The Vertical Screw Assembly

By R.G. Sparber

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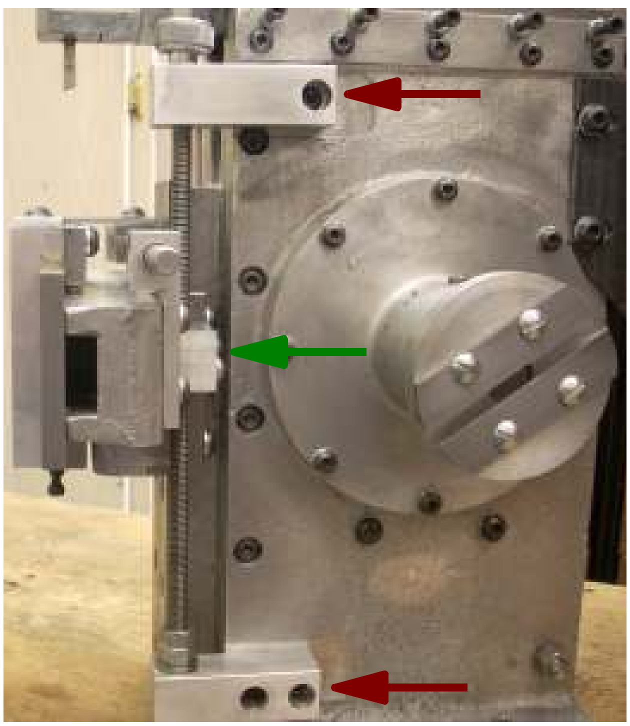
I almost had as much trouble with this assembly as I had with the horizontal cross feed screw and nut. This is rather embarrassing since, in hindsight, I ran into the same problems and rediscovered the same solutions.



In the end, all worked out OK and the work table smoothly goes up and down under the power of the vertical screw. I did make a few changes to Gingery's design which will be explained later.

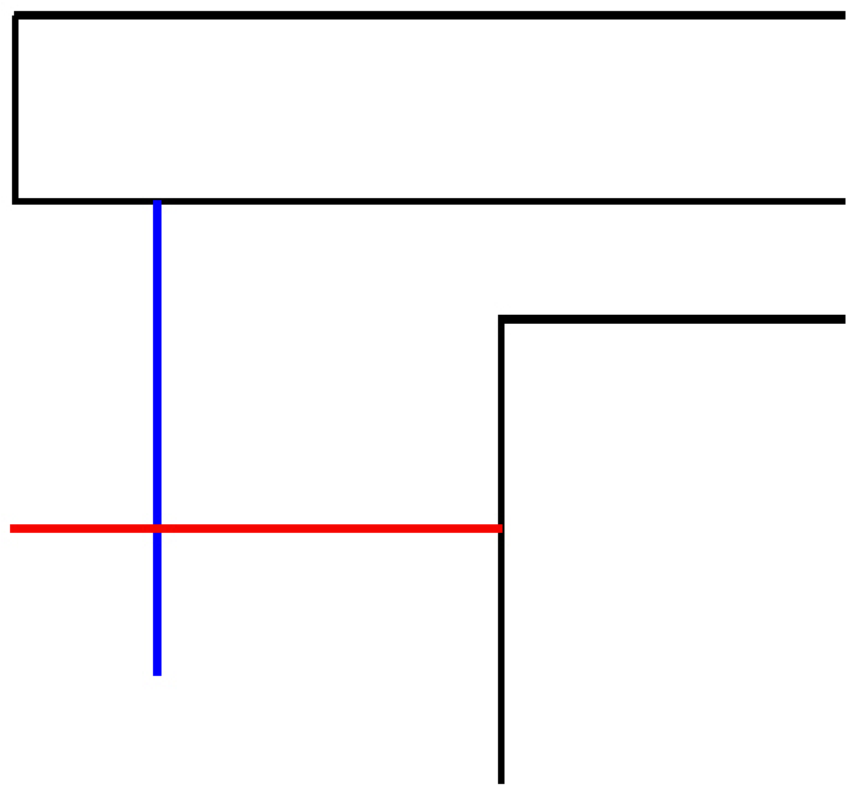
It is a little hard to see the vertical screw assembly. I have used red arrows to indicate the upper and lower support blocks. A green arrow points to the vertical screw nut.

Why does the vertical screw bind?

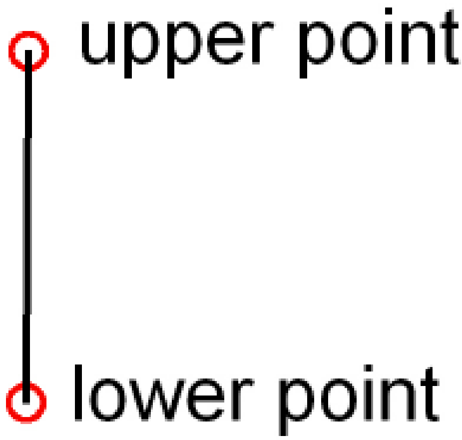
Before we get into machining, I want to explain the idea of an over constrained system since we potentially have one here.

I don't want any binding as I crank from one end to the other. This means that I must avoid having an over constrained system. The first step is to identify what motion is important and which are not. The vertical screw must drive the work table up. Gravity will probably be enough to move it down. If this assumption is wrong, I will add two more locking nuts and a washer. Any motion perpendicular to this vertical motion is not important. This means that there is no reason to have close fitting holes in the upper and lower supports. I will do my best to align the two supports and nut but will then leave room in case the threaded rod is slightly bent.

For a moment, assume that I was able to get the side of the column perpendicular to the back of the cross slide.



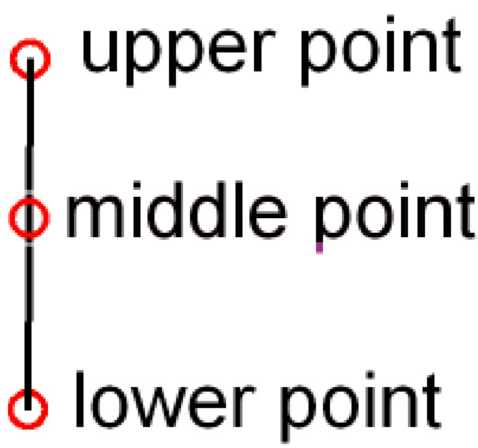
This is a top view. The box at the top represents the cross slide and the corner on the right is part of the column. I have drawn a blue line perpendicular to the cross slide and a red line perpendicular to the column. The intersection defines my first point. Next, move the cross slide down the vertical ways and draw a new set of blue and red lines. I now have my second point defined.



I can draw a line between these two points without any trouble. The line is "constrained" in that it must hit both the upper and lower points. It can do that so there is no conflict.

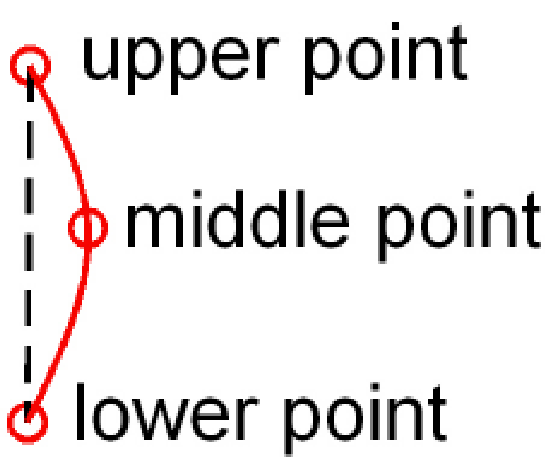
But what if there is a third point? This time, move the cross slide so it is between the upper and lower points and draw a new set of blue and red lines.

