a ¼-28 set screw. It locks in a piece of ¼" HSS that will later be shaped to a cutter. I offset the hole to leave room for both a smaller cutter blank and for a bar that can hold a cutter on the end. It will be used to cut inside slots.

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