Adding a DRO to a Rong Fu Mill/Drill

By

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Why a DRO?

- Trying to achieve a precision of 0.001 inches.
- Experience has shown that my Rong Fu Mill/Drill is potentially capable of 0.001 inch precision.
- DRO is cheaper than a new mill and a CNC system.
- DRO is faster and easier to use than a micrometer.

DRO

- From DRO Pros
- Model EL 400
- 3 Axis DRO
- Magnetic scales and read heads (no glass rods).
- $1200
- Problem: Mounting equipment designed for a Bridgeport style machine.

DRO

- A close up of one of the DRO magnetic read heads.

DRO

- Close up of Scale
- End shown bolted in place.
- All scales had to be trimmed to fit the mill.

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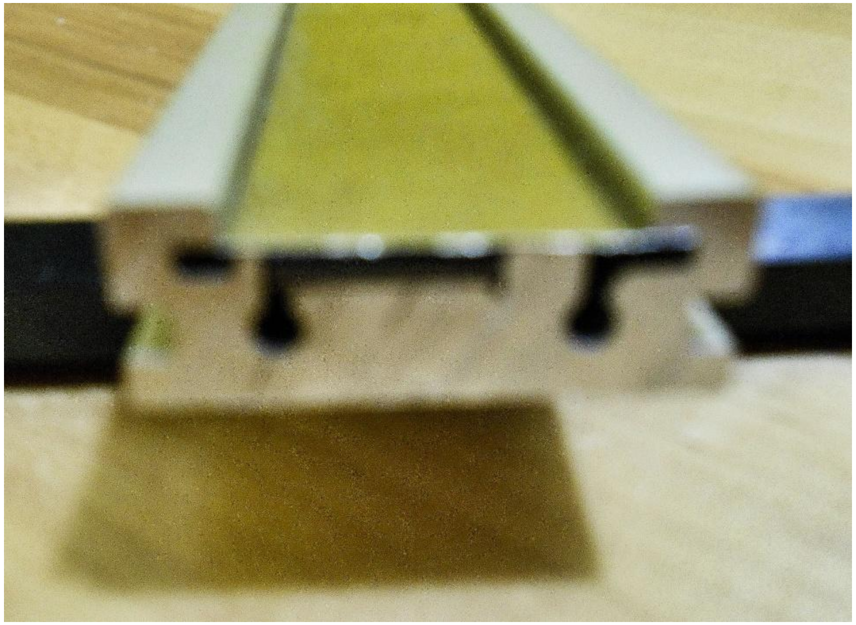
DRO

- Scale shown in cross section.



The Rong Fu Mill/Drill

- The Rong Fu Mill/Drill does not have the same large wide open areas for mounting a DRO that a Bridgeport style mill has.
- The EL 400 mounting brackets will not fit and cannot be used on a Rong Fu mill/drill.
- This creates an engineering opportunity.

Design of new mountings

- 2 man-months spent measuring and designing a series of new mounts.
- Detailed drawings were made.
- Materials
  - 1018 cold rolled steel
  - 6061 and 7075 aluminum
  - 360 brass
  - Stainless steel bolts (mostly)
- Imperial system threads selected for general purposes .
- Some metric screws kept from EL 400 mounts to avoid modifying scale bars and read heads. This would have invalidated the warranty. *

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Design continued

- New design heavily over-engineered.
- Extra set screws added to facilitate adjustment of read heads vis-à-vis the magnetic scales.
- Attempt made to keep iron or steel surfaces from contacting magnetic scales.
- Everything put together with socket head cap screws, button head cap screws and set screws. No welding.

X-Axis Components

- 5 parts
  - Swarf shield (Al)
  - Swarf shield mounts (2)
  - (Al)
  - Base rail (steel key stock)
  - Read head platform (Al)

X Axis Assembly

- Magnetic scale trimmed to length.
- Magnetic scale installed on back side of mill work table.
- Work table drilled and tapped for metric screws.
- Magnetic scale leveled with dial indicator.

X Axis Assembly

- Base rail attached to mill table with SHCS.
- Pre-existing holes used.
- Formerly holes held end of swarf shield.
- Old swarf shield removed from mill.

X Axis Assembly

- Read head platform attached to base rail with SHCS.

X-Axis Assembly

- Read head attached to read head platform.
- White plastic behind read head is a gauge used to set space between scale and read head.

X Axis Assembly

- Gauge removal proves read head is not too close to scale.

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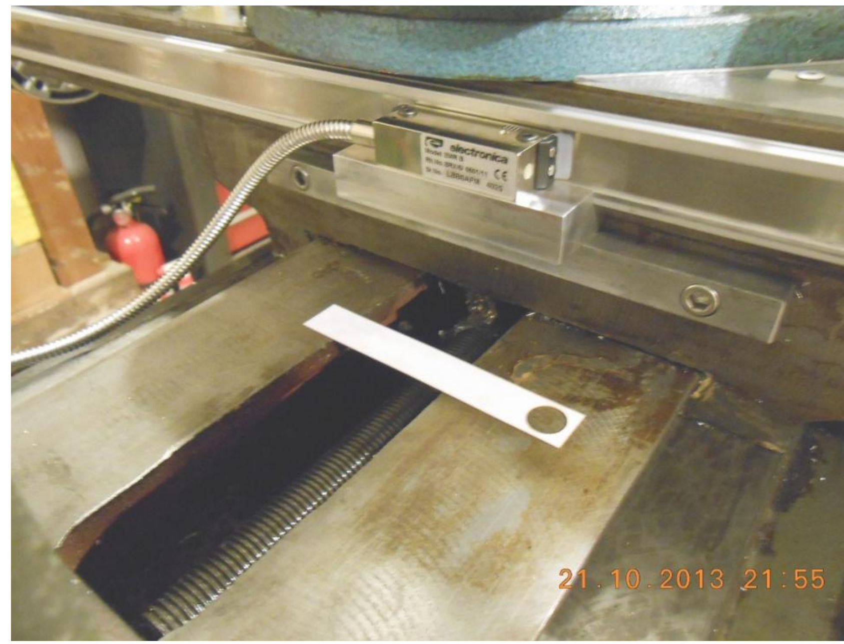


