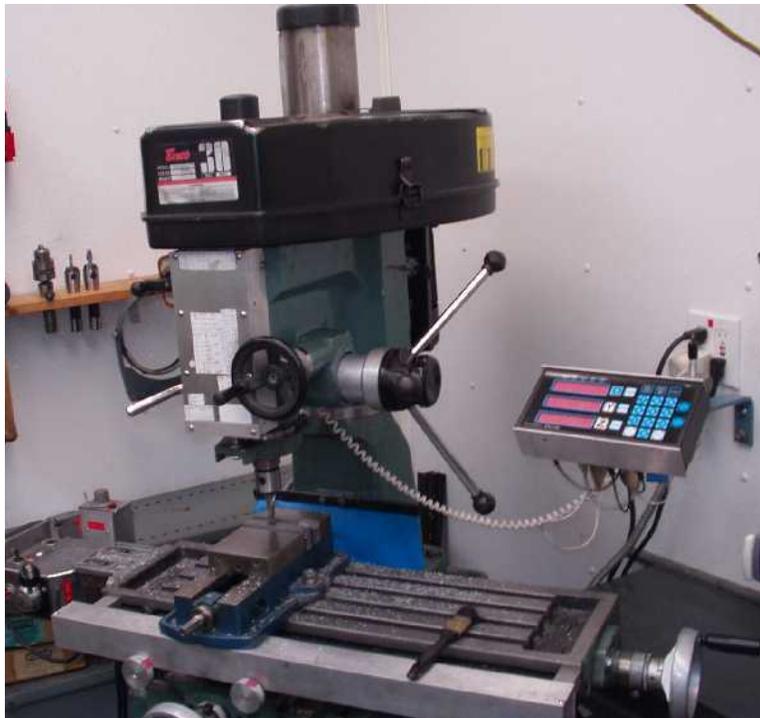


# **The *Unauthorized*** **ShumaTech DRO-350 User's Guide,** **Version 4**

By R. G. Sparber

July 23, 2009

Copyleft<sup>1</sup> protects this document.



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<sup>1</sup> See <http://en.wikipedia.org/wiki/Copyleft> for details.

# Revision History

## Version 3

I have updated the Zero Preset and Tachometer function descriptions thanks to Les Jones. There is also a comment related to the Bolt-Hole function thanks to Bob Pinkus. Thanks to Larry Gill for numerous comments.

## Version 4

I have added an alternate explanation of how incremental preset works. A Table of Contents has also been added. Absolute preset is not supported.

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## Background

I decided to title this document “*Unauthorized*” because the real guide is on the Shumatech.com site. I strongly encourage you to download and print it<sup>2</sup> because I will be following it closely. Scott Shumate has done a masterful job of creating the hardware, software, and documentation for the ShumaTech DRO-350. In his user's guide you will find what buttons to push in order to enable the multitude of available functions. What I found lacking was an explanation of *why* I would want to push those buttons. I hope to supply at least some of the ways these functions are useful in my shop. I have limited myself to the mill version of the software because that is all I own.

Throughout this article you will find pointers, like <9>, to Scott's user guide by page number.

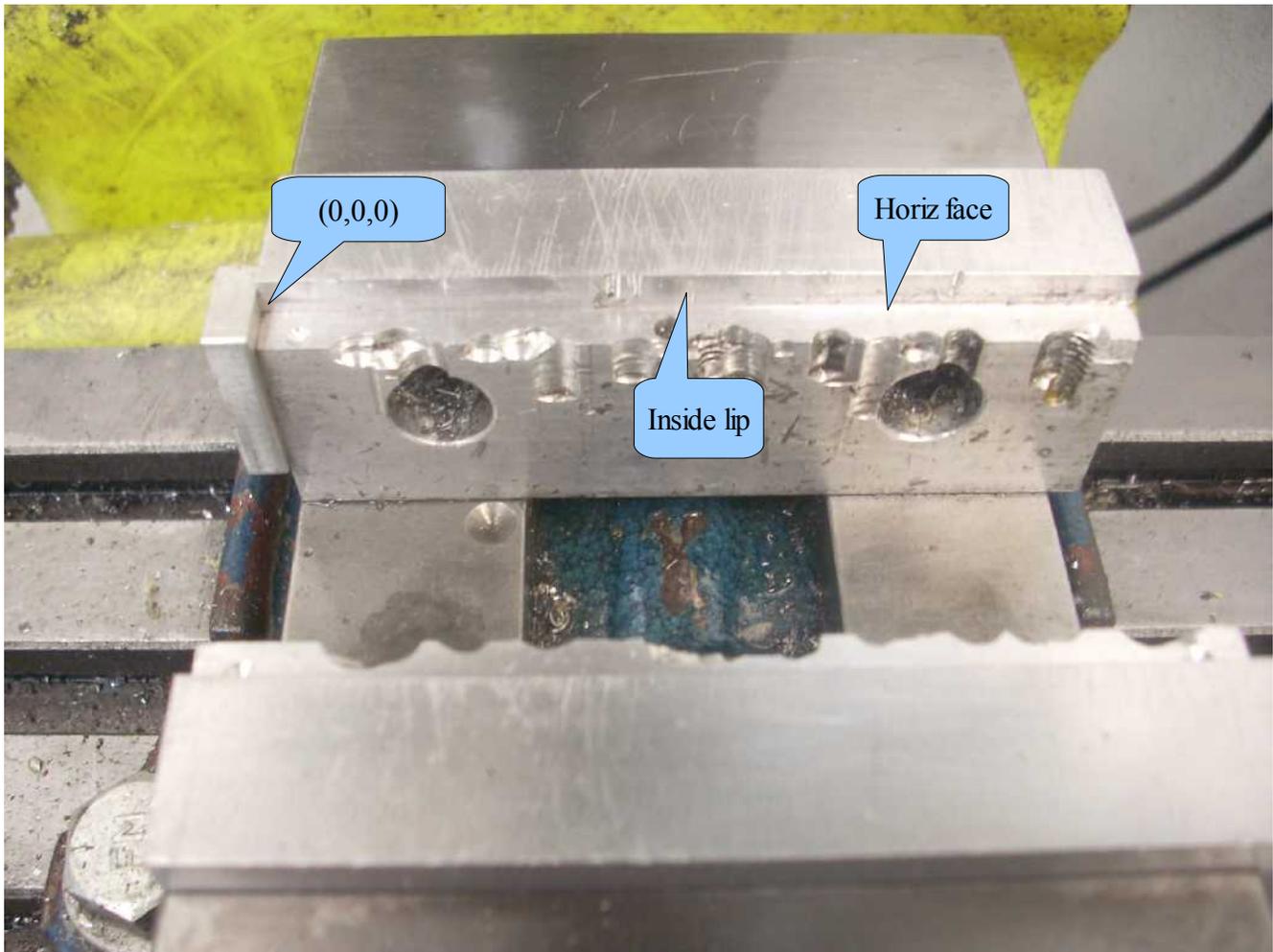
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<sup>2</sup> <http://shumatech.com/products/dro-350/guide.htm>

## Mill Functions

### ***Absolute Zero <9> at the Current Position***

We all have to start someplace. The mill has X, Y, and Z axes but we must define what we mean by zero on each one.



I know these “soft” jaws<sup>3</sup> look rather ratty but they are, in fact, very precisely aligned with the X and Z axis. The back jaw is fixed and the front jaw can move. Attached to the left side of the back jaw is a stop. I usually want to define  $X = 0$  as the right face of this stop.

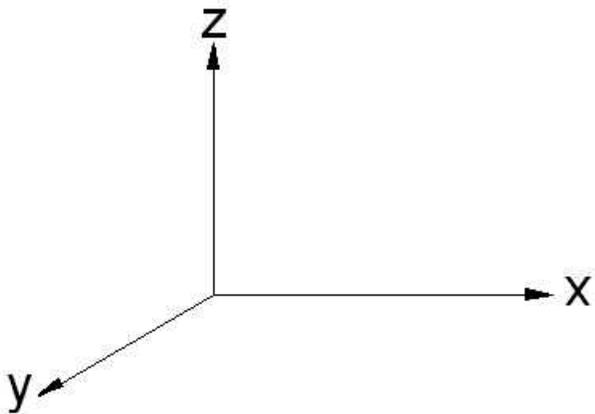
There are two ways to define  $Y = 0$ . The CNC standard is to set  $Y = 0$  at the inside lip of the movable jaw. Whenever a new sized part is clamped into the vise, one must touch down on the reference surface to define  $Y = 0$ .

I prefer to define  $Y = 0$  against the inside lip of the fixed jaw. In this way I don't have to keep touching