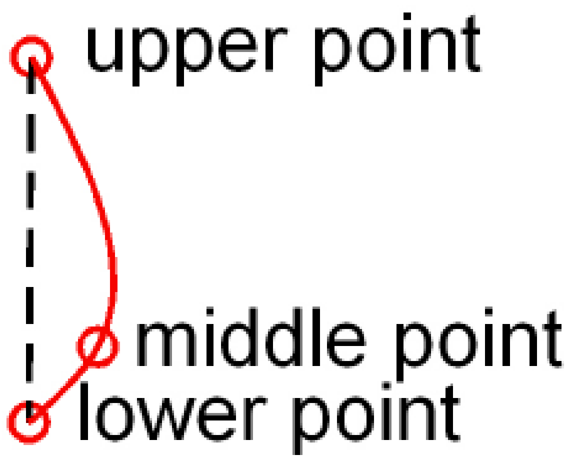
Now I have three points.



If these points line up perfectly, then I can draw a straight line between them.

Things ***never*** work out that well for me. Instead, I get three points that do not perfectly line up. I can only connect the three points by bending the line. This is an over constrained system since I can either have my misaligned three points and a bent line ***or*** a straight line if I throw away one of the points. Life is not always fair.





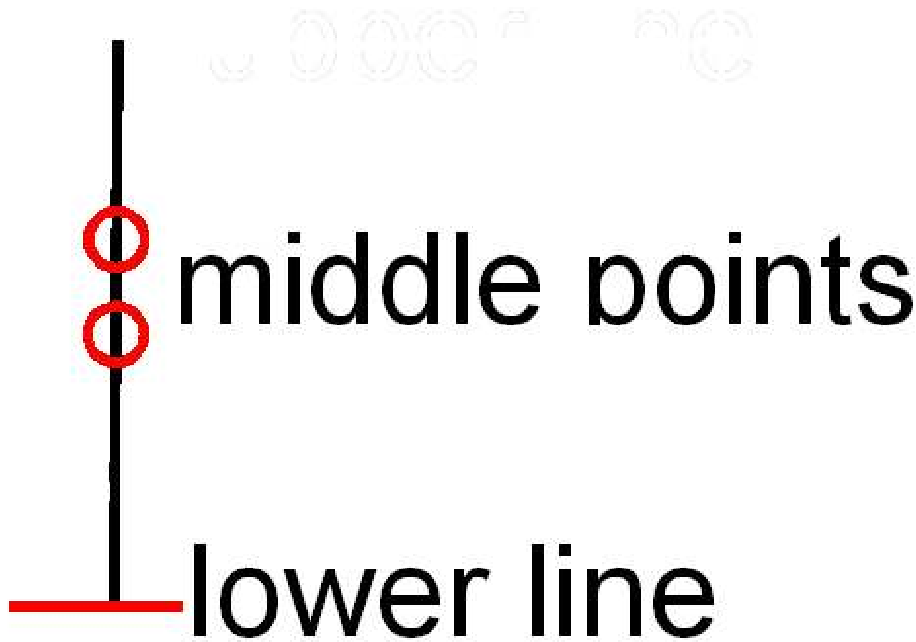
Things actually get worse with this over constrained system. Consider what the line must do when I move the middle point near the lower point. The line must bend even more[1].

Returning to the practical problem at hand, if the upper and lower supports are not perfectly lined up with the nut, then the screw will bind up with increased side pressure as I move towards a support. Exactly where it binds up depends on what I line up and what is left off the line.

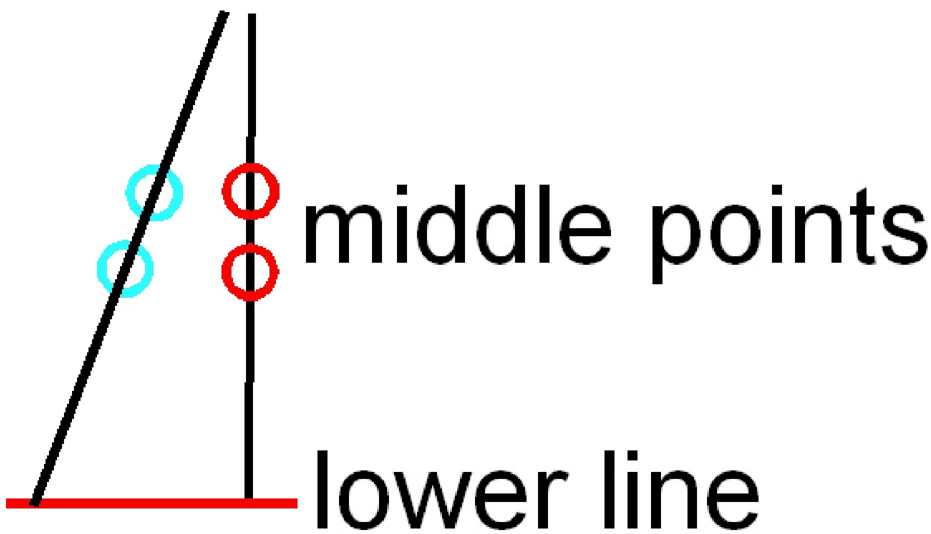
The solution is a wonderful engineering trick that I learned decades ago: “If you can't solve the problem, change the problem!”

The following is a two dimensional view of the solution.

1 If you own a mill, have you ever noticed if the X axis feed binds when you have the table all the way to the right or left? If so, this might be because the X axis lead screw is not perfectly lined up with the nut that is secured to the base. Mine has this problem. Having some play in the nut does help but in my case the the end support was off by 1/8” so I ended up having to move it.



I have defined two middle points. They completely define the orientation of the line. In place of a lower point I now have a line.



The lower end of the vertical line is free to move along the lower line. This means the vertical line is no longer constrained at the bottom. My middle points are free to move and therefore change the orientation of the line. Nothing is constrained so there can't be any binding.

Back to the practical side. The two middle points are within the nut. The lower line is the top face of the lower support. A washer under a set of nuts prevents the threaded rod from falling through a large hole in this lower support.

But, but... there is a top support! Well, sort of. You will see that it is normally not touching the threaded rod.

So much for theory, now back to grease and chips.

Machining the Lead Screw

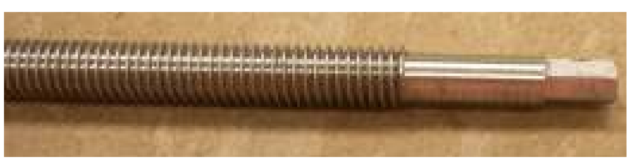
I will be machining a length of threaded rod on both my lathe and mill. If I just clamp it into my lathe chuck, the threads will be crushed. Instead I will make a threaded collet that will fit both my lathe chuck and a collet that goes into my spin collet on my mill.

