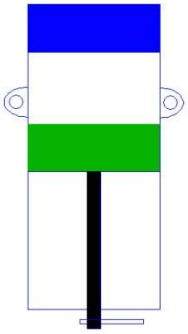
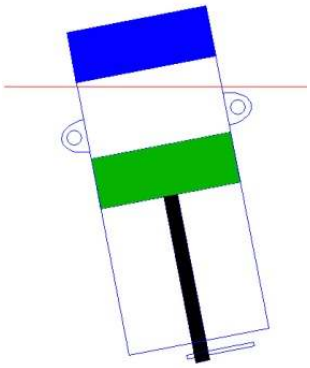
Aligning to an Axis

By R. G. Sparber

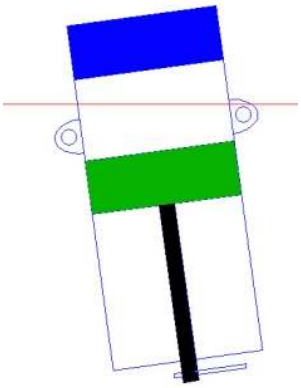
There are many times when it is necessary to align something to an axis, especially on a vertical mill. Often it is a vise.



It can be an exasperating experience. You set your Dial Test Indicator on the surface to be aligned and zero it. Then you move over and see the needle move. So you gently tap the vise being aligned until the needle again reads zero only to discover that your original set point is no longer zero. What is going on here?



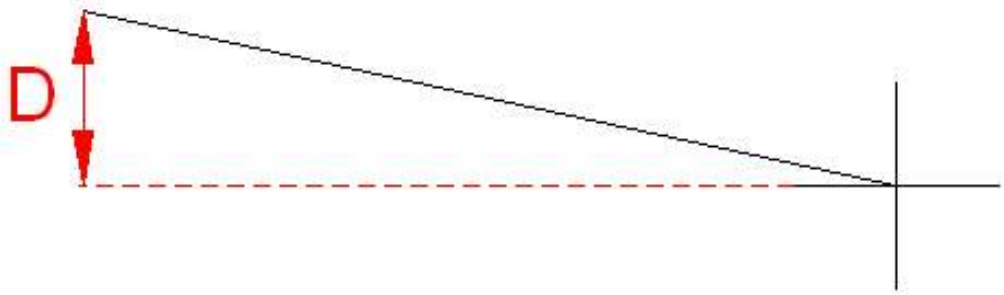
I will exaggerate the error to make it easier to see. We start with the vise tilted so the fixed jaw is rotated counterclockwise.



The action of tapping the vise does rotate it clockwise but also has moved it away from the DTI. You can re-zero, move, and tap all day long and never arrive at the desired orientation. Yet it doesn't have to be like this. You really can tap once and get alignment.

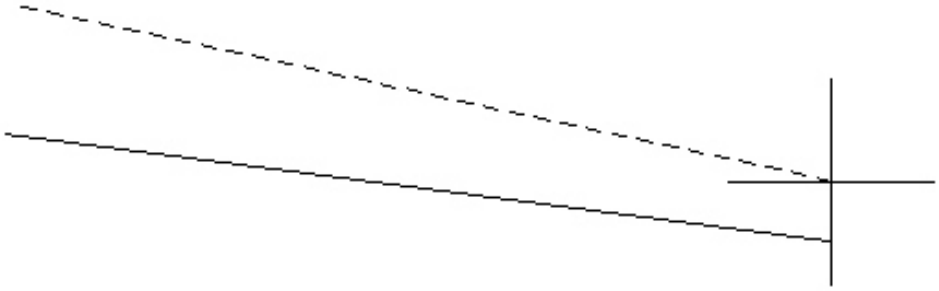
[1] You are free to copy and distribute this article but not to change it.

Let us boil this problem down to its basic elements.



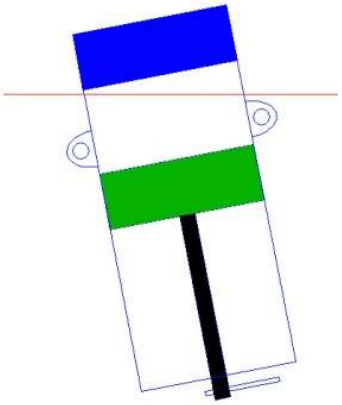
Our dashed red line is the X axis of our mill. The sloped line is the face of our fixed jaw on our vise. But wait; there is another element here that is of supreme importance. The cross on the right is our pivot point. If we pivot the sloped line around this point a distance “D”, alignment has been achieved.