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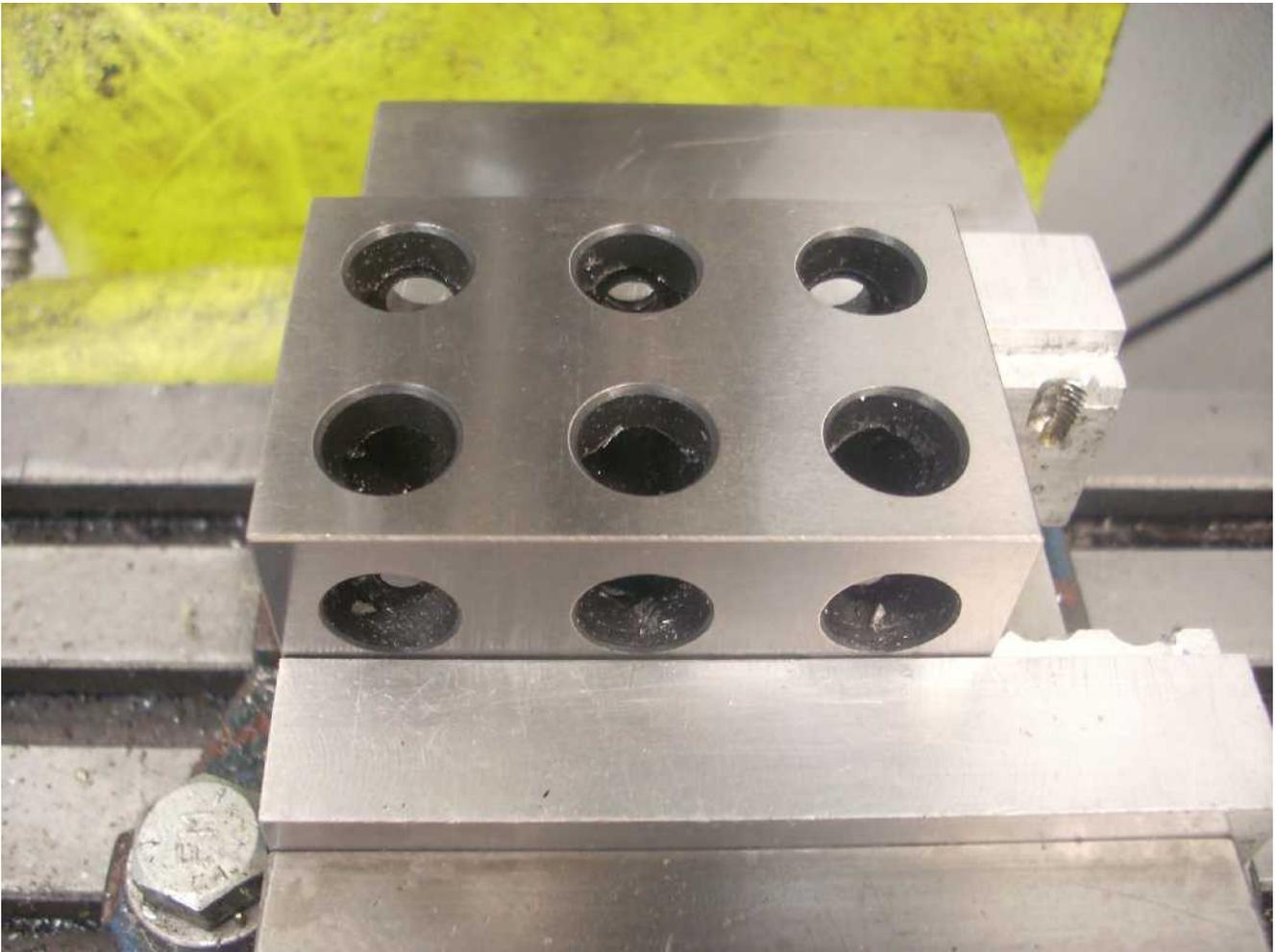
<sup>3</sup> <http://rick.sparber.org/Articles/sj/sj6.pdf>

down on my reference surface in order to find  $Y = 0$ . Similarly, I set  $Z = 0$  on the horizontal face of the lip.



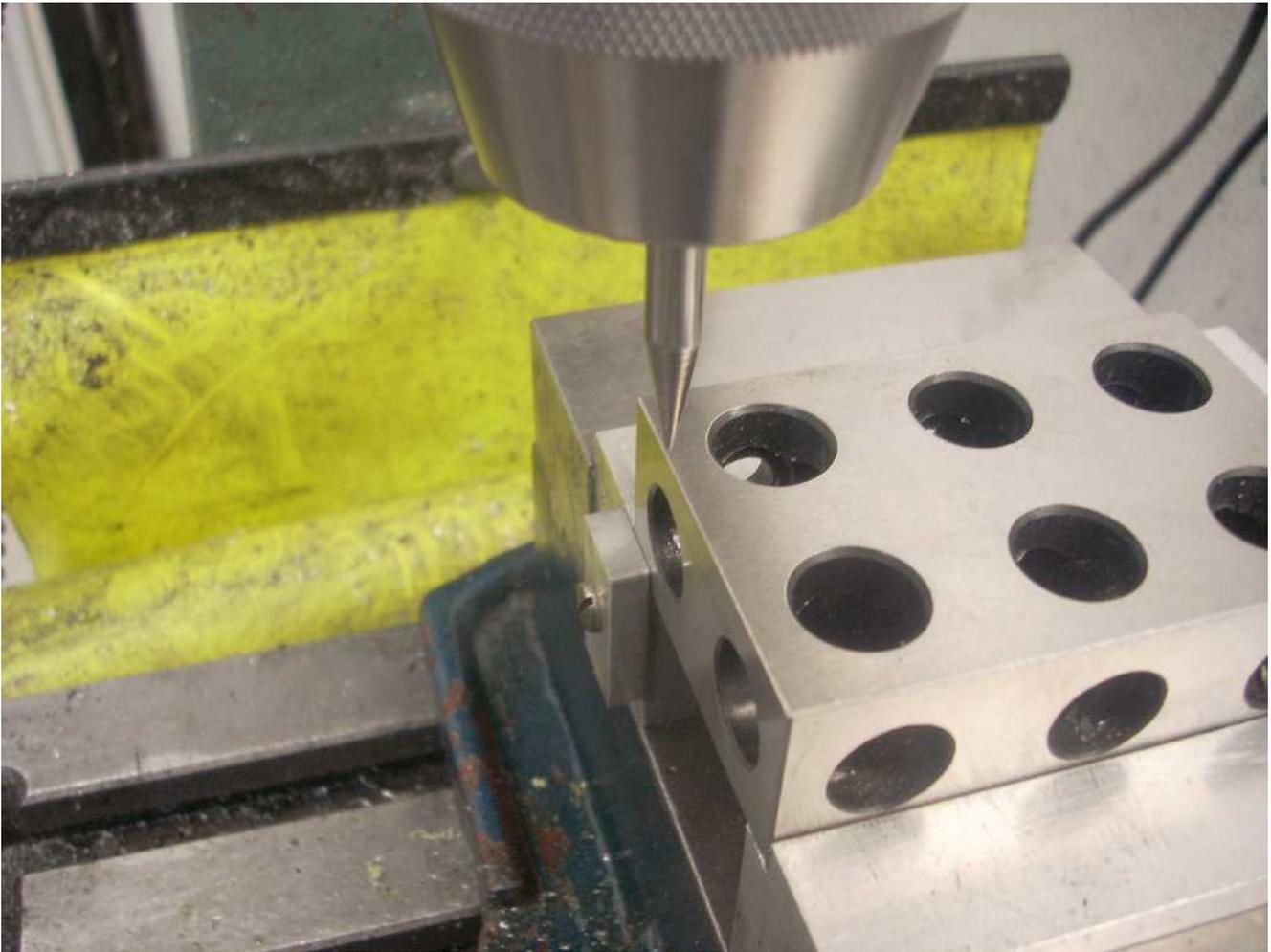
The intersection of my X, Y, and Z axes is my  $(0,0,0)$  reference point which is also called the origin.

Note in this graph that X becomes larger as I move away from the origin to the right. Y becomes larger as I move to the front. Z becomes larger as I move up.



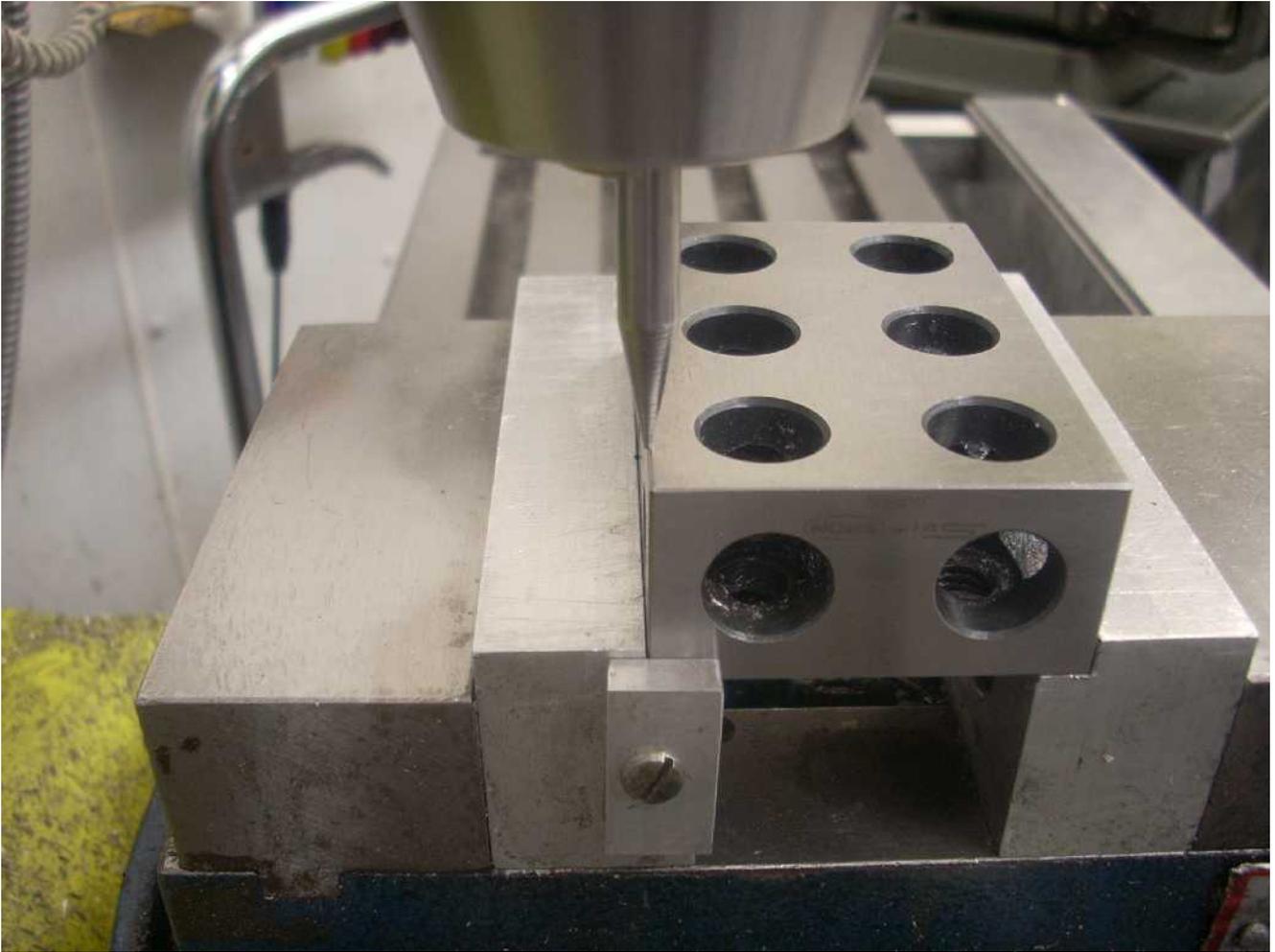
After cleaning off all mating surfaces, I have clamped a precision 1-2-3 block into my vise. This is for

instructional purposes only. I have no intention of touching this hardened block with a cutter.