The first step is to grab a piece of 12L14 in my lathe chuck and turn the OD to 5/8”. The end was then faced off, drilled and tapped for a 3/8”-16 thread to a depth of about 1”. I then sawed it off on my bandsaw and made two perpendicular cuts down about 7/8”.

The result is a handy tool for holding threaded 3/8”-16 rod.

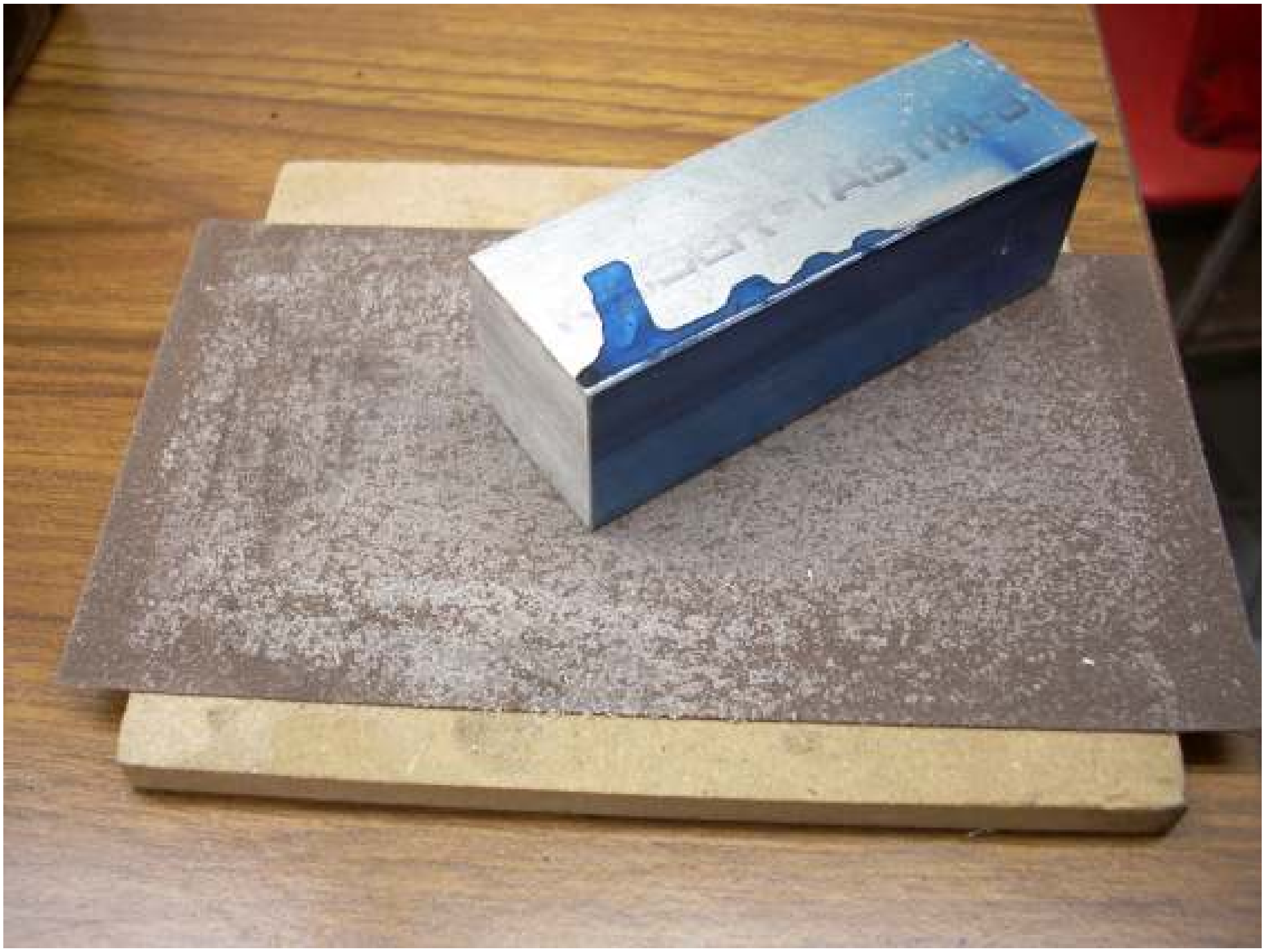
I used the same procedure as used to cut the coupler nuts for the cross feed screw. The result was a standard ¼" hex shank on the end of the threaded rod. I liked this arrangement better than using a cap screw as Gingery specifies on page 113.

I then moved the threaded rod with the threaded collet to my lathe. About 1" of thread was removed so it would smoothly enter the top support. I did this work before realizing that the top support should not even touch the rod.

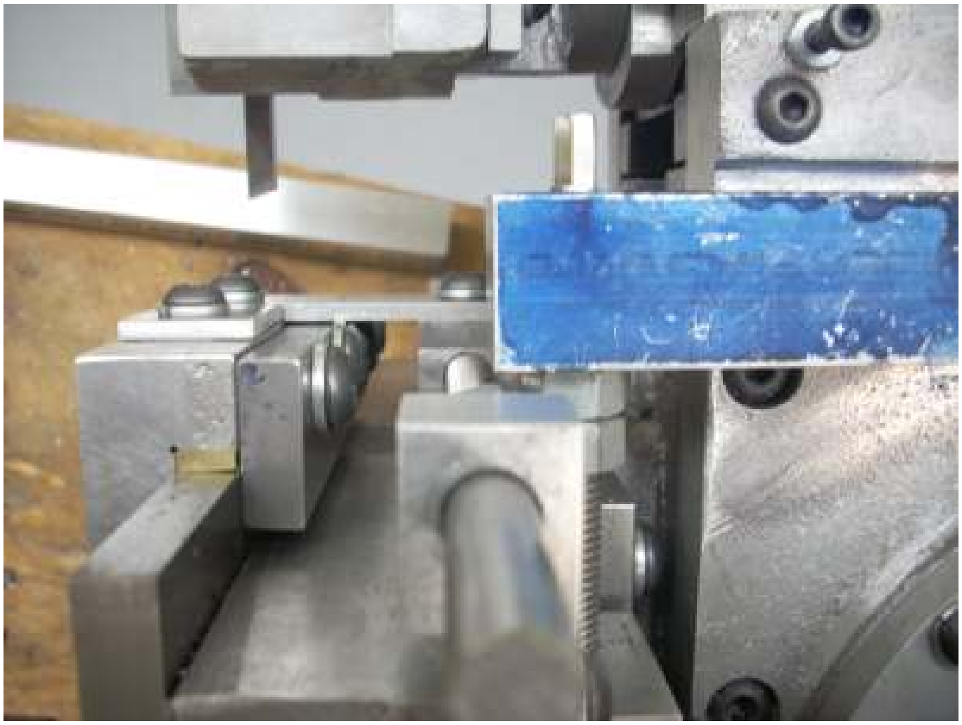


The other end of the rod was also turned down for about 1" so it would smoothly enter the lower support. In this case it is useful since it is possible that the shank will hit the side of the hole in the lower support.