X Axis Assembly

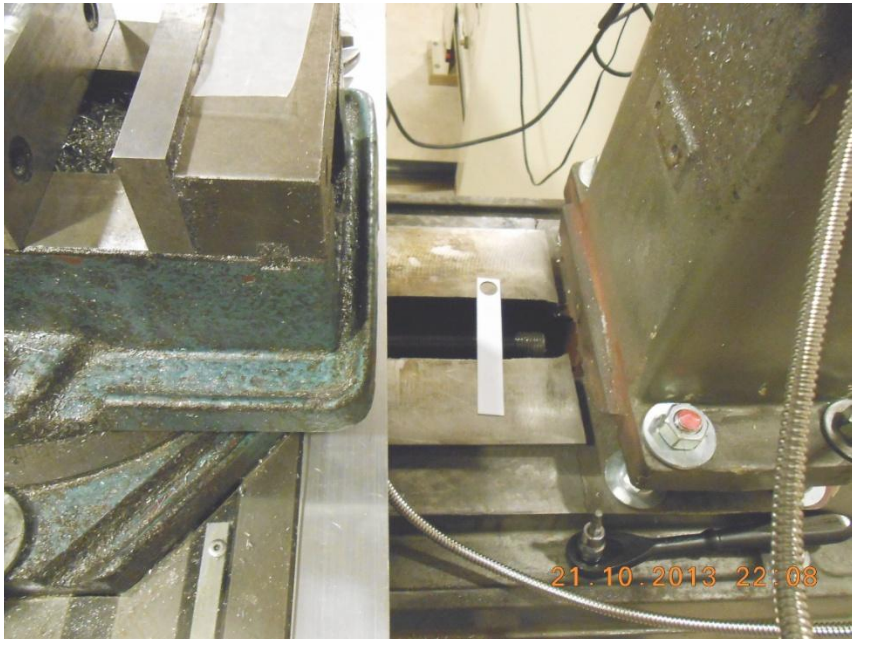
- Swarf shield mounts installed.

X Axis Assembly

- Swarf shield installed.
- X axis installation complete.

X Axis Space Consumption

- DRO X axis has consumed about ¼ inch of the space available between the vise and the mill column.



Y-Axis Components

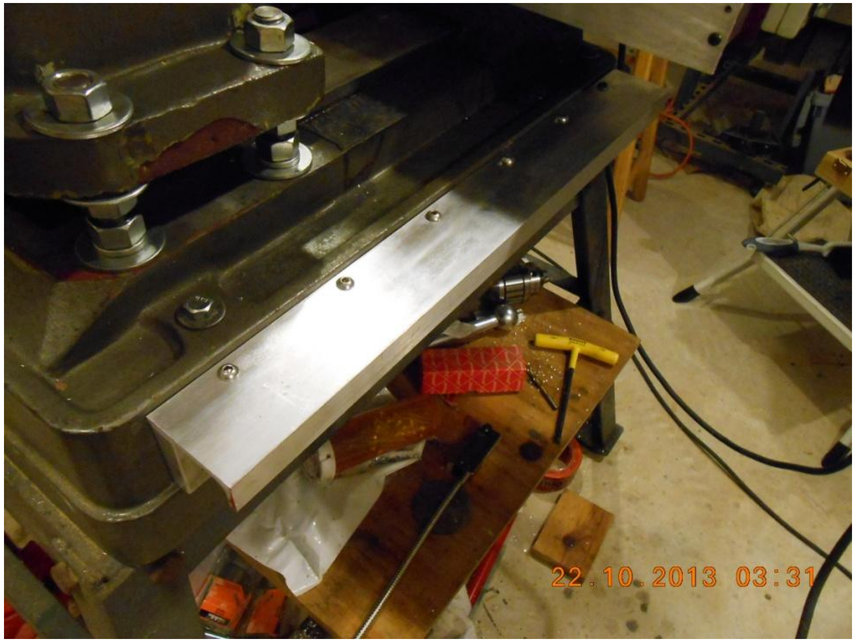
- 7 parts
  - Mount for Y scale and swarf shield.
  - Swarf shield.
  - Read head base plate (Al)
  - Read head horizontal extensions (Al)
  - Read head vertical extension (Al)
  - Read head mounting plate (Al)

Y Axis Assembly

- Y scale / swarf shield mount attached to mill.
- Y axis scale cut to length and mounted on Y scale base.
- Note set screws in near end of swarf shield mount. These are used to make sure the scale is held vertically.

Y Axis Assembly

- Y axis swarf shield installed.