The block is snug against the fixed jaw's lip and the fixed jaw's X axis stop. I have put a “spud” into my drill chuck as a means of locating surfaces. This is not particularly accurate but is easier to understand than if I used my Electronic Edge Finder. I'll get to the EEF later.

In order to set Absolute Zero <9> on the X axis, I start by moving the Y axis such that I'm away from the corner. The tip of the spud is then lined up with the left face of the 1-2-3 block. I then press the ZERO button for the X axis **twice**. This has been a point of confusion for me but after a closer reading of Scott's User's Guide, I now have it right. The first push of an axis' zero button says we want to set a zero. The second push of that same zero button says we want to set zero at the present physical location.



Next I move to the back of the 1-2-3 block again staying away from the corner. When the tip of the spud is lined up with the back face of the block, I press the ZERO button associated with the Y axis **twice**.

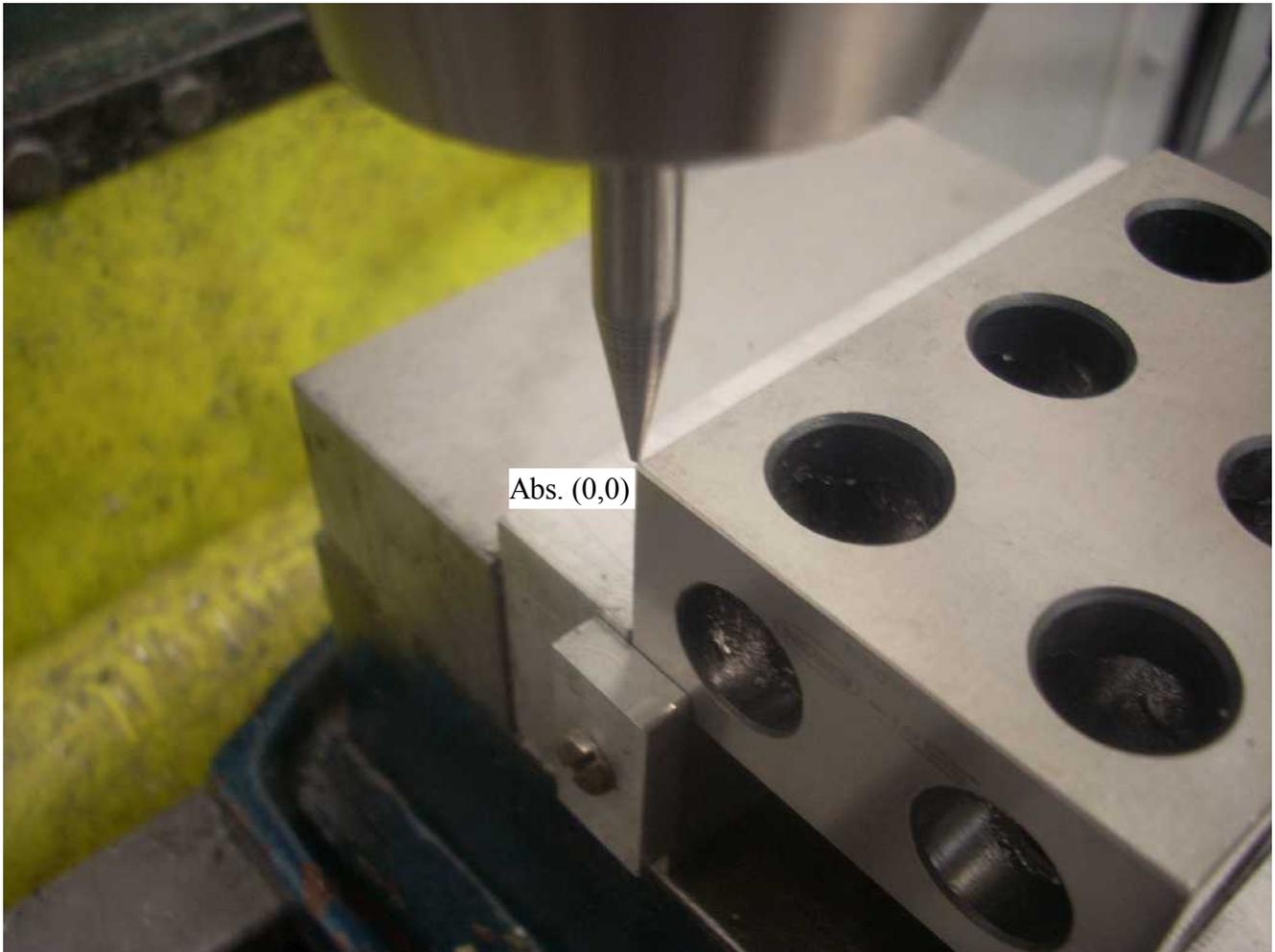
Why stay away from the corner? Because it is hard for me to accurately sight both axes at the time. If using an EEF, it is essential you are completely on a flat surface so away from the corner.



Sorry about the glare, but you can hopefully see that I now have my X and Y axes zeroed. My X axis shows a negative sign in front of my zeros while the other two axes are positive zero. This is not important. Both mean zero.

If you are paying close attention, you will note that I have a lathe faceplate on my DRO but have pasted over the Y and Z buttons next to their displays. It is just not worth the trouble to pull off this faceplate and stick on the right one. Who knows, I may yet move this unit to my lathe.

I have zeroed my Z axis display too but have not defined the location yet. That is a function of the tool I mount in my spindle. Once the tool is mounted, I can touch the end of it down on the horizontal face of my fixed jaw and set  $Z = 0$ .



To recap, I have defined  $X = 0$  at the left face and  $Y = 0$  at the back face of my 1-2-3 block. In all cases I have set zero by pushing the associated zero button **twice**.

One very confusing thing for me was “Polarity” <18>. With the back left corner of the block defined as my origin, I want the numbers to increase as I move my **cutter** to the right and/or to the front. But wait, the cutter isn't really moving! The part is moving.

My solution was to ignore reality and think of it as the cutter moving while the part stands still. This bit of fiction has served me well over the years.

If you want to have my “Polarity” for the scales, then go to Setup <18> and set

X – Po

Y – Ne

Z – Po

Oh yes, one more thing. I have labeled each of my axis hand cranks with a “POS” and “NEG”



rotational direction in hopes of minimizing the number of times I move the cutter in the wrong direction and spoil my project. It has saved me a few times.

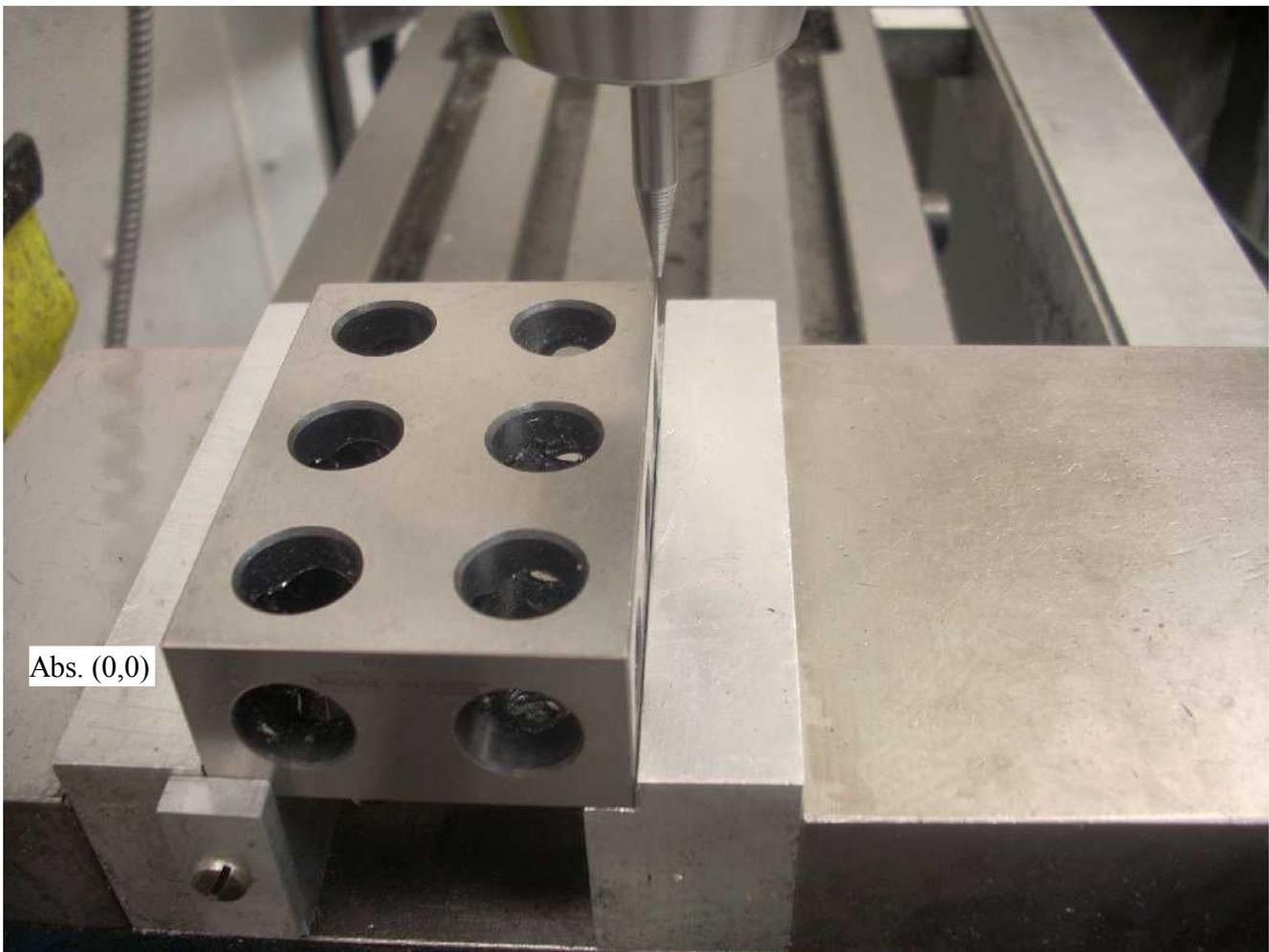
I have now cranked the X axis so my spud is 3.0005” to the right of my origin and my Y axis 2.0000” . These are the exact value on the display. Please do not confuse the precision of the numbers with with



the absolute accuracy of the DRO. That is a different can of worms<sup>4</sup>.