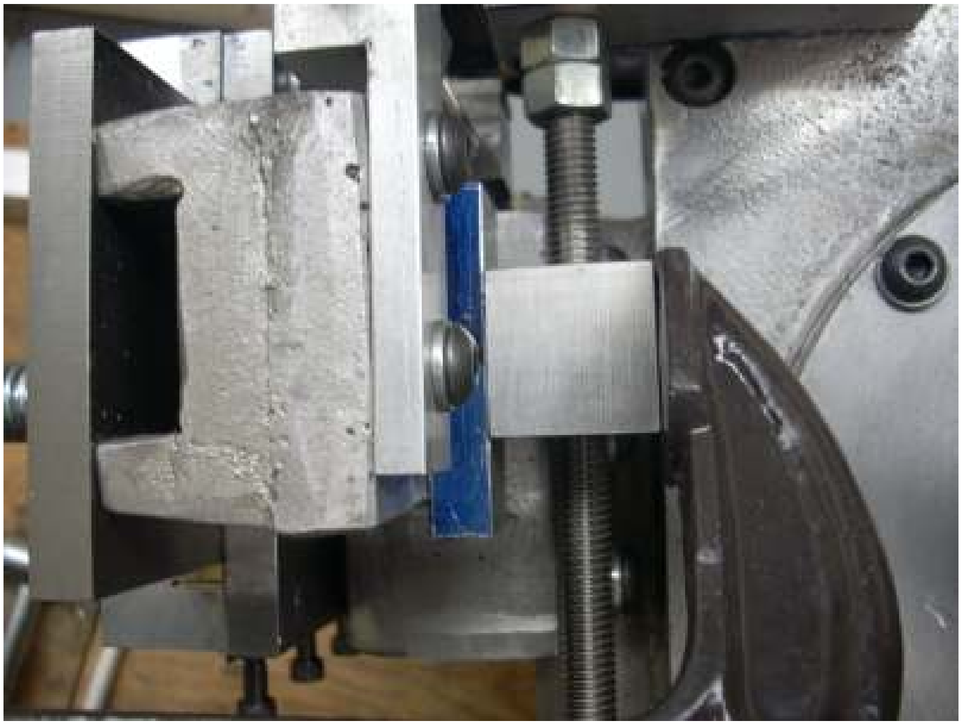
The Support blocks and Nut



I chose to use 1”x 1” aluminum bar stock for the support blocks and nut rather than casting them. Here I am trying out a new idea given to me by “Darryl from Olympia/Portland”. 120 grit Emery cloth is glued to a flat board and paraffin wax rubbed into it. I am able to deburr the bar stock quickly and accurately. Thanks Darryl! I did find that this trick does not work well on 320 grit so it does have its limitations.


The top support is dry fit first. I don't want it to hit the cross feed screw's nut.


After drilling a close fit hole in the upper support, I clamped it in place. Note that the nut, already drilled and tapped, has been clamped to the cross slide ways.

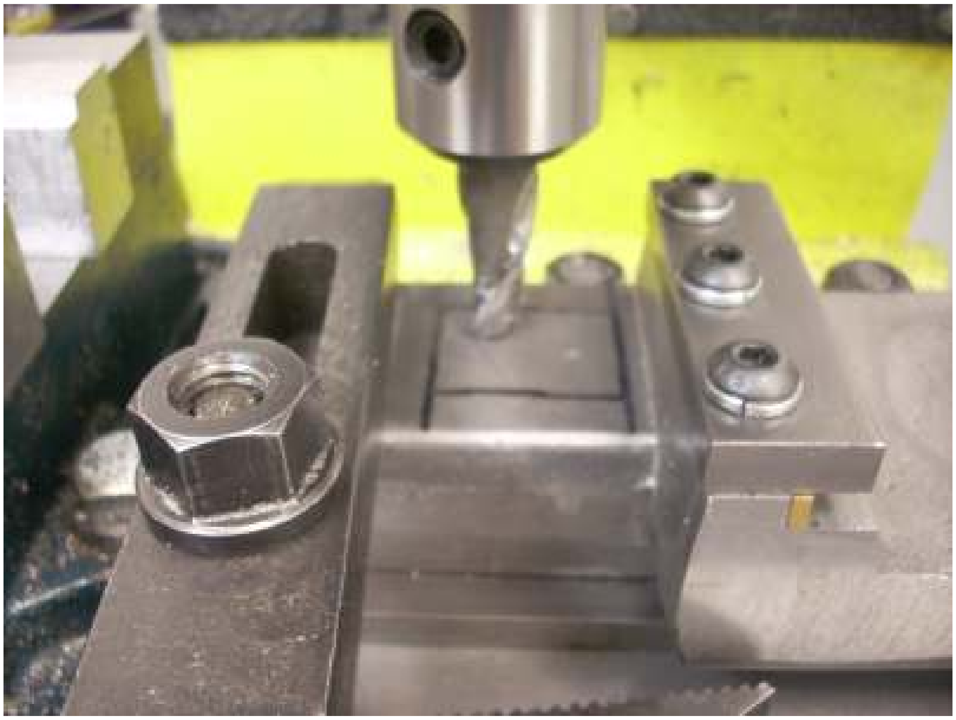


For this trial fit, I found that I needed the nut to be about ¼" out from the cross slide ways. Later I found that I didn't need to do this.

When I clamped the lower support in place, I woke up to the fact that I was bending the threaded rod. Yup, over constrained system but I didn't see it yet. My first inclination was to machine all surfaces that would contact the support blocks and nut. That should help them all align.

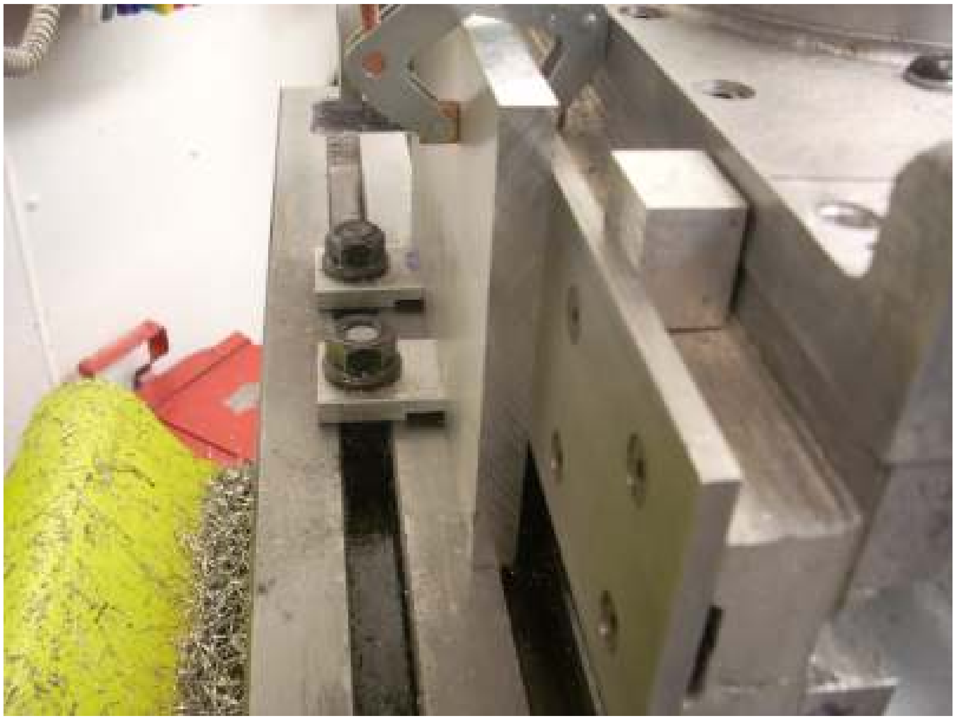
Machining Lands for the Support Blocks and Nut

Before I realized I had an over constrained system, I wanted the parts to line up as close to perfect as possible. The problem was that Gingery wanted me to bolt my support blocks and nut directly to cast surfaces. My castings are just not that true. So I decided to machine lands for the support blocks and nut.