Instead, we get…



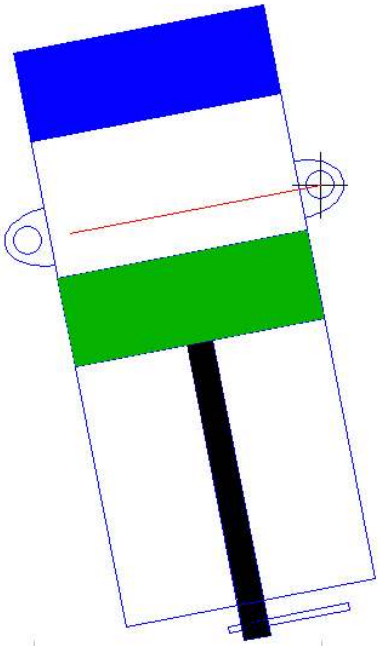
some rotation and some shift.

By locking the right end of the sloped line to the pivot point, we go from a shifting, frustrating odyssey to a simple rotation. The rotation is just like moving a door on its hinges. No surprises. I would just zero my DTI at the pivot point, move over some convenient distance, and then tap the vise until the needle reads zero again. It really is that simple. Well, it’s that simple if you have access to the pivot point.



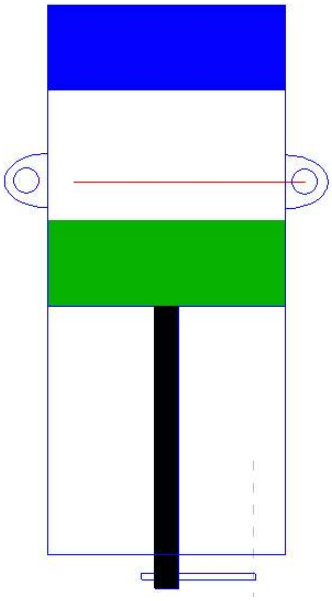
Take a close look at my mill vise. I hold it down with those two ears. Typically the bolts are in place but left loose when I am aligning it. I may try to use the right bolt as my pivot point but the play between hole and bolt is large. So my pivot point is not fixed and any tapping will rotate the vise and move me around that hole. The solution is simple; replace the right bolt by something that is a sliding fit in the hole plus a snug fit to the T nut below[2]. The T nut must be a snug fit to the T slot. This can be done by making a new T nut or wrapping an old one with a strip of aluminum such that it doesn't shift.

The second problem is that it is not convenient to set the DTI at this pivot point. The closest I can get is the right side of the fixed jaw shown here in blue.

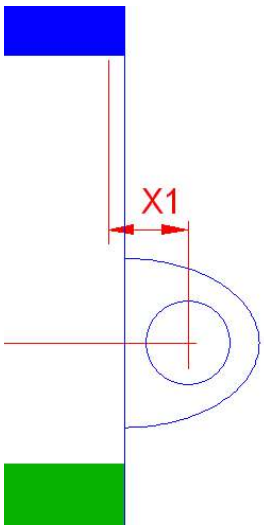


What if we draw a red line parallel to the fixed jaw but move it so the right end is located at my pivot point?

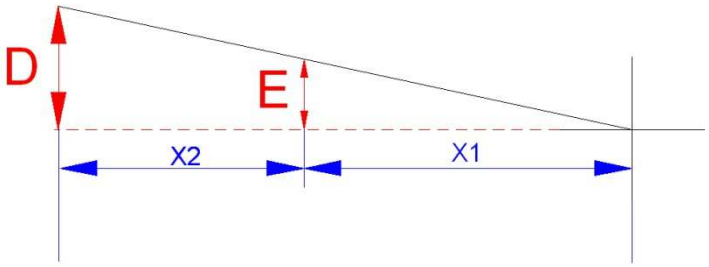
When the vise is aligned to the X axis, my line would be too. The trick is how to do this alignment without being able to put my DTI on the pivot point.