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4 See many articles related to accuracy at <http://rick.sparber.org/sh.htm>.



The lower left corner of my 1-2-3block is my origin. My spud is at  $X = 3.0005''$ ,  $Y = 2.0000''$ .

In many cases the exact location of the origin is not that important. What often matters is that the relative position of machined features be precise. As long as the origin does not move, everything works out fine. If you must have the origin precisely aligned with two reference faces, a Dial Test Indicator or Electronic Edge Finder can be employed.

### ***Absolute Zero <9> at an Offset from our Current Position***

**Note: I received an email from Scott Shumate on 7/21/2009 saying that this function is not supported.**

This function lets me move my zero point on a given axis by a specified value. What is very confusing here is that the polarity of the resulting offset is a function of the axis polarity defined in Setup (FUNC 0). As you saw on page 9, I have my X and Z axes defined as positive but my Y axis defined as negative. A positive defined axis causes the sign of the offset to change while a negative defined axis causes the sign of the offset to not change.

I believe there is a bug in the code. Let me illustrate with three examples:

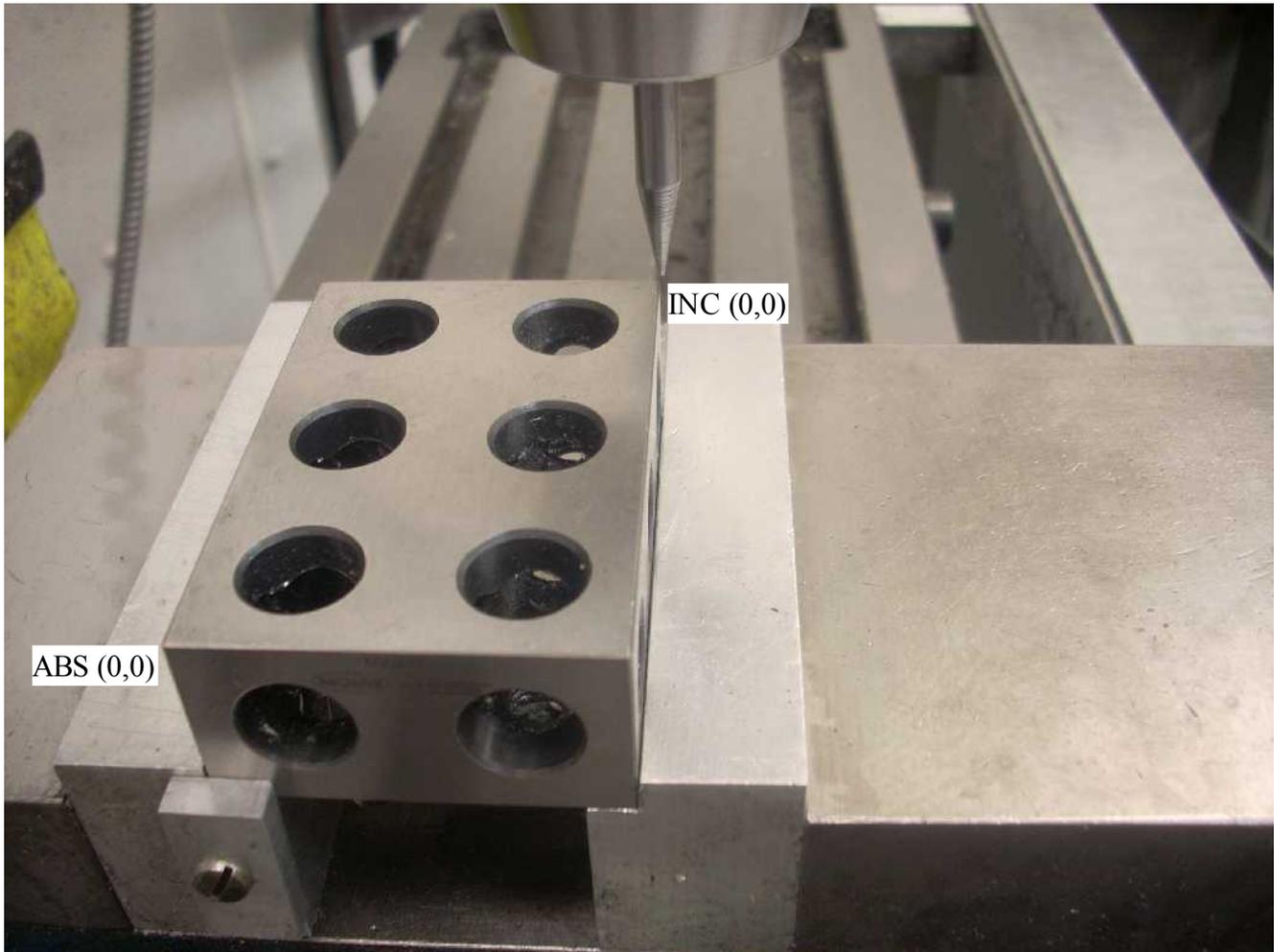
1. My X axis is defined to have a polarity of positive. Say I set  $X = 0.000$  by pressing the Zero button twice for my X axis. I then press this Zero button again and the Zero LED turns on. I enter "1" on the keypad and then press the "Enter" button. My X axis will now display -1.000. Do you see that I entered +1 but the display shows -1? Understand that the DRO is taking the current value for X and subtracting 1 from it. If I had started with an  $X = 1.234$ , the final value would have been 0.234. See page 24 for why this makes sense to me.
2. My Y axis is defined to have a polarity of negative. Say I set  $Y = 0.000$  by pressing the Zero button twice for my Y axis. I then press this Zero button again and the Zero LED turns on. I enter "1" on the keypad and then press the "Enter" button. My Y axis will now display 1.000. I believe this is backwards as explained on page 24.
3. And finally, my Z axis is defined to have a polarity of positive. Say I set  $Z = 0.000$  by pressing the Zero button twice for my Z axis. I then press this Zero button again and the Zero LED turns on. I enter "1" on the keypad and then press the "Enter" button. My Z axis will now display -1.000. See page 24 for why this makes sense to me.

### ***Absolute Zero <9> set by an Electronic Edge Finder***

An Electronic Edge Finder is just a probe that is insulated from the rest of the machine but connected to the DRO via the Auxiliary Device input. The probe is fitted in place of a cutter. When this probe comes in contact with a surface electrically connected to the machine, a circuit is made. This circuit can be used to tell the DRO that we just touched down. When used in combination with Tool Offset <15>, we can easily set zero for a given axis on a given surface. More on this subject can be found on page 39.

## **Incremental Zero <10>**

There are times when some machined features must be precisely set relative to our origin while other times I must be a precise distance from a different point. The latter case is when defining an incremental zero is handy.



For example, say I want to define the absolute location (3.0005", 2.0000") seen above as an incremental origin. I first push the ABS/INCR button such that the INCR LED lights. Then, without moving either axis, I press the Zero button on both the X and Y scales.

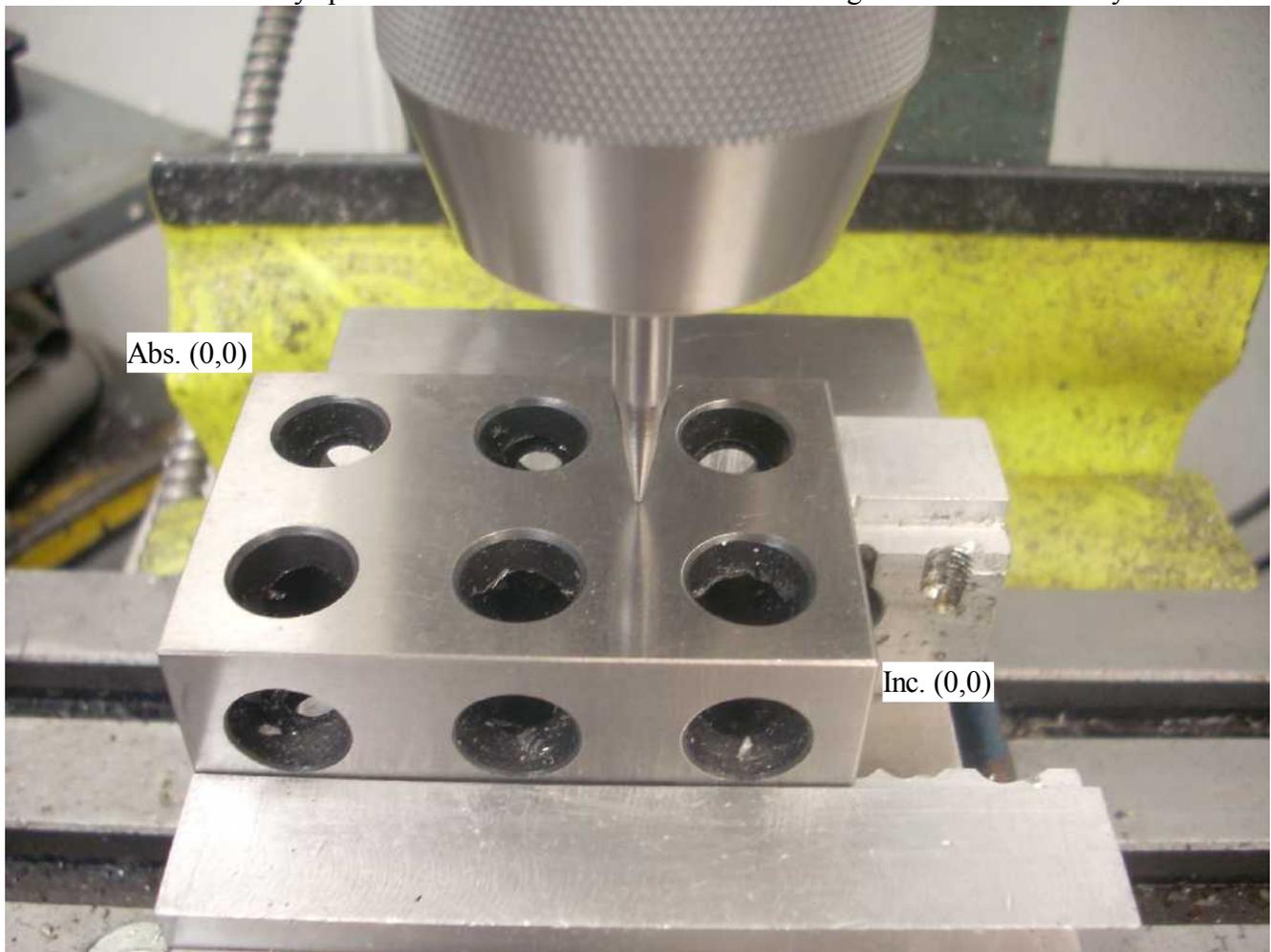
I now have my absolute (0,0) point at the lower left corner of my 1-2-3 block and my incremental (0,0) point at the upper right corner. Just by pushing the ABS/INCR button I am able to switch between these reference points.