Y Axis Assembly

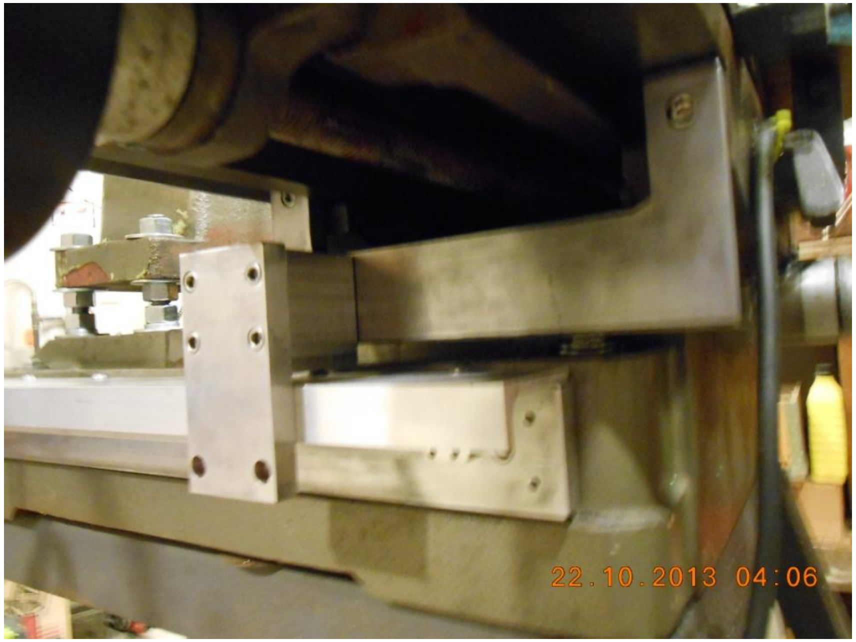
- Read head base plate installed on mill.

Y Axis Assembly

- Read head horizontal extensions installed.

Y Axis Assembly

- Read head vertical extension installed.



Y Axis Assembly

- Read head mounting plate installed.

Y Axis Assembly

- Read head installed..

Y Axis Assembly

- Another view of the completed Y axis assembly.
- Note how the Y axis assembly reaches around the swarf shield. This awkward reach is one of the reasons for the heavy over-engineering.

Z-Axis Components

- 9 parts
  - Swarf shield (Al)
  - Base plate (1018)
  - Scale plate (Al)
  - Sliding rail and tracks (360 brass)
  - Top side cover (Al)
  - Read head mounting block (Al)
  - Quill connecting plates.

Z Axis Assembly

- Z-axis scale trimmed and installed on scale plate.
- Brass outer rails installed on scale plate.

Z Axis Assembly

- Read head mounting block bolted to sliding rail.

Z Axis Assembly

- Sliding rail and read head mount installed on scale mounting plate.

Z Axis Assembly

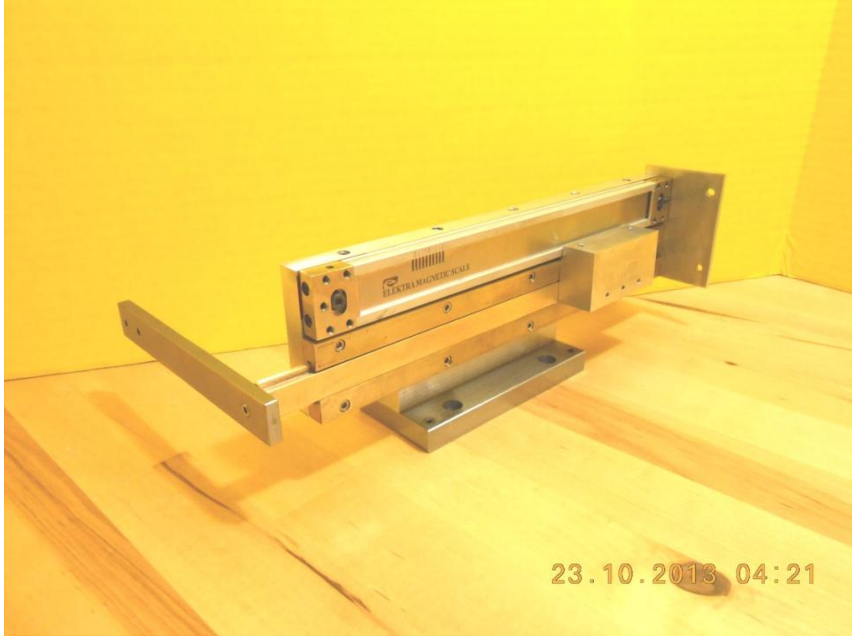
- Base plate attached to scale plate.

Z Axis Assembly

- Top side cover installed on scale plate.

Z Axis Assembly

- First quill connecting plate attached to sliding rail.



Z Axis Assembly

- Second quill connecting plate attached to first quill connecting plate.