[2] I first addressed this subject in http://rick.sparber.org/Articles/VA/VA.htm



Let's take a close look at the pivot point of my vise. With the vise aligned to the X axis, I can measure the distance along this axis from my pivot point to where I want to zero my DTI. Call this distance "X1".

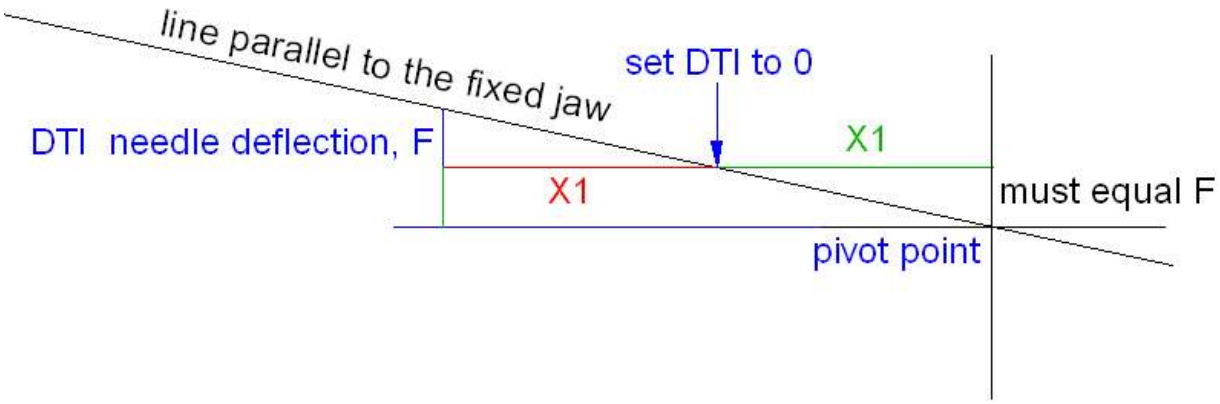


But our vise is not in alignment with the X axis so we are back to our sloped line. If I move[3] my DTI that distance X1 from the pivot point and zero it, I am actually in error along the Y axis by a distance of "E". If I then move an additional distance X2, I will get an error of "D".

The distance X2 could be anything along the fixed jaw but what if I make it equal to X1? And what if I draw a new line parallel to the red dashed line that causes E to equal zero. This zero point is exactly what I get when I zero my DTI on the right side of the vise jaws.

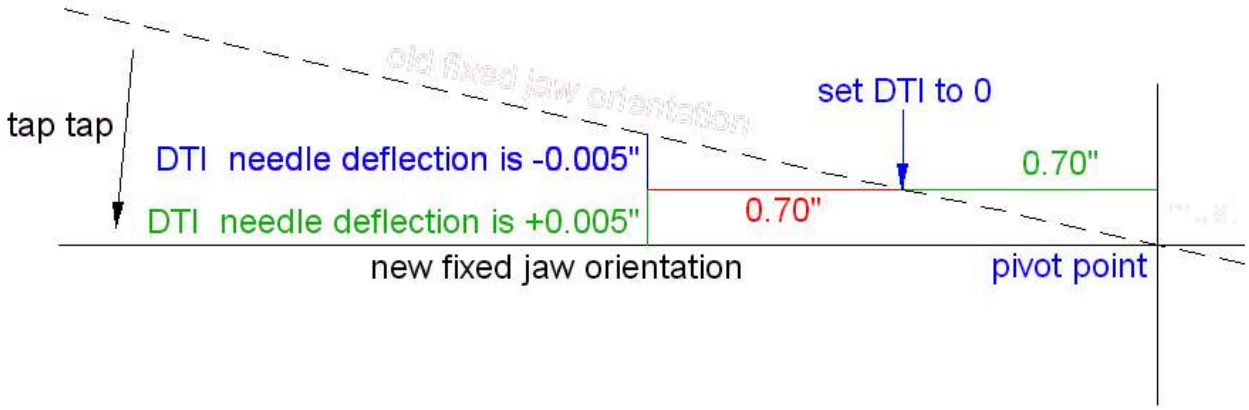
[3] All such movements are done by moving the mill table.

