A large Dial Roller Bearinged Compound Screw Assembly for the South Bend Workshop Lathes.

INTRODUCTION

In another application note I have described how to change the cross-feed into a large dial. When I completed this project I just had to have a large dial for the compound. Ed Goodwin, (**eng4turns@yahoo.com**), has a note on this site on doing this same project. Ed however chose to make the assembly extended. In his note he provided a drawing of a non-extended housing. I chose the shorter version for my conversion Ed's drawing had some dimensional which I have corrected.
In this note I will provide new drawings and a detailed fabrication process with pictures. It is, however, to remember that there are "Many ways to skin a cat". The processes I used may not be the only way to get the final solution and are based on the tooling I have.

OVERVIEW
Figure 1 shows the Large Dial compound parts before assembly

Figure 1Large Dial Compound Assembly Parts.

Starting from the left on the bottom row, there is the **Bushing and Bearing Housing**, one set of **Thrust Bearings** and **Washers**, the **Retainer Ring** and **Screws**, The second set of **Thrust Bearings** and **Washers**. Above on the left is the new **Compound Feed Screw**

and Bearing Block, the **Key** and the Original **Hand Lever** . A the top is the **Dial**, the **Thumb Screw** and the **Shoe**.

The:
Bushing and Bearing Housing
Retainer Ring
Compound Feed Screw and Bearing Block
Dial
Thumb Screw
Shoe
Are all fabricate and will be discussed, in turn.
Detailed drawings are provided below.

DIAL FABRICATION

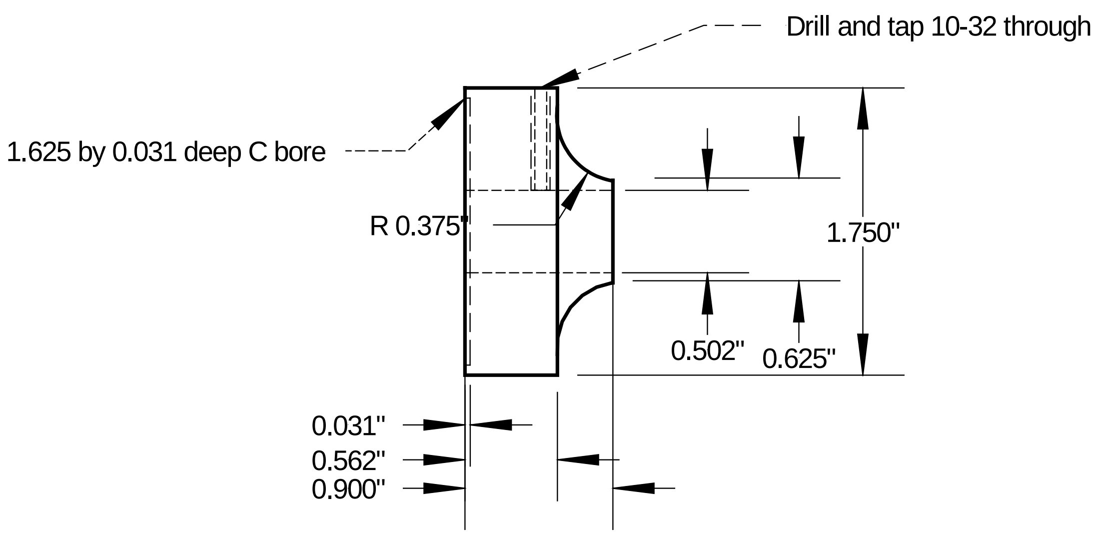

Figure 2 Dimensions for the Calibrated Dial

The first part I fabricate was the dial. This was chosen since I had never made one and wanted to try it before spending a lot of time on the rest of the components. I found a piece of 1 ¾" rod in the scrap barrel. I am not sure, but looking at old purchase orders I believe it was 1018 steel.
According to the drawing in Ed's write-up, the user side of the dial has a curved surface. I started by approximating the curve with a series of steps. I copied ED's drawing to a drafting program I use (AutoSketch) and scaled it to size. I then drew the stepped approximation and measured it and made a table.

It is important to note that the dimensions shown in Figure 2 and for that matter all dimensions are nominal. There will be a small amount of "fitting" at assembly or during fabrication. For instance, the overall dial thickness is shown as 0.900. Mine actually measured 0.899. Now the dial thickness is balanced against the length of the longer ½" diameter on the screw shaft where the dial sits. You need to dial to have 0.001 to 0.003" of slop but not much more, You can remove material from the 0.900 dimension if its too tight or from the 1.085 length if its too loose. In a similar manner the short ½" diameter lenght on the shaft should protrude from the bearing no more than 0.010. The thickness of the flange, (0.128) or the depth of the bore on the Bearing housing must be adjusted to give between 0.001 and 0.003" of bearing [reload.

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I machined the steps onto the blank Note the use a 4 Jaw chuck and of copper strips to prevent marring of the surface.

Figure 3 Step approximation to the dial curve.