While in INCR mode, I have moved 1.0005" to the left of my INCR X = 0 point and also 1.000" in from my INCR Y = 0 point. Note that my INCR LED is lit.

Remember how I set up my Polarity? Moving my spud to the right or towards me is positive.

You can see here that my spud is to the left and back from the front right corner. This is why both X

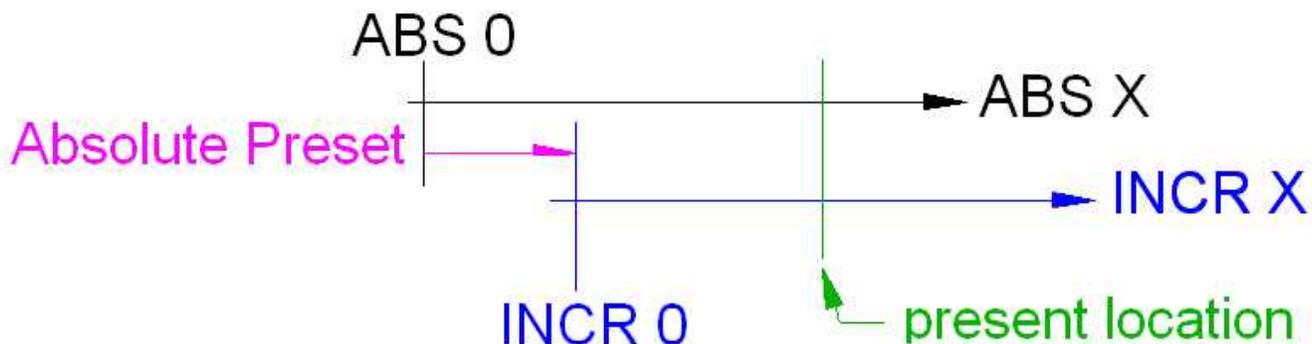


and Y are negative with respect to my INCR origin which is the front right corner.

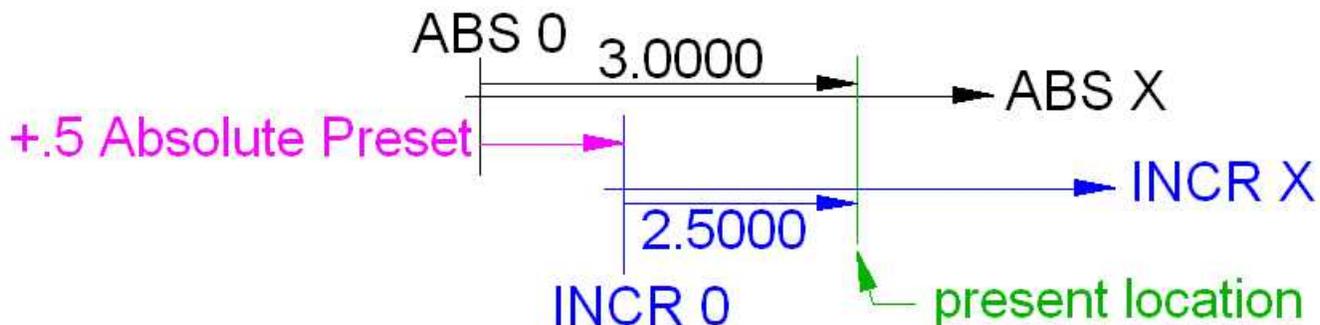
If I switched back to ABS, the display would read  $X = 1.9995''$  and  $Y = 1.0000''$ . If INCR had been  $X = -1.0000''$  instead of  $-1.0005''$ , then ABS X would be  $2.0000''$  rather than  $1.9995''$ .

## Absolute Preset <10>

This one sure had me turned around for a long time. Start by thinking only about the absolute X axis and the incremental X axis.



On the top I have my ABS X axis with its ABS 0 set. Below it is the INCR X axis and its INCR 0 set. These two axes are normally unrelated. By using the ABS and INCR Zero functions, we can set both at any location we want. But what if we wanted to set a relationship between them? Say I want my INCR X axis to be shifted by a fixed amount relative to my ABS X axis. This shift is accomplished with my Absolute Preset function. Let's move on to a concrete example.



Say I want my INCR X to be shifted 0.50000" up the ABS X scale. I would have input a +.5 Absolute Preset. I happen to be at an ABS X location of 3.0000". When Enter is pressed, my INCR X zero point will be set to a point lined up with an ABS X value of +0.50000". This means that when my ABS X value is 3.0000", my INCR X value will be 2.5000".

Now, lets do it again but this time looking at the DRO. I start out at an ABS X = 3.0000". I press the X preset button and input ".5" which displays at "0.5". Internally it will be stored as 0.50000".



I then press the Enter button and we see:

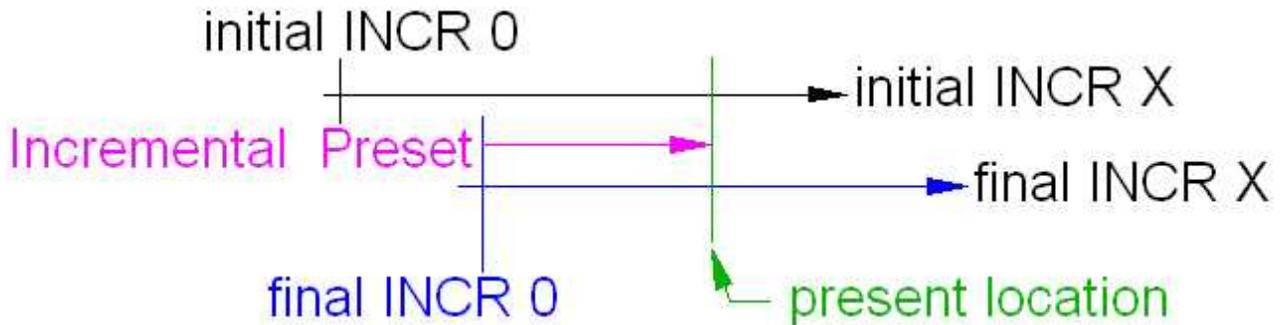


You can see from the LEDs that we are now in INCR mode. Our INCR X value is now 2.5000". The INCR Y value just happened to be zero and INCR Z was 0.008". The change to the INCR X axis has no effect on the Y and Z axes.

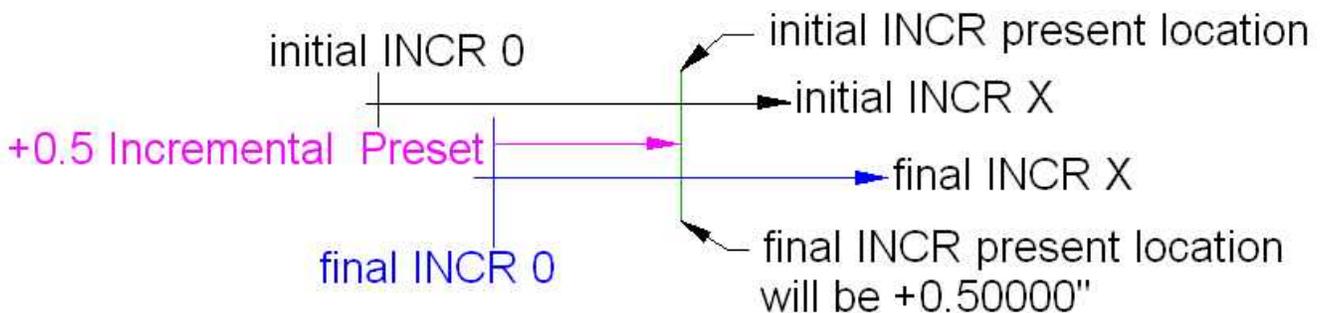
Hopefully I have explained to you what Absolute Preset does. Now, as to **why** you would use this function, I can't think of one right now. Hopefully others will read this article and help me out.

## Incremental Preset <10>

Similar to the Absolute Preset, Incremental Preset also changes only the Incremental zero point of an axis.