I now have a new way to look at my two right triangles.



Note that I now have two identical right triangles. One is formed by my red X1 and the height F. F equals my old height D minus E. My second triangle is formed by my green X1. The two triangles share the same angles so its height must equal F as shown on the right. The two horizontal lines are parallel so if they are separated by F on the right, they must also be separated by F on the left. So that vertical green line on the left must have a length equal to F. That's nice, but so what?

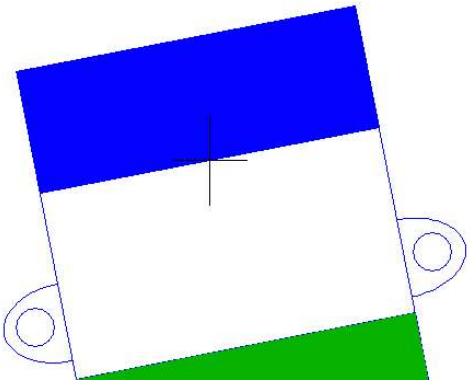
OK, time for the practical. X1 = 0.70” on my vise. I set my DTI on the right side of the fixed jaw and zero it. I then move to the left a distance 0.70”. The DTI now reads, say, -0.005”.



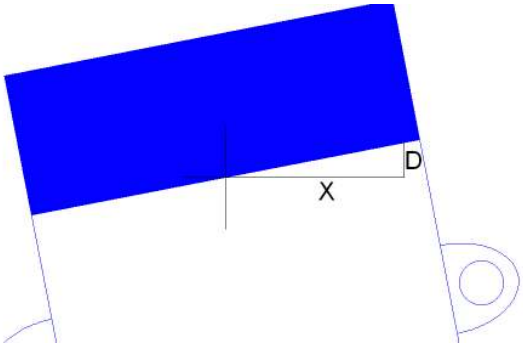
I then tap on the vise to rotate it about the pivot point until the DTI reads –F or +0.005”. The fixed jaw is now in its new orientation, parallel to the X axis. Had the DTI first read +0.005”, then I would tap until it read -0.005”. I then tighten the bolts and run the DTI one more time to be sure nothing shifted. Ta da!

Note that if I had just moved the vise until the DTI read zero, I would be only half way there. This is because my DTI was zeroed at a point some distance from my pivot.

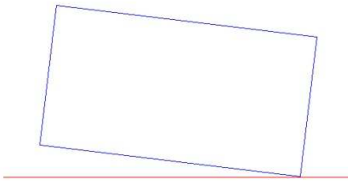
Some mill vises are mounted on a pivoting base. Assuming the pivot doesn't have any play, we can apply these same ideas to align it in one pass.



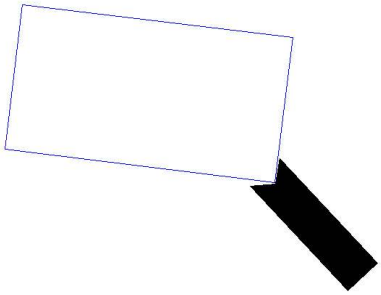
The first step is to locate the center of the fixed jaw within about 0.1". Doing it by eye is probably good enough.



You now move the DTI over some convenient distance, X. The DTI will now read some value, D. I would move over until the DTI read some large number that is easy to remember. Then you just tap on the vise until the DTI again reads zero. Clamp and re-check the alignment. If you do see movement, your pivot is not staying put so will need some modification.



This alignment technique works equally well with parts to be machined. Say I want to align a block with the X axis. All I need to do is constrain one corner so it acts as a pivot. Then I set my DTI at zero at this pivot point, feed over, and tap the block until the DTI again reads zero. Apply hold down clamps as needed.



One handy way to do this is with a notched piece of metal that is clamped down. Zero your DTI close to this pivot point, move over some distance, and tap the block until you again read zero. You will need to press on the block while you pivot it so the corner stays seated in the notch.

In all of these examples, the concept is embarrassingly simple: establish a pivot point and understand how you move around it. When you are able to do alignments in a single pass, there will be more time for making chips.

You questions and comments are always welcome. All of us are smarter than any one of us.

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