Z Axis Assembly

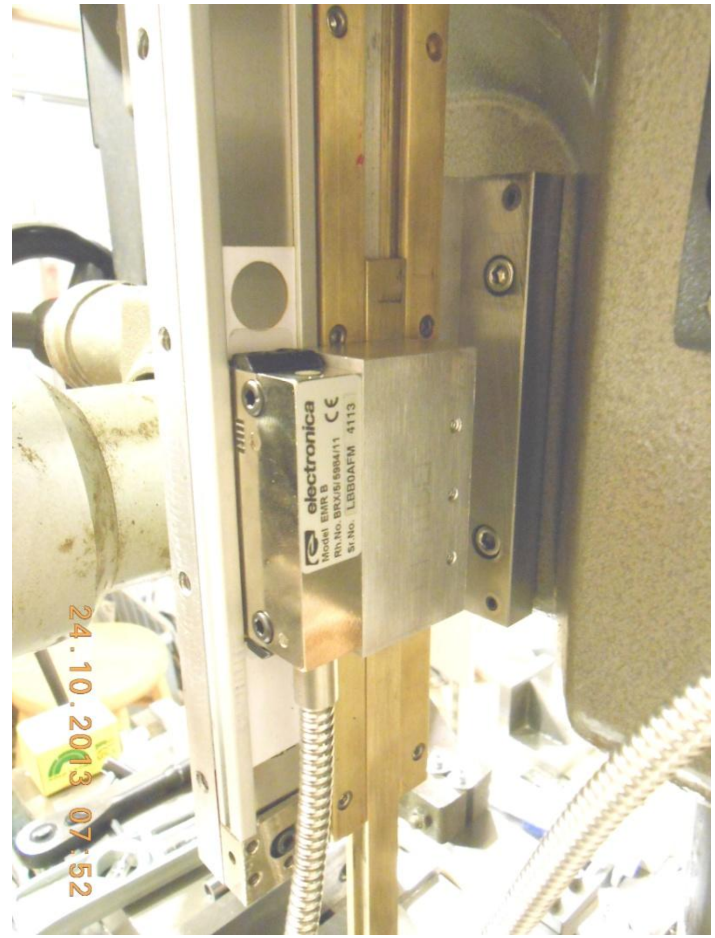
- Z axis assembly attached to mill.

Z Axis Assembly

- Quill attachment plate bolted to quill and vertical brass slide.

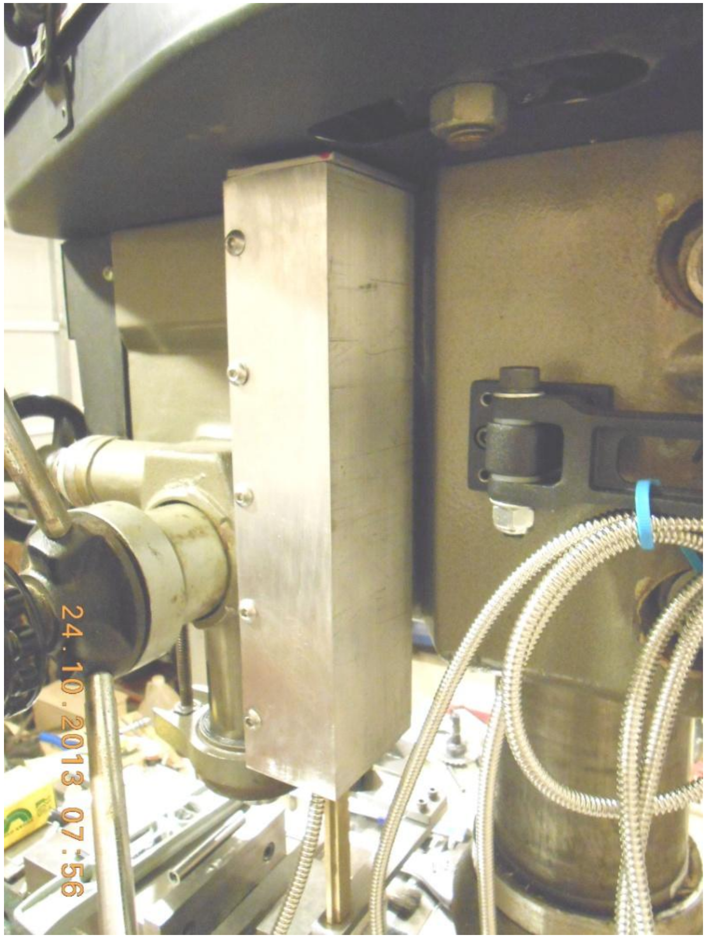
Z Axis Assembly

- Read head attached to read head mount.
- Note clearance gauge behind read head.



Z Axis Assembly

- Swarf plate installed.



Z Axis Assembly

- Final view of the Z axis assembly.
- Note the congestion and lack of space on this side of the mill.

Control Panel Installation

- Base of extension arm bolted to mill.