We have an initial INCR 0 set point which will be modified by the Incremental Preset to produce a final INCR 0 set point. Only the INCR axis is changed and the initial INCR 0 is lost.



Say I am sitting at some initial INCR position on the X axis. I want to define my INCR 0 to be some distance from my present location. If I wanted that distance to be 0, I would just use my Incremental Zero <10> function. But if I wanted my INCR 0 to be such that I was sitting at +0.5000", I would use my Incremental Preset function. I don't physically move my position. My INCR 0 moves. Kind of hard to get your mind around.

Let's look at a few screen shots.



I am in INCR mode as can be seen by the LED. My INCR Y display says I happen to be at 0. Say I want to move my Y axis INCR 0 such that I am at +0.5000”.



I first press the Y preset button and then input .5. the display shows 0.5” but internally it will be stored as 0.50000”.



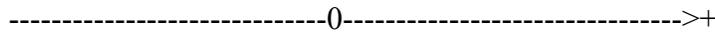
When I press the Enter button, my Y display shows 0.50000". My mill table did not move. I just defined my INCR 0 for the Y axis to be 0.5000" in back of my present location.

Incremental Preset can define INCR 0 at any point within the range of the DRO relative to your present location.

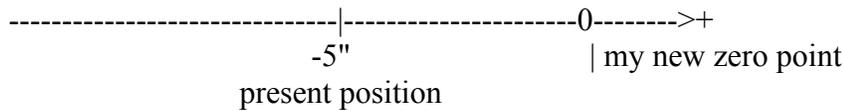
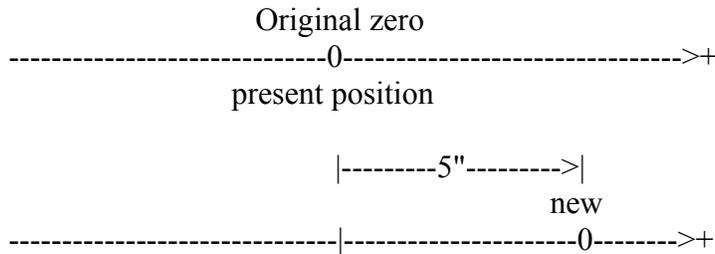
Hopefully I have explained to you what Incremental Preset does. Now, as to **why** you would use this function, I can't think of one right now. Hopefully others will read this article and help me out.

One point of confusion is that you input an offset and after pressing Enter, the display shows the negative of this number. Some expect to see just the number. Here is one way to look at the logic.

I am at zero on a given axis.

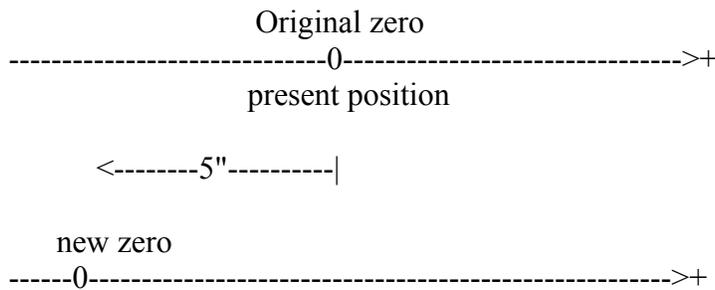


I want to define a NEW zero point on this axis. Now, I am not physically moving the table. When I say I want my zero to move by +5 inches, picture the zero point being picked up and moved to +5 inches.

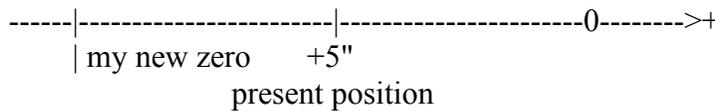


my present position relative to my new zero point is -5. The display shows my present position as "-5.000". When I have move the table so the display reads 0, I will have moved +5 inches.

Now, consider what it means if entering +5" causes the display to show +5".



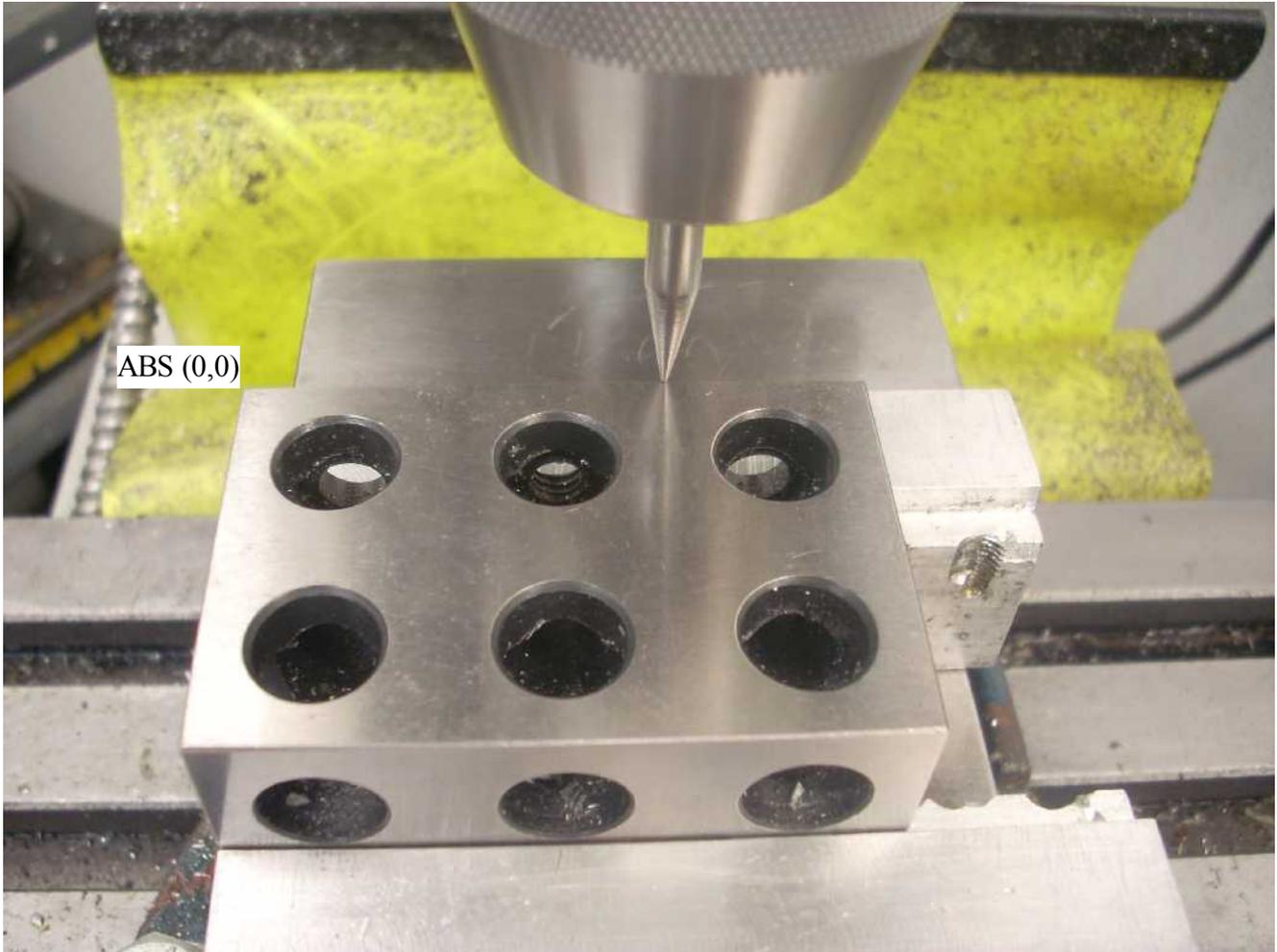
I must move my new zero to the left if I want my present position to show +5".



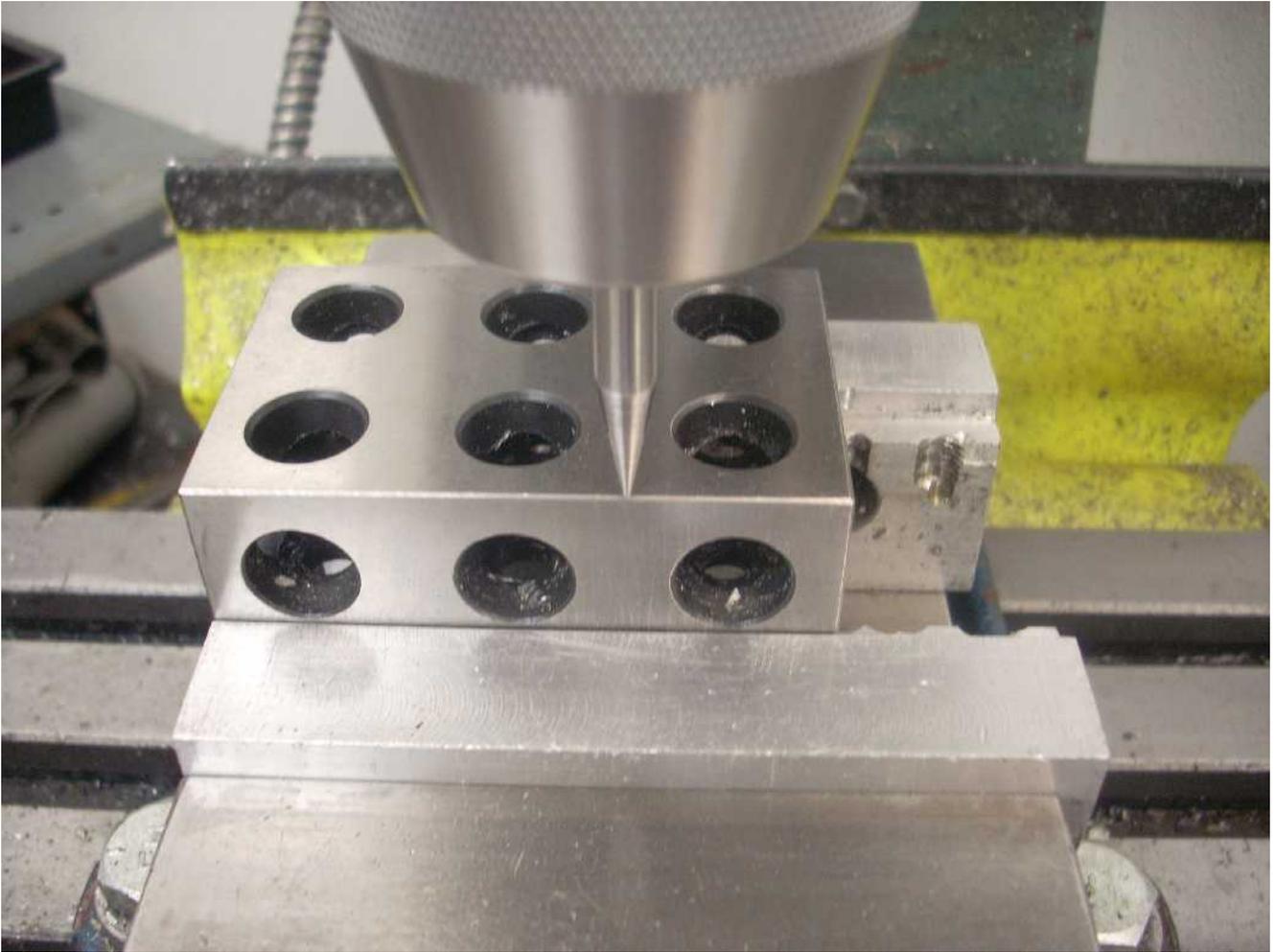
So in this case you entered +5 to move the zero point positive 5 inches and it actually moves it negative 5 inches. Is that what you really wanted to do?