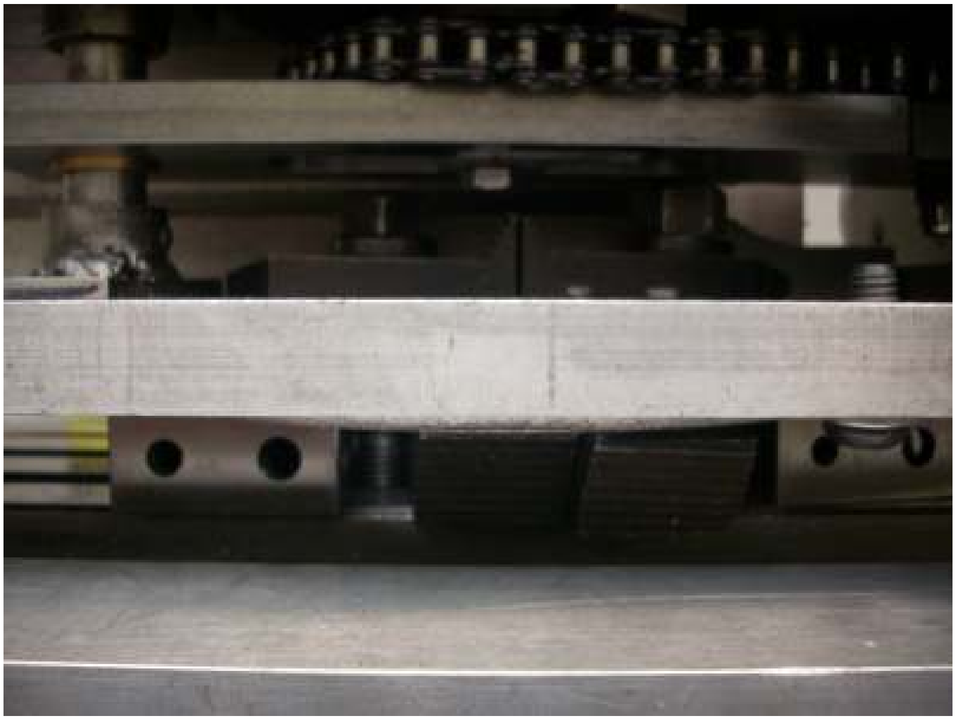
I trial fit the support blocks and nut and then marked out the areas to be machined flat. Here I am ready to true up an area on the cross slide casting. I just want to take enough off to get a surface that is parallel to the cross slide ways' face.

The area cleaned up nicely with about a 0.005” deep cut.

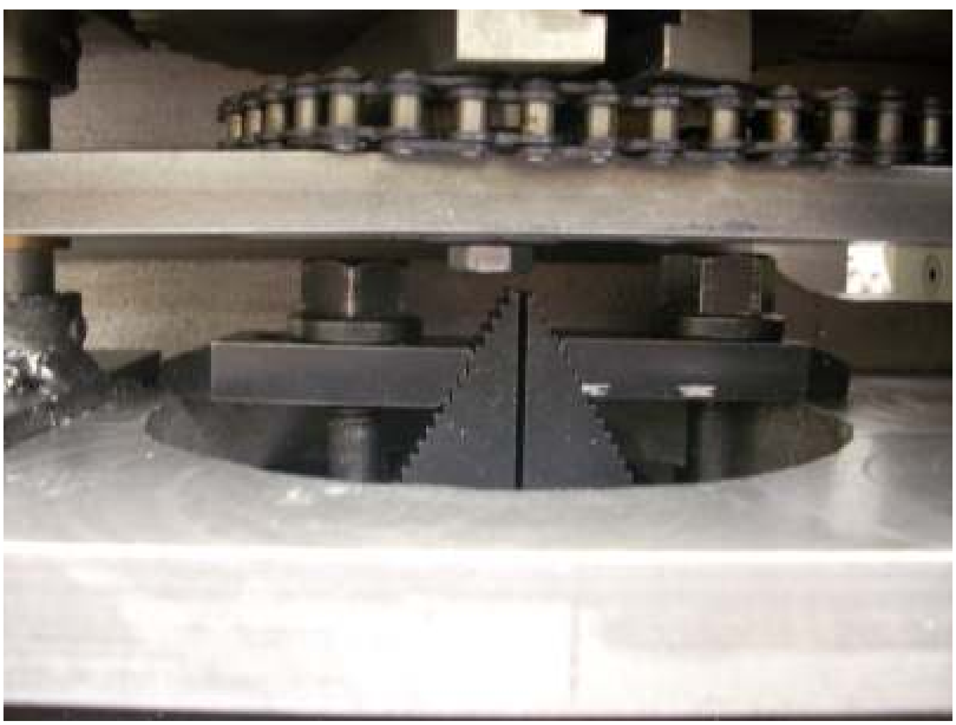


Cleaning up the side of the column was a little harder to do, mostly because I had to remove a few parts and wrestle the remainder onto the mill. This shaper is starting to get heavy!

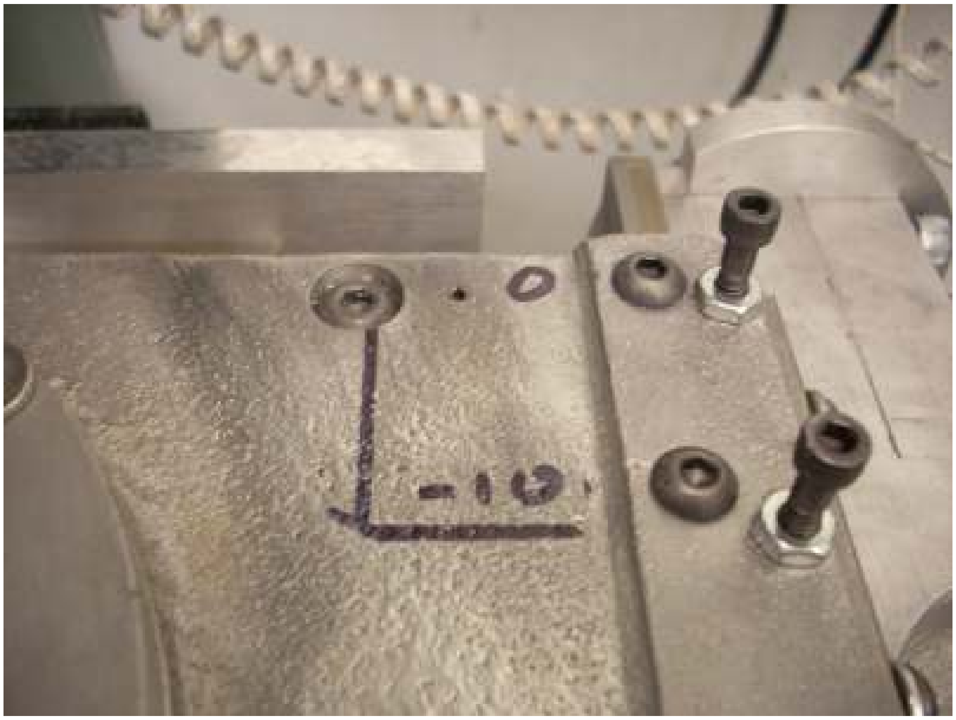
You can see my precision vertical surfaces in contact with a plate that has been clamped to the cross slide ways. It is not essential that the areas being machined are true but it was easy to do so why not?