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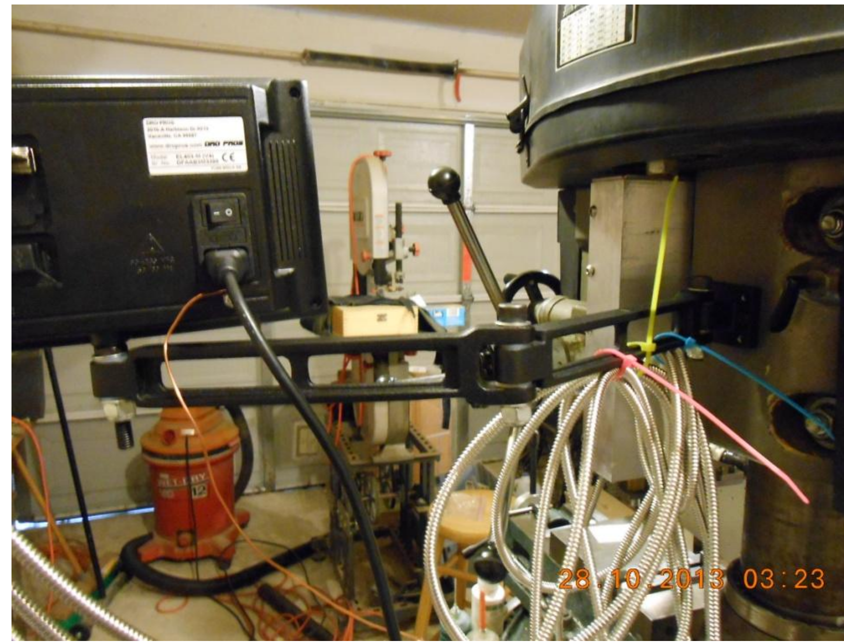
Control Panel Extension

- Looking at back of DRO control panel.
- Kit came with only one extension arm. Put control panel in collision range of vertical axis control arm.
- DRO Pros sent free second extension arm.



Protecting the Y axis lead screw

- Removal of old swarf shield has left Y axis lead screw exposed.

Protecting the Y axis lead screw

- Made new swarf shield from poster board, denim, and rubber cement.
- DRO installation complete.

Testing the DRO

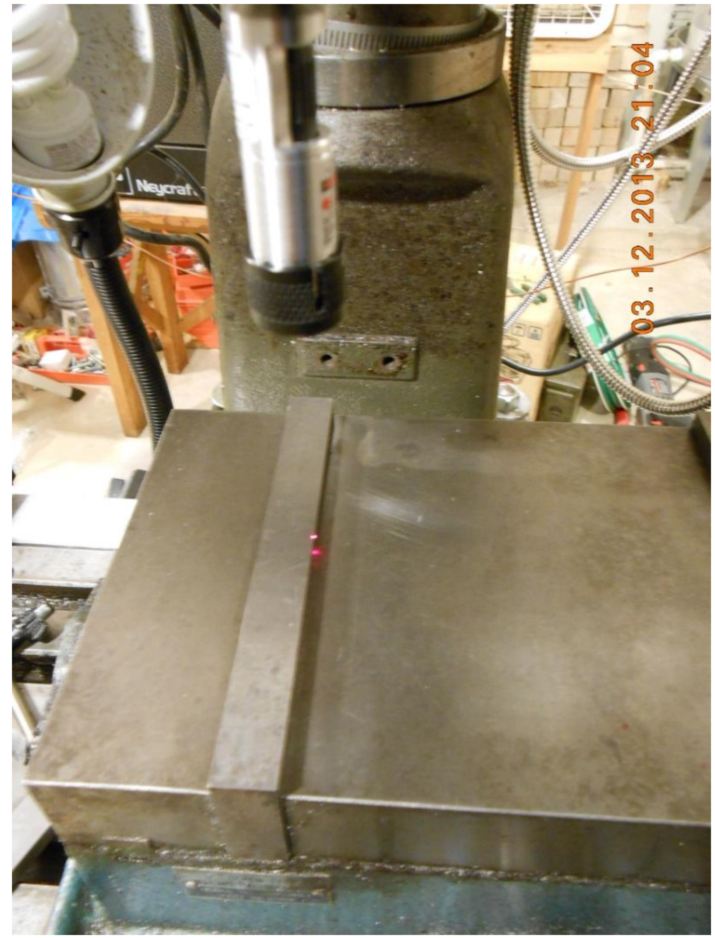
- Standard gage blocks used to test DRO.

Footnote on Edge Finders

- First tried carbide rod and feeler gage. Worst accuracy
- Next tried standard 0.500 edge finder. Better.
- Next tried standard 0.125 edge finder. Better.
- Finally tried laser edge finder. Best accuracy.

OK, but does X axis work?

- Positioned edge finder against vise jaw.
- Note that edge of laser beam barely touches vise jaw.
- Set X coordinate to 0.0000 on DRO.

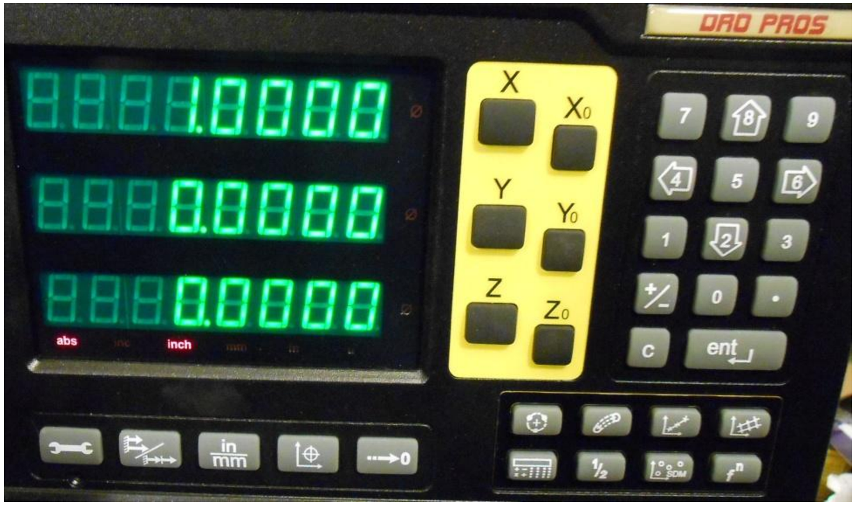


Does X Axis Work?