The final form was then machined using a "Form" tool. This was a ¾" radius router bit. Tilted at an angle and held in a QC tool holder. (See Figure 4). The normal pilot shaft has been ground off.

I have used this approach, router bit form tools, many time in the past . Always with good success, both on the lathe and also on the mill. This bit happens to be a HSS bit. The 1 ¾" blank seemed to machine and finish quite well. I have used carbide router bits but did not need them in this case. As you can see the finish was good and the curve looked very nice. The blank was then faced, do that the length of the curve was correct and drilled through, letter U, and then reamed to 0.376.

I cross drilled and then tapped for the 10-32 thumb screw first. Note that I judiciously turned the chuck to allow room for the screw hole. At this point it does not matter where the hole goes (Figure 5)

At this point the blank was removed from the 4 Jaw chuck. I super glued a piece of 3/8 drill rod into the 0.376 bore held the blank in a collet and faced the part to length. With the shaft still attached the part was then switched over to the Burke Mill for “engraving of the graduations. (Figure 6) (Here is an area where there are several solutions. Conventional wisdom would leave the part in the lathe and attaché a graduated wheel to the lathe and the markings would be scribed. I chose to use a thin (0.010) slitting cutter, with the mill set up as a horizontal slitter. This gives a clean deep cut which takes colored fill well) The little index head I have has several index plates.

Figure 4 Finishing the machining of the curve with a Router Bit form tool.

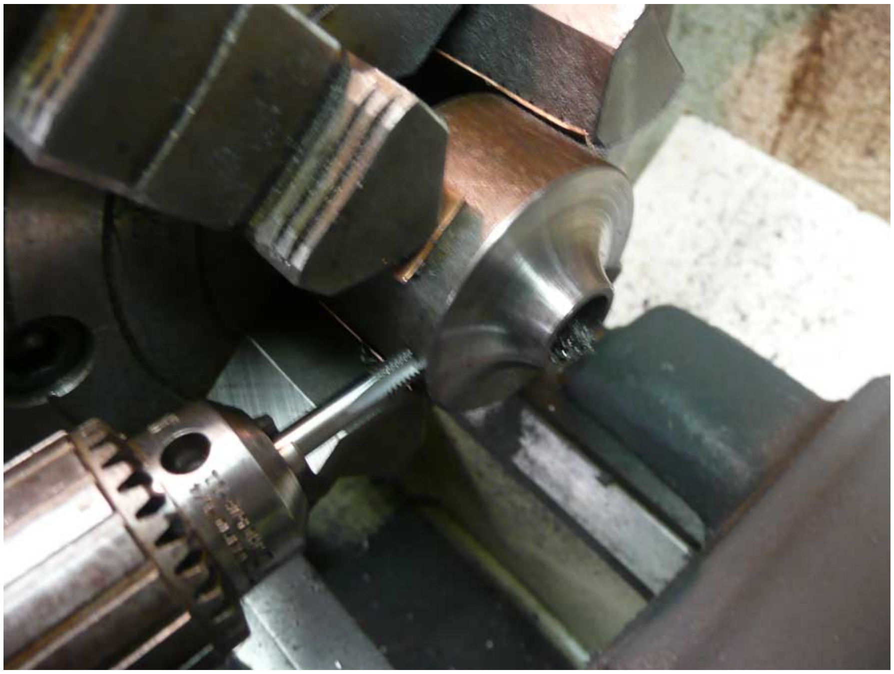
Figure 5 Tapping for the Thumb Screw after cross drilling.
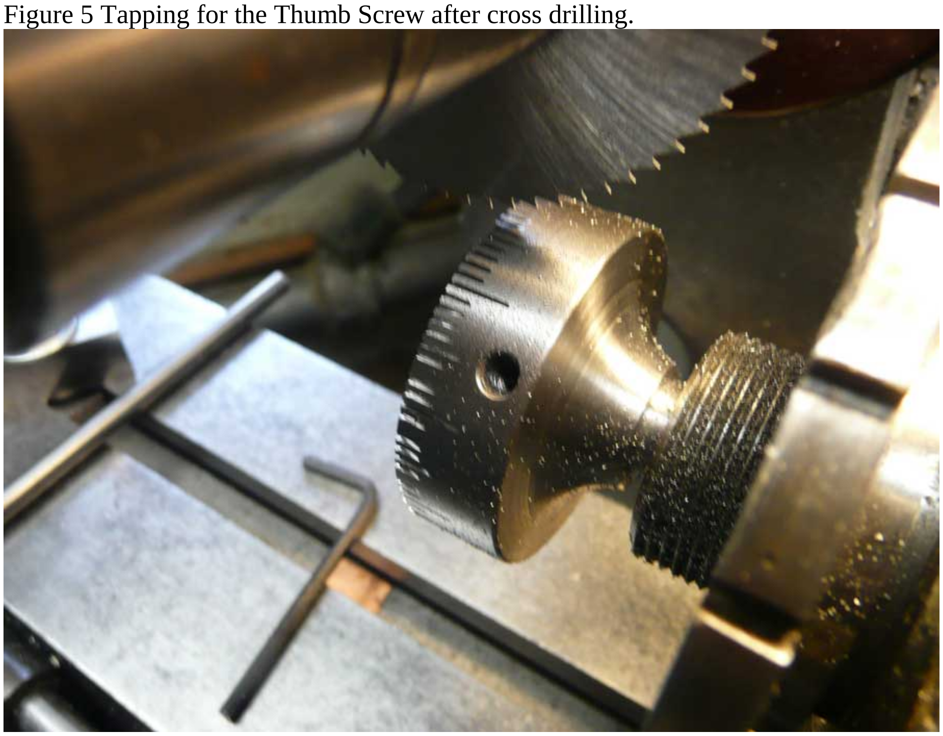
Figure 6 Marking the graduations. The dial is held in a collet and slot length are measured with a DI