## ***The Centerline Function <11>***

Plans sometimes specify a feature as being on the centerline of a part. Using FUNC 1 you can find that point quickly.



My ABS origin was previously set up to be the back left corner of the fixed jaw step. When I drop in my 1-2-3 block, its back left corner will be at the origin. I have moved my spud to  $X = 2.0000''$  and  $Y = 0.0000''$ . The goal is to find the centerline of the block along the Y axis.



My Y axis crank is turned until my spud is lined up with the front face of the 1-2-3 block.



My Y display shows 2.0000" as expected since this is a 2" wide precision ground block.

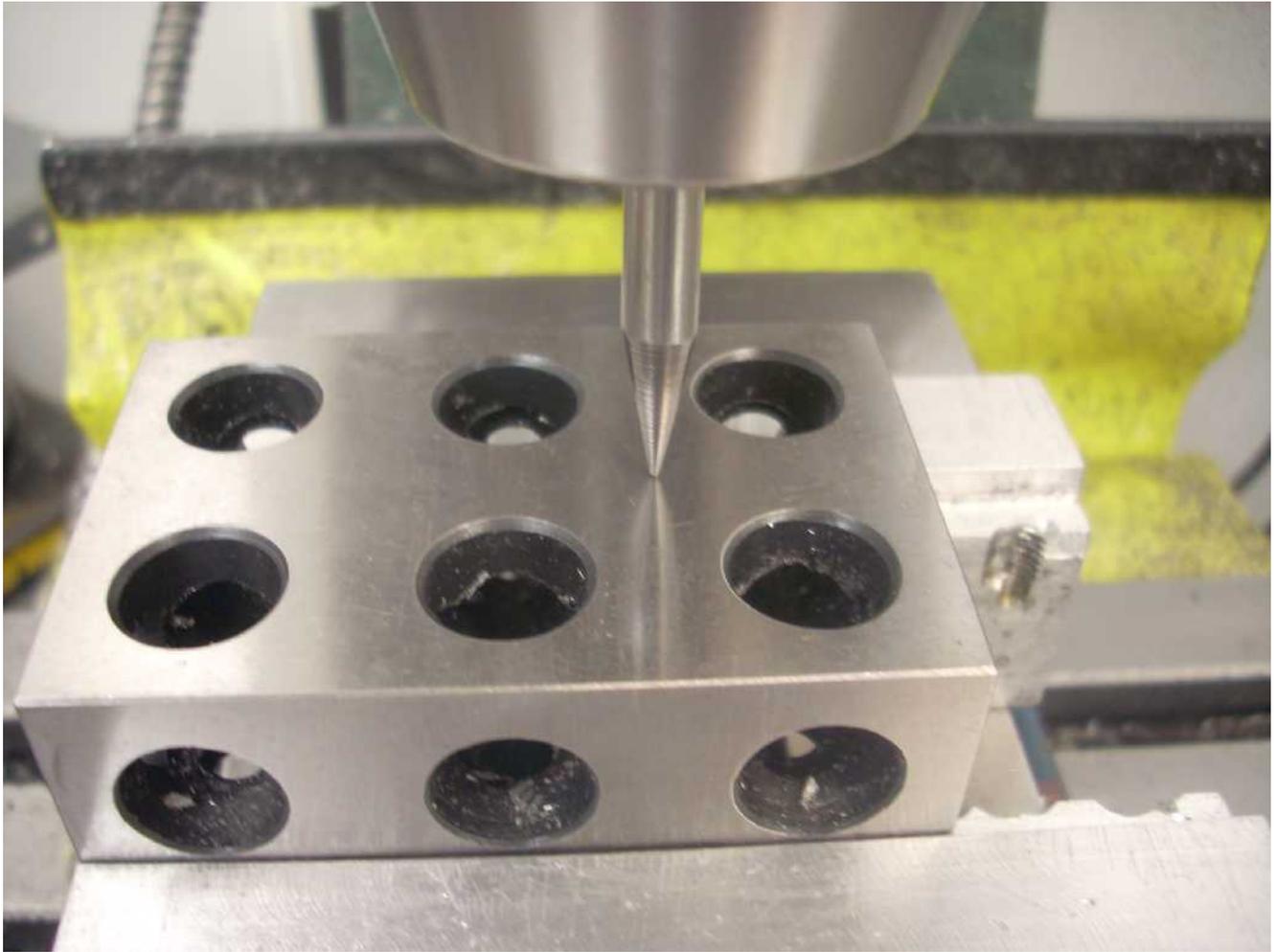
Next, the FUNC button is press followed by the "1" button. That brings up the centerline function. The software will halve one of the displayed values in order to calculate the center line along that axis.



The software responds with this prompt of “CENTER SELECT” We want the Y axis so push the Y preset button.



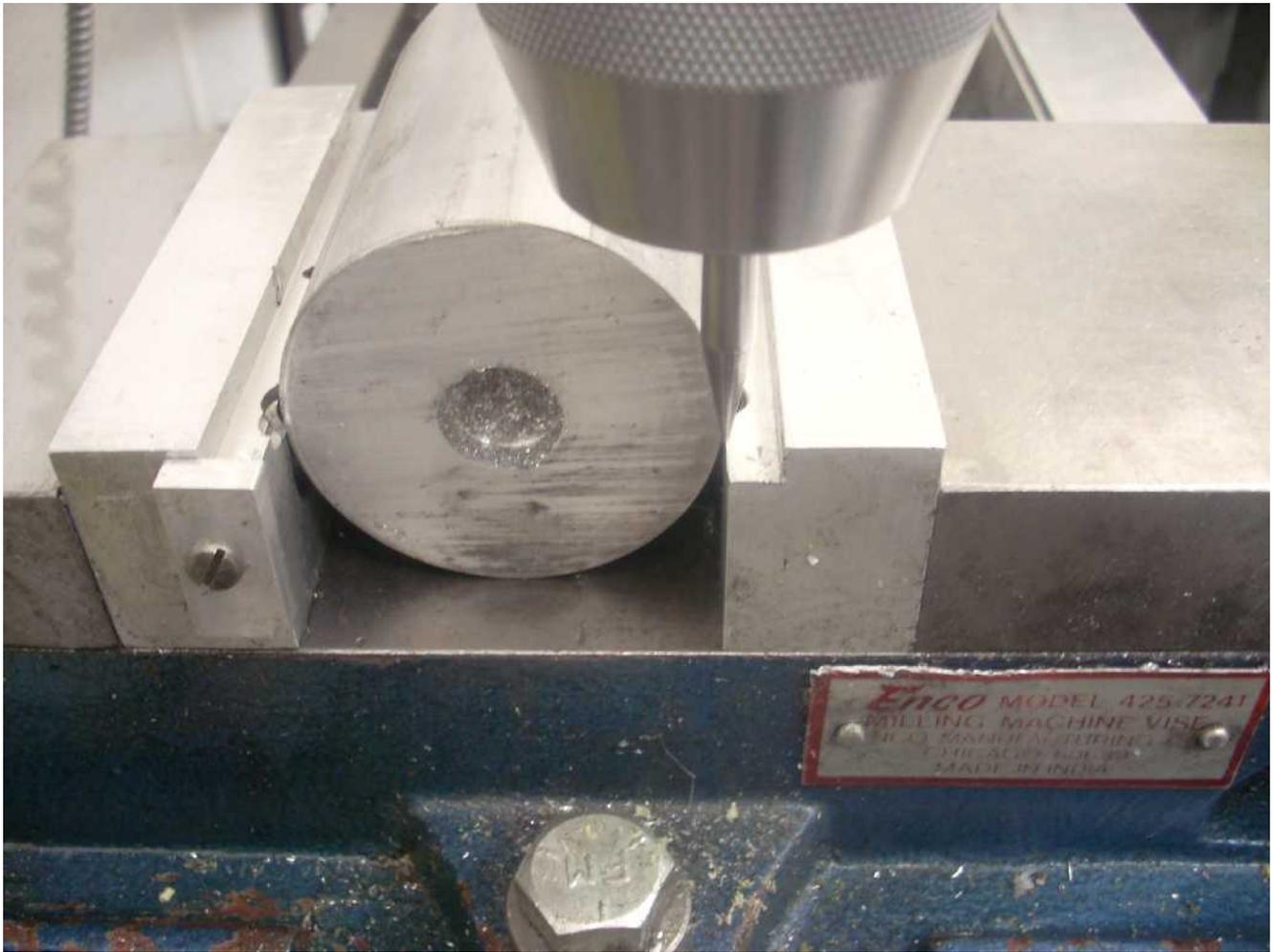
Our Y axis now shows a value that is half of the previous one. We can now crank the Y axis until we get to a  $Y = 0$  which will be our centerline.