- Positioned 1 inch gage block against front vise jaw.
- Positioned edge finder against gage block.

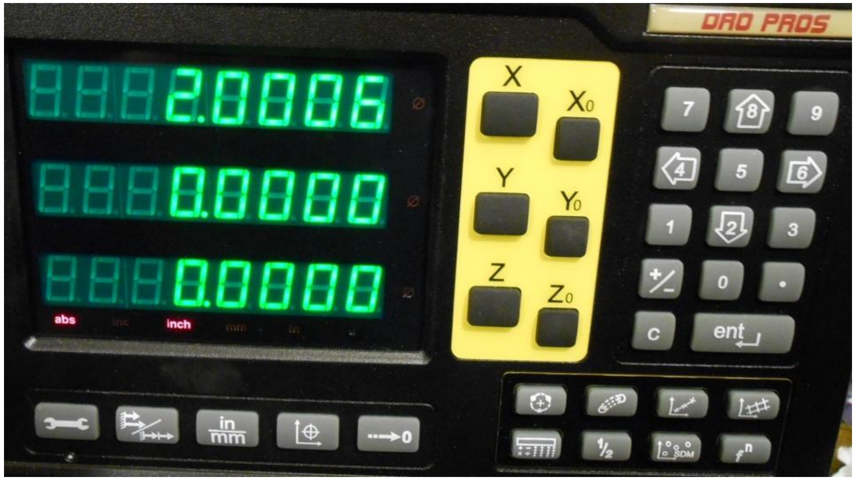
Does X Axis Work?

- 1.0000 inch gage block measures 1.0000
- DRO has an apparent resolution of 0.0002 inches. Cannot measure less than this.



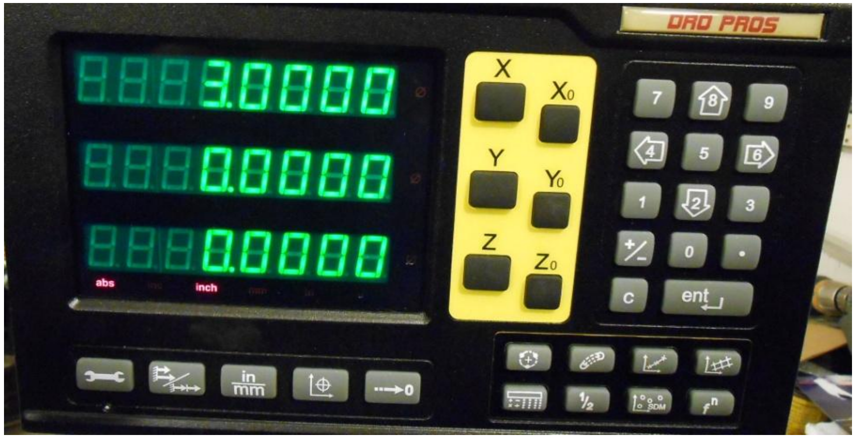
Does X Axis Work?

- 2.0000 inch gage block measures 2.0006 long.
- 0.0006 inch too long.



Does X Axis Work?

- 3.0000 inch gage block measures 3.0000 long.



Does X Axis Work?

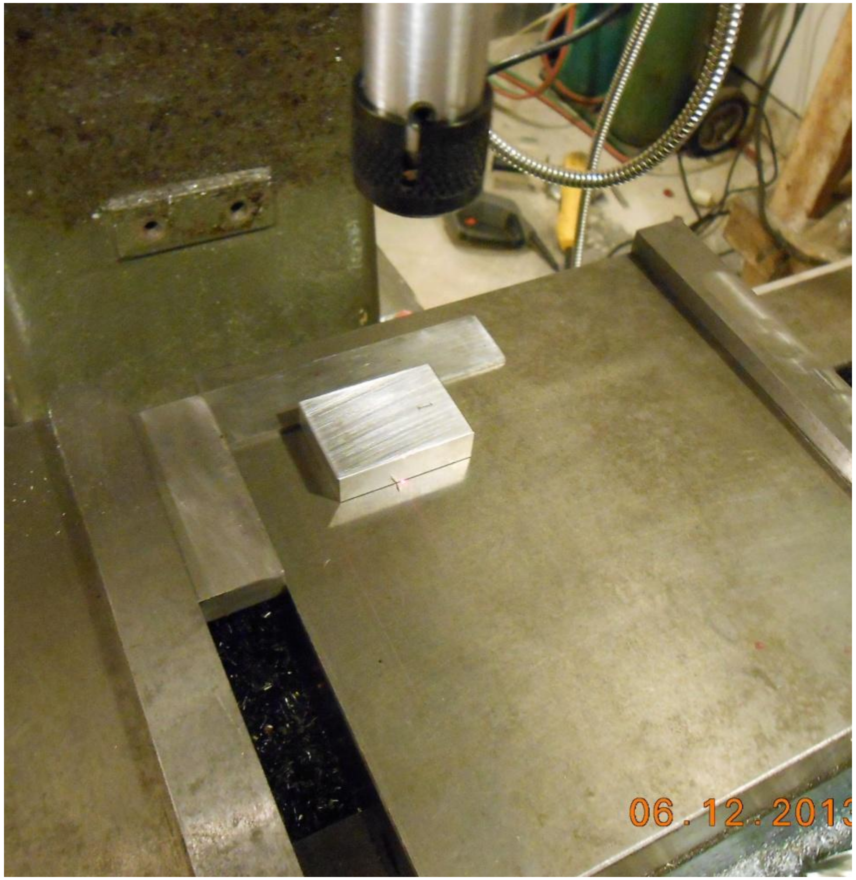
- 4.0000 inch gage block measures 3.9990 long.
- 0.0010 inch too short.