We are looking at the non-crank face of the column facing down on the table. I have it up on two 1-2-3 blocks that contact the bolt ring face. This puts the assembly close to true.

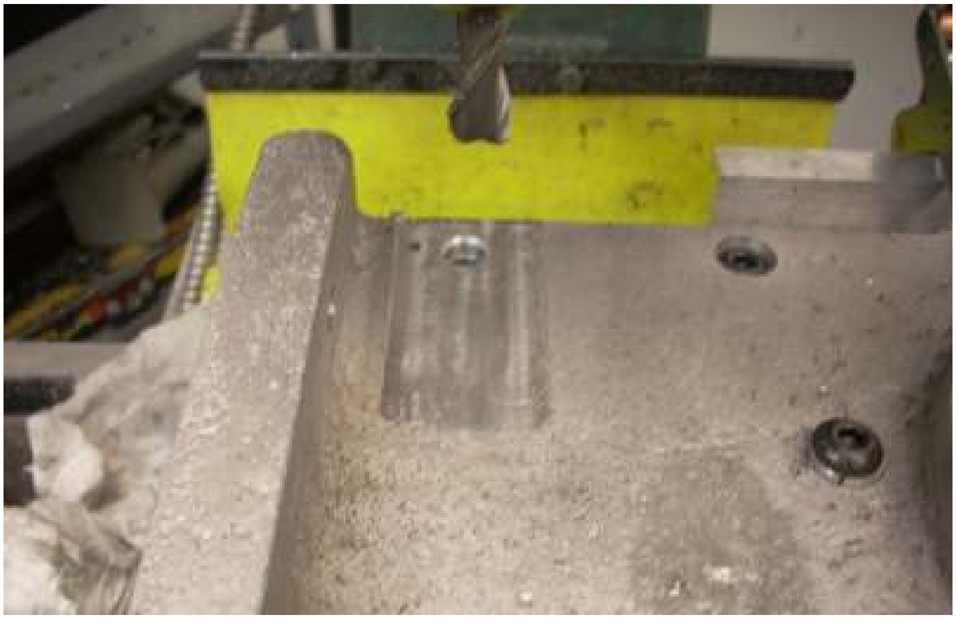


Hold down clamp inside the bolt ring are holding the assembly down to the table. Not much room in there to work.



Next, I took stock of what needed to be removed. Using the DRO, it was easy to set zero as noted above and then move around and find the contour. I'm down 0.010” here.

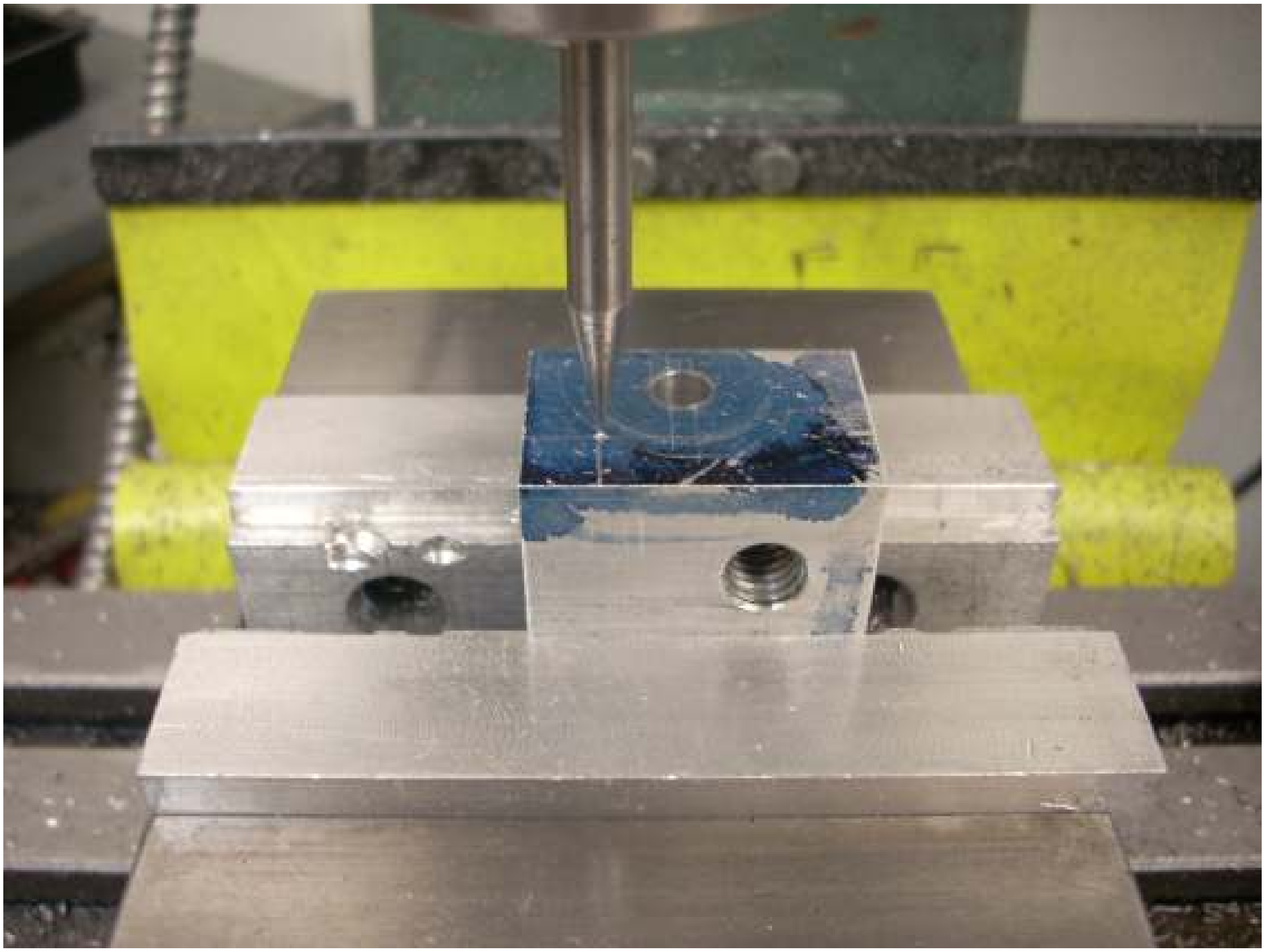
The lower end of the column had some shrinkage so you can see I was down 0.033”.