My spud is now at the centerline of the block along the Y axis.  
The Centerline Function works equally well when in INCR mode.



Another common need for finding a centerline is with round stock. In this case I must define a new value for  $Y = 0$  because the round stock does not touch the vertical surface of the back lip. If I wanted to preserve my ABS  $Y = 0$  value, I would use INCR here and define my INCR  $Y = 0$  as shown.



I then move the Y axis until I reach the front jaws face.



The round stock's diameter is 2.249”.

When I press FUNC and then “1” followed by pushing the Y preset, I get



which tells me that my Y axis zero is 1.1245” back from the present location.



I have turned the round stock end for end so you can see how the spud lines up with the center.

My spud was used to illustrate the centerline function but it works equally well with an edge finder as Larry Gill has pointed out. You do not need to use the tool offset function either. Say you define the center of the edge finder as zero. You move to the fixed jaw and touch down. You are now a radius away from the fixed jaw. Next you move to the movable jaw and touch down. Again, you are a radius away. But since you have this same error on both ends of the line, the centerline is still in the right place. Similarly, you can use the edge finder against the part and get the same result.

### ***Bolt-Hole Pattern Define <12> and Bolt-Hole Pattern Use <13>***

I found the user's guide clear enough that I won't duplicate the work here. Do be aware that you will be put into incremental mode in order to locate each hole.

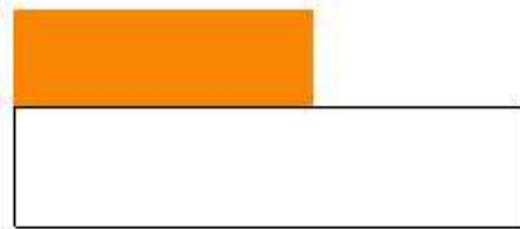
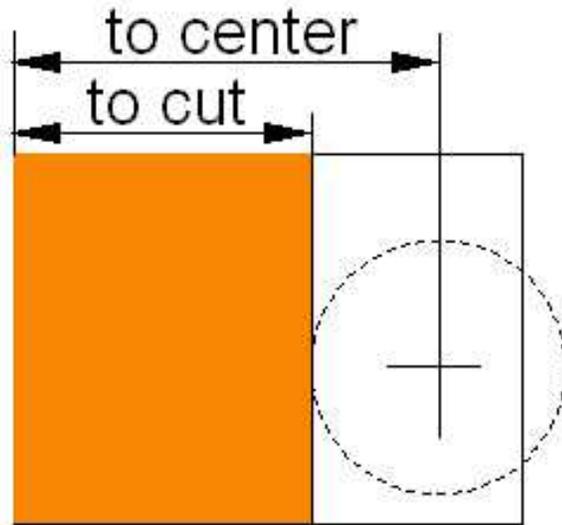
You can see an example of me using this function at

<http://rick.sparber.org/Articles/CD/CDM/cbs.pdf>

and turn to page 6.

## Tool Offset Define <14> and Tool Offset Use <15>

Using the X and Y axes, we can accurately locate at any point<sup>5</sup>. Then what? If we want to drill a hole, we just fit up the drill and make some chips. But what if we want to mill a feature?



If we just start cutting with an end mill, there might be a surprise in store. The center of our end mill will be at the chosen location but the step we cut will be at a distance equal to half of the end mill's diameter. What do we do if we want the step to be at the defined location? The answer is to use the Tool Offset functions.

Assume the my origin is at the upper left corner of the block. With no tool offset set, the DRO will show me the distance from the origin to the center of the end mill. What I want is to know the distance from the origin to the side of the end mill that will cut my step. In this example, I am cutting with the left side of the cutter. This means that I want the DRO to subtract half of the diameter of the cutter from its previous reading. Then it will display the distance from the origin to the cutting side.

If I wanted to cut on the right side of the end mill, I would tell it so and the display would then equal the original value plus half of the diameter of the cutter. The same goes for cutting on the front or back side of the end mill.

If you buy new end mills, then it is very likely that the diameter marked on the cutter will be the true diameter. If you got a good deal on resharpened end mills, it would be wise to measure their diameter. I measure them by cutting a 0.1" deep slot in a piece of scrap aluminum. The width of that slot tells me the cutter's effective diameter. Any run out in the cutter or holder will be included in this measurement.

I maintain a table showing tool number and diameter which is stuck to the front of my mill. There is room for 9 tool diameters and, so far, this has been plenty. One of the tool diameters is for my Electronic Edge Finder and the rest are cutters.

Let's run through an example. Say I have the block of metal shown above and I want to cut a step at a distance of 2.0000" from my origin. To do this I will use my brand new 5/8" end mill. Since it is new, I

<sup>5</sup> Les, from the Shumatech Yahoo group wrote: One point it might be worth pointing out about the tool offset function is that if the mode is changed from metric to imperial it will change the offset. This is because the offset value is stored as the number of 0.01mm in metric mode and the number of 0.001 inches in imperial mode. So if the offset is set to 1.000 in imperial this becomes 10.00 mm in metric mode. All other values seem to be stored as "counts" so they are the same in both modes.

will assume it has a diameter of 0.625". It will be my tool number 2.

I push the FUNC and then the 5 buttons to call up the Tool Offset Define function. I then tell it I want to define tool number 2 by pressing the 2 button. I then enter in the tool diameter of .625" (don't enter the leading zero). Hit Enter. It will then prompt you for the Z offset. I leave it at 0. Using the Z offset involves a class of machining that I normally don't worry about. Instead, I just touch down my cutter and set Z = 0. Hit Enter and you are done.

The next step is to use the newly defined cutter. I push FUNC 6 and then push the 2 button. The cutter's offset is now loaded and waiting to be used. I have 5 choices:

no offset	push button 5
left	push button 4
right	push button 6
rear	push button 8
front	push button 2

If you look on the face of your DRO, you will see that these are not hard to remember, arbitrary associations of function and number.

	8	
4	5	6
	2	

Since I will be cutting on the left side, I push the 4 button. If later I want to remove the offset, I just press the 5 button.

You can imagine milling a pocket and need to change offsets as you go around the hole. First you cut the left wall so press 4. Then you cut the back wall so before moving into position, press 8. Then you press 6 to cut the right wall. And finally, you press 2 to cut the front wall. Finish by pressing 5 so you remove the offset. Sure is handy!

## Functions Common to both Mill and Lathe

### ***Tachometer <16>***

This function is enabled by setting the Auxiliary Device <20> to “yes” as explained on page 38. Pressing FUNC 7 repeatedly, you should then see the Z axis display toggle between “0” and a 4 digit number that contains one or two decimal points. When you see “0” you are in Tachometer mode. Connecting a tachometer to the AUX input on the back of the DRO will enable you to measure the rotational speed of a shaft. I don't own a tachometer yet so have not tried this function out. More on the tachometer can be found at

<http://shumatech.com/products/dro-350/add-ons.htm>

### ***Surface Feet Per Minute <16>***

I have not used this function yet.

### ***Power Off <17>***

I leave my DRO plugged in all of the time so use this function to turn off the display which is the main current drain. This lets me preserve my zero sets and a few other bits of data that are lost when power is removed. I have also found that my jitter sometimes increases after power is disrupted. I just keep unplugging and plugging in the the power cube until things quiet down. After that I don't mess with the power unless absolutely necessary. I have no idea why the jitter acts this way although many interesting theories have been advanced.

### ***Fast Mode Toggle <17>***

I used this feature while trying to understand jitter on the displays but don't touch them anymore.

### ***Counts Display <17>***

This is a really hard core debugging function that is also used when trying to understand DRO jitter and later the limits of the DRO's accuracy. There is no harm in pressing FUNC and then INCH/MM if you like to see a long string of hexadecimal numbers. If you want to see how far you can push your DRO's accuracy, you can read

<http://rick.sparber.org/Articles/sb/sb.htm>.

### ***Auxiliary Device <20>***

Hidden way back at the end of the Setup section is this innocent looking heading. This is where you tell the DRO if you have an auxiliary device or want to display the Z axis. An auxiliary device can be a tachometer or an EEF. When the display shows AULArY (Auxiliary), you can toggle between “yes” and “no”. If you plan to use either the tachometer or EEF, select “yes”.

## **Auxiliary Device <20> for Tachometer**

Refer back to the Tachometer (FUNC 7), page 38, for more on enabling the tachometer function after Auxiliary Device is set to “yes” as explained in the previous paragraph.

## **Auxiliary Device <20> for Electronic Edge Finder**

I use my EEF a lot and really enjoy it. The basic idea is that you press the ZERO button for whichever axis you want to zero. Then you crank the table until the EEF touches the part. This causes an electrical circuit to complete and tells the DRO to zero the display. I always back up and verify it got the right point. Any tiny bit of swarf will cause error here. So will any insulating material like oxide. Usually two tries is enough to give a very accurate zero set.

Don't forget our old friend “Tool Offset” explained on page 36. We will be touching down on one of the faces of the EEF so will need to tell the DRO to compensate. My EEF tip is 0.200” in diameter and I have it defined as tool 9 so it is easy for me to remember.

Say I plan to pick up the rear jaw's lip as my  $Y = 0$  point. I would go to Tool Offset and pick tool number 9. then I would press the “8” button to tell the DRO I was going to use the rear side of the tool. I would then press ZERO on my Y axis and crank until the EEF touched my reference surface. This zeros the display. Normally I will set up my  $X = 0$  point at the same time so just need to press “4” and touch down with the left side of the EEF. For more on my EEF, see

<http://rick.sparber.org/Articles/eef/eef1.0.htm>

and

<http://rick.sparber.org/Articles/ea/ea.pdf>

In the end, I took the commercial EEF and modified it to work with the circuit. My home made EEF probe was not repeatable enough for me.

## **Acknowledgement**

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