X test summary.

Gage block length	DRO results	Error
1.0000	1.0000	0.0000
2.0000	2.0006	+0.0006
3.0000	3.0000	0.0000
4.0000	3.9990	-0.0010

Does Y axis work?

- Positioned 1 inch gage block against square held in vise.
- Positioned edge finder against gage block.



Does Y axis work?

- 1 inch gage block measures 0.9890 inches.
- This is 0.011 too short.

Does Y axis work?

- 2 inch gage block measures 1.9886 inches.
- This is 0.0114 too short.

Does Y axis work?

- 3 inch gage block measures 2.9954 inches long.
- This is 0.0046 too short.

Y Test Summary

Gage block length	DRO results	Error
1.0000	0.9890	-0.0110
2.0000	1.9886	-0.0114
3.0000	2.9954	-0.0046

Does Z axis work?

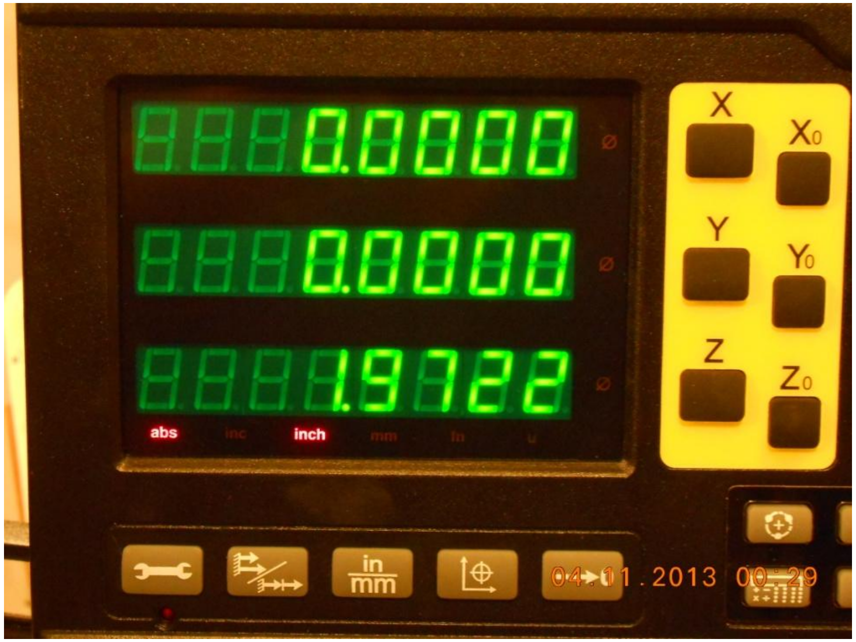
- Positioned 1 inch gage block against square and against front jaw of vise.
- Positioned edge finder on top of gage block.

Does Z axis work?

- 1 inch gage block measures 1.0002 inches.
- This is 0.0002 too tall.

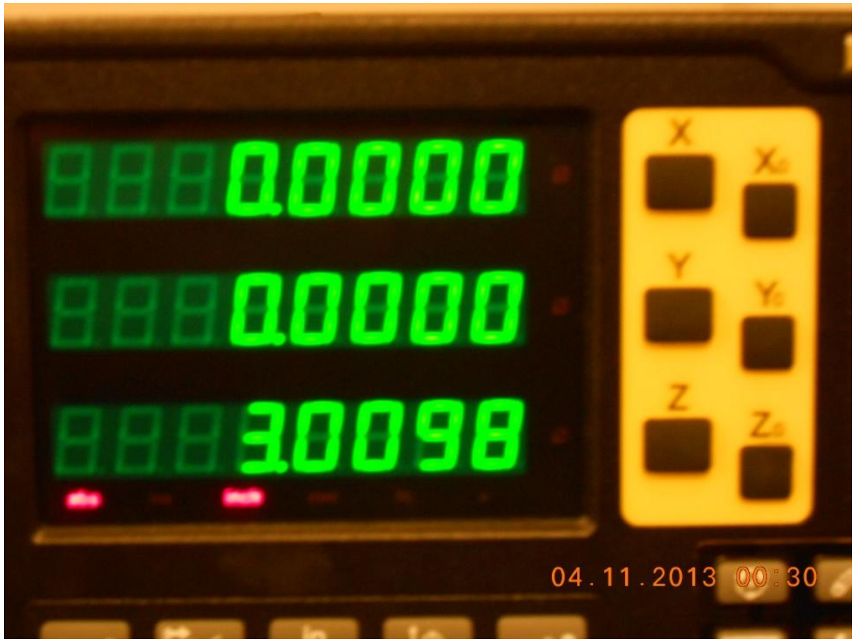
Does Z axis work?

- 2 inch gage block measures 1.9722 inches.
- This is 0.0278 too tall.



Does Z axis work?

- 3 inch gage block measures 3.0098 inches.
- This is 0.0098 too tall.