Only the 20 slot plate would divide into the desired 100 graduations evenly.

In order to get the additional marks I made a paper
Vernier dial. I made this by carefully measuring the distance from the center of the index head to the dial area, and laying out the divisions on AutoSketch. I printed out the scale and super glued on to the head. With this modification I could cut either 100 or 200

divisions. Starting with a large blue line moving the next adjacent smaller blue line on either side and then the second smaller blue adjacent line and so on will add five graduations between Major graduations. 5 times 20 = 100 marks. If I used every red and blue line I would get 200 lines.

Figure 7 Vernier Scale added to Index Head

I also set up a 2" dial indicator on the table so that all slots would be the correct length. As seen in Figure 4 the slots are of 3 different lengths, 7/16, 3/16 and 1/8". I first cut each 7/16 graduation, then each 3/16 graduation and then all the 1/8 graduations around the dial to minimize the possibility of messing up. It seemed to work .

The next step adds scale numbers to the dial. I purchased a set of Young Brothers number and letter stamps, on sale. While the letter stamps were not needed it was fortunate that I did acquire the set. It contains a pointed stamp to be used as a decimal point or period.

Ed had noted that a holding fixture was needed in his note and I had made one from some scrap. Just a large piece of round with a square shank brazed to it and a slot, a few thousands larger than the stamps milled into it. This is just shown in Figure 8.

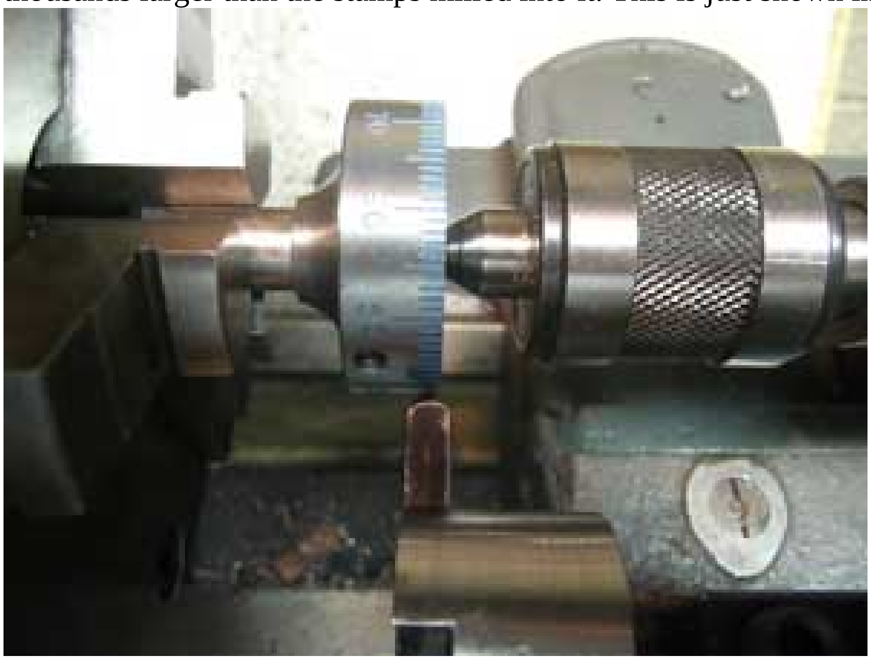

Figure 8 Stamping the numbers on the fabricated dial

I start by locating the point stamp on center. This will put all the number stamps on center. Then I locate the large graduation line with the pointed stamp. Since the graduations are quite deep the point easily fits into the grove.

Figure 9 The finished dial with Retainer Ring relief.

I then turn the dial one graduation above/below the large line, again located with the point. I then remove the point and insert the proper number stamp and move the carriage to the marking point. This is located with a dial indicator stop on the ways. The most difficult part is consistently hitting the stamp with the proper force.

This should have finished the dial construction, however there was an error found later and eventually the dial was remounted on the 3/8 shafting and a 1/32 deep step was machined to clear the retainer ring and allow it to extend into the dial. (Figure 8)

Compound Feed Screw and Bearing Retainer Shaft