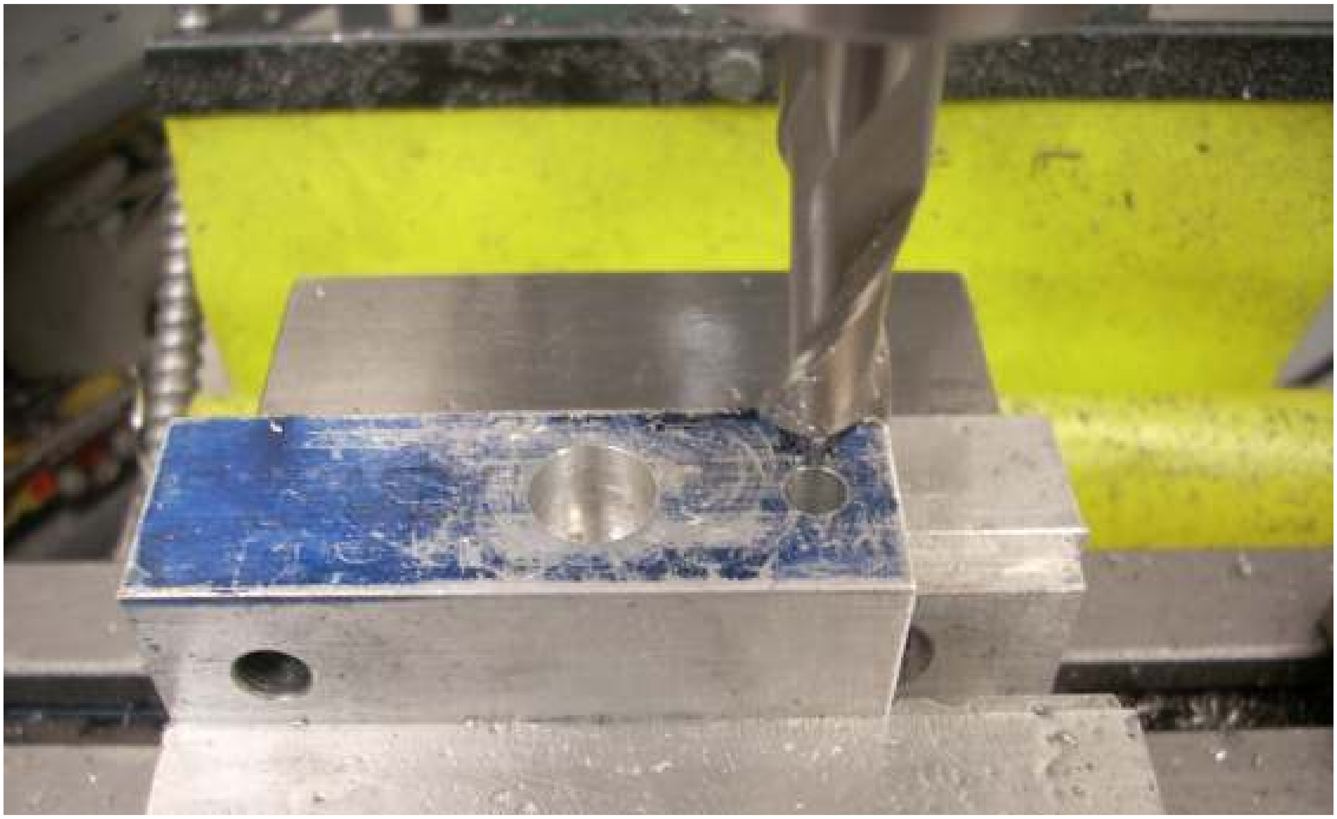
I took 0.01” deep cuts because I didn't trust the clamping arrangement that much and went down a total of 0.034” on both areas. I didn't want to have to recut these areas later to went 0.3” wider than the bar stock and about 0.5” longer.

The small hole to the right of the recessed screw is an alignment roll pin. I was able to tap it down below the surface so avoided milling it. Since they are made of spring steel, I didn't want to find out how they mill when set in soft aluminum.

Fitting of the Supports and Nut

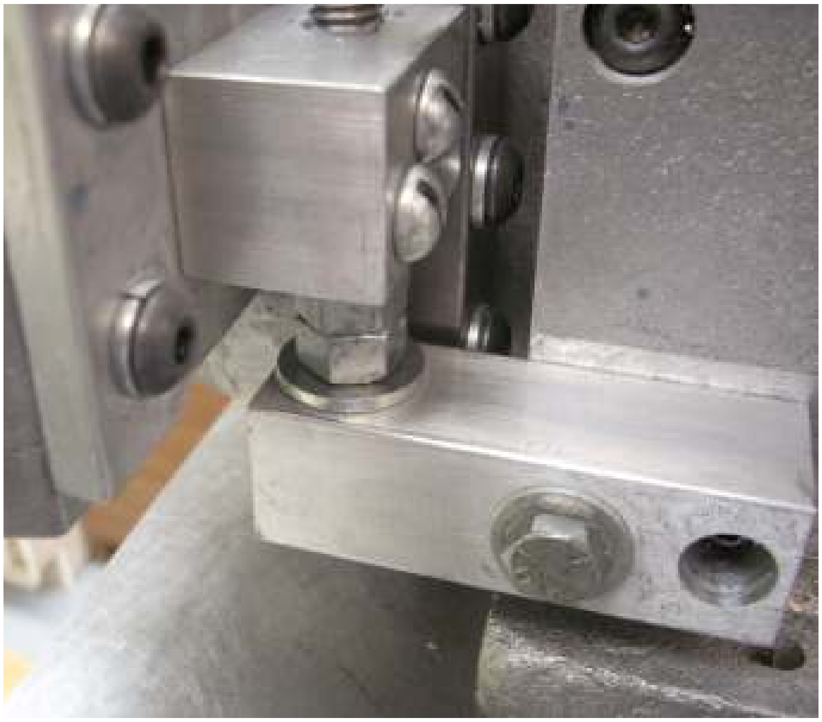


Here I am drilling two holes for the nut. Gingery only uses one but I was concerned that it might rotate under load.



This is the lower support. I counter bored down 0.5” because my screws are only 1” long. I'm using a ½” two flute end mill for the counter boring. Both holes are drilled for ¼”-20 clearance.

While fitting the lower support I suddenly discovered that I was supposed to use the existing 5/16”-18 screw! Oh well, so much for going for a close fit. About this time I realized that I had an over constrained system anyway so just opened up the lower hole from a close fit to one that is wide open. Note the temporary cap screw in that first hole.