Z Test Summary

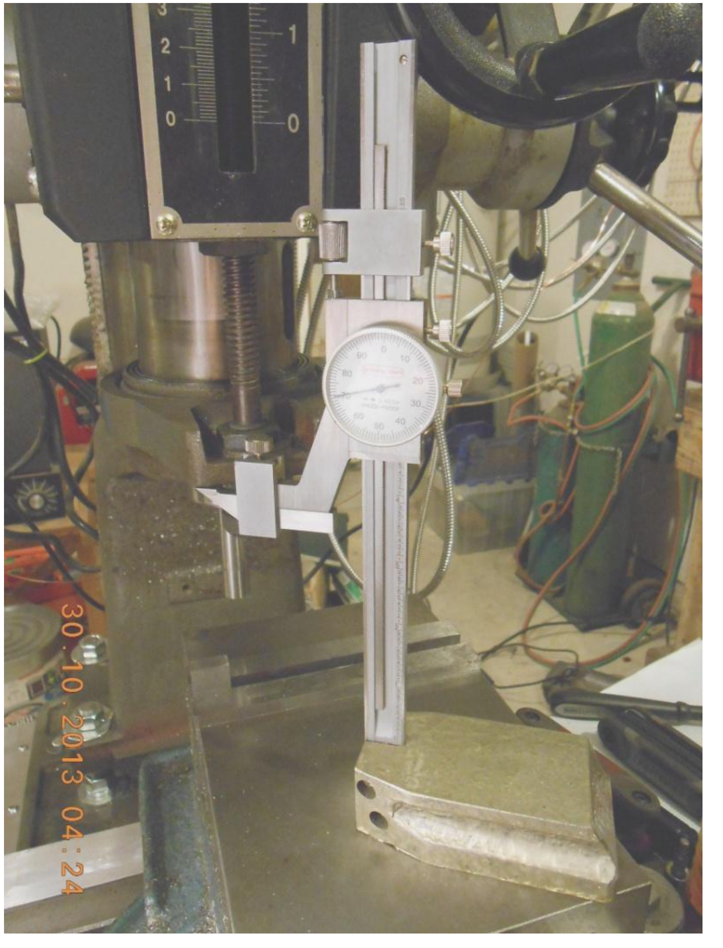
Gage block length	DRO results	Error
1.0000	1.0002	+0.0002
2.0000	1.9722	-0.0278
3.0000	3.0098	+0.0098

Conclusions

X Axis	**1. Errors on order of 0.001 or less.** **2. Seems to work tolerably well.**
Y Axis	1. Errors average 0.009 2. Significant problems. 3. Perhaps DRO error correction features will improve or cure this.
Z Axis	1. Errors average 0.0126 2. Severe problems.

Z Error Analysis and Resolution

- The real problem with Z axis measurements is the rack and pinion drive used for quill movement.
- There is a lot of play in it.
- Formerly I used a height gauge to reset the quill.
- Note that the height gauge pointer is upside down.
- It fits under the bottom edge of the quill and can be used to make minute adjustments.
- The technique is to flip the height gauge in and out while slowly lowering the quill with the fine adjustment wheel.
- Have to check work piece after every cut.



Metal working techniques

- Metal removal with end mills is more time consuming and costly than other methods.
- Whenever possible I remove larger masses of metal with drills and saws.
- The vertical slot was cut with an end mill. The slot makes room to get a saw into the middle of the work piece.

Metal working techniques

- Reciprocating saws will cut 1018 steel but not tool steel.

Metal Working Techniques

- Diablo makes metal cutting blades of stainless steel with carbide teeth.
- They will cut mild steel… aluminum and brass.
- Blade will cut ½ inch thick mild steel at rate of about 16 inches/hour.

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Metal Working Techniques

- End mill used to finish the cut.
- Finished part is the base of the Y axis mount.

Metal Working Techniques

- Installation guide recommended a table saw blade to trim scale components to length.
- Carbide teeth make cutting aluminum easy.

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Metal Working Techniques

- By setting the table saw at an angle it was possible to cut the Y axis base so that it fit against the sloped side of the mill.

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Metal Working Techniques

- A slitting saw mounted in the mill made it possible to evenly cut long pieces of aluminum.
- Cuts limited to 0.030 inches per pass.
- Multiple passes needed to complete a cut.

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Metal Working Techniques

- Y axis swarf shield cut with mill slotting saw.

Metal Working Techniques

- Encountered several problems with counter bores.

1. Pilot cutter too large
2. Head slot cutter too large
3. Counter bore went dull quickly

Substituted drill bits for counter bores

- Used smaller drill just barely larger than threaded section of the SHCS.
- Used larger drill just barely larger than head of SHCS.
- Resulted in very tight fitting counter bores.

Z Error Analysis and Resolution

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- Have to check work piece after every cut.

Questions

- Does this installation seem reasonable?
- Any suggestions for fixing the problems?

Future Problems

- Mill stand is a weak and flimsy affair made of angle iron and sheet metal.
- One leg is slowly giving way.
- Mill looses level after 2 weeks of use.
- Mill looses tram after 1 hour of use.
- Need new much heavier duty mill stand.
- New stand to have:
  - table top of 2 sheets of ½ inch steel plate.
  - legs of 4 inch square mild steel ¼ inch thick.
  - heavy duty pivoting feet that have leveling screw.

The End