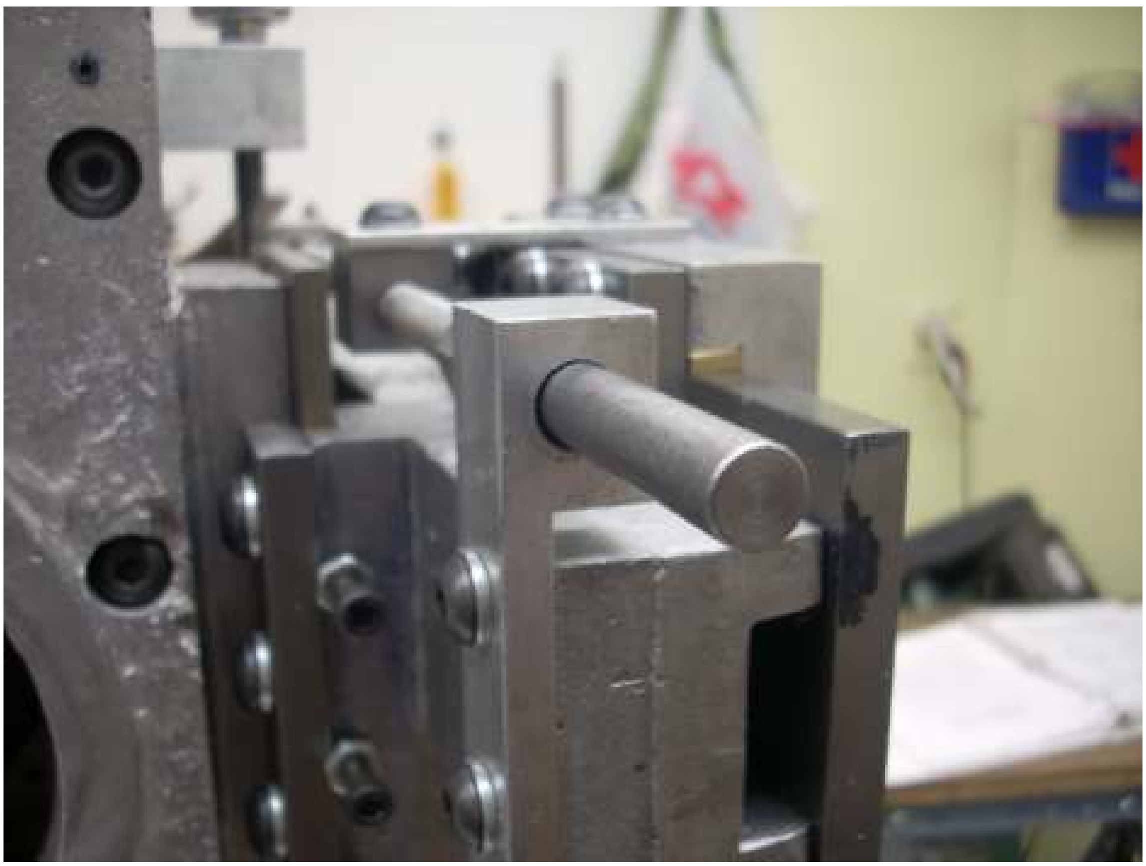


This is a classic case of making lemonade from lemons. The larger hole enabled me to live with the “surprise” constraint of needed to use that 5/16”-18 screw.

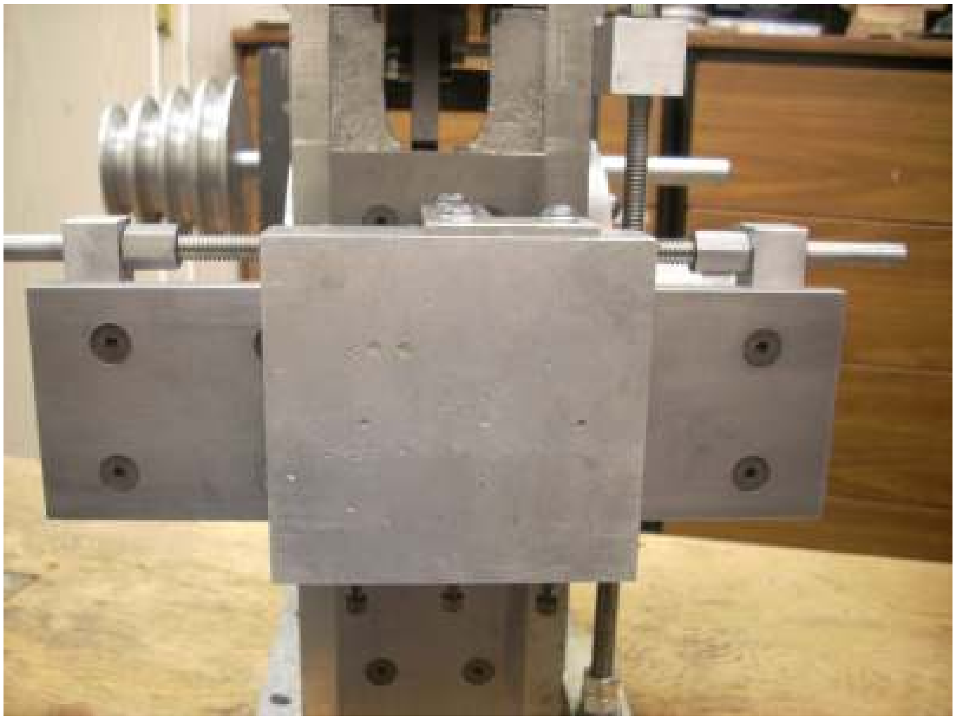
The washer was cut from 12L14. The two nuts lock together to complete my thrust bearing.

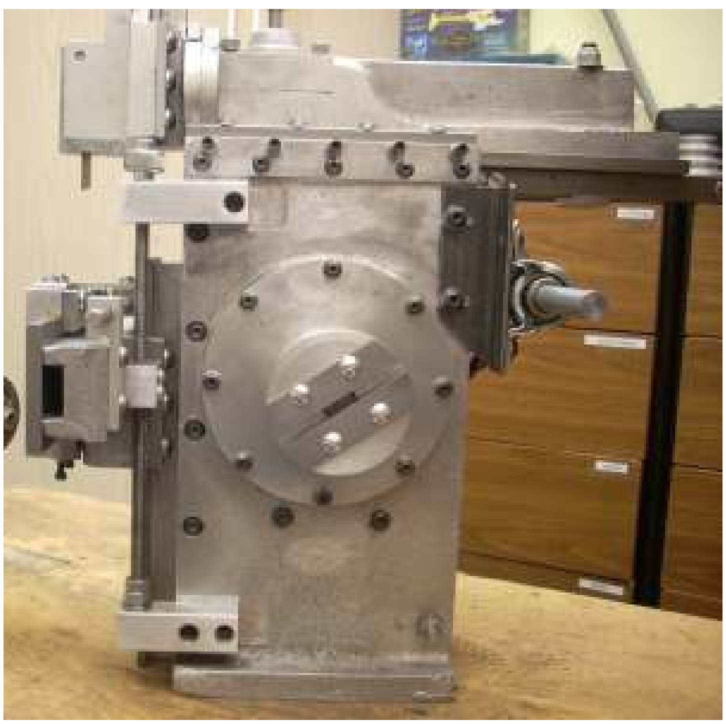
Here you see the hex drive end of the vertical screw poking out the top of the top support block. The hole is large enough to not touch the rod. It will only support the rod if there is a side force when the hex is being driven. Otherwise it just floats.

The cross feed nut clears the vertical screw ***because*** I trial fit the parts first.



While I was thinking about over constrained systems, I decided to drill out one of the cross slide bearings. It did improve the cross feed screw action yet should not add any play.


The vertical screw installed and freely moving.



The knob on top of the vertical screw has a hex hole in it. I can move the table support down with it since gravity is on my side. An electric screwdriver easily raises the table support now. Once the table has been added, it might be far more of a struggle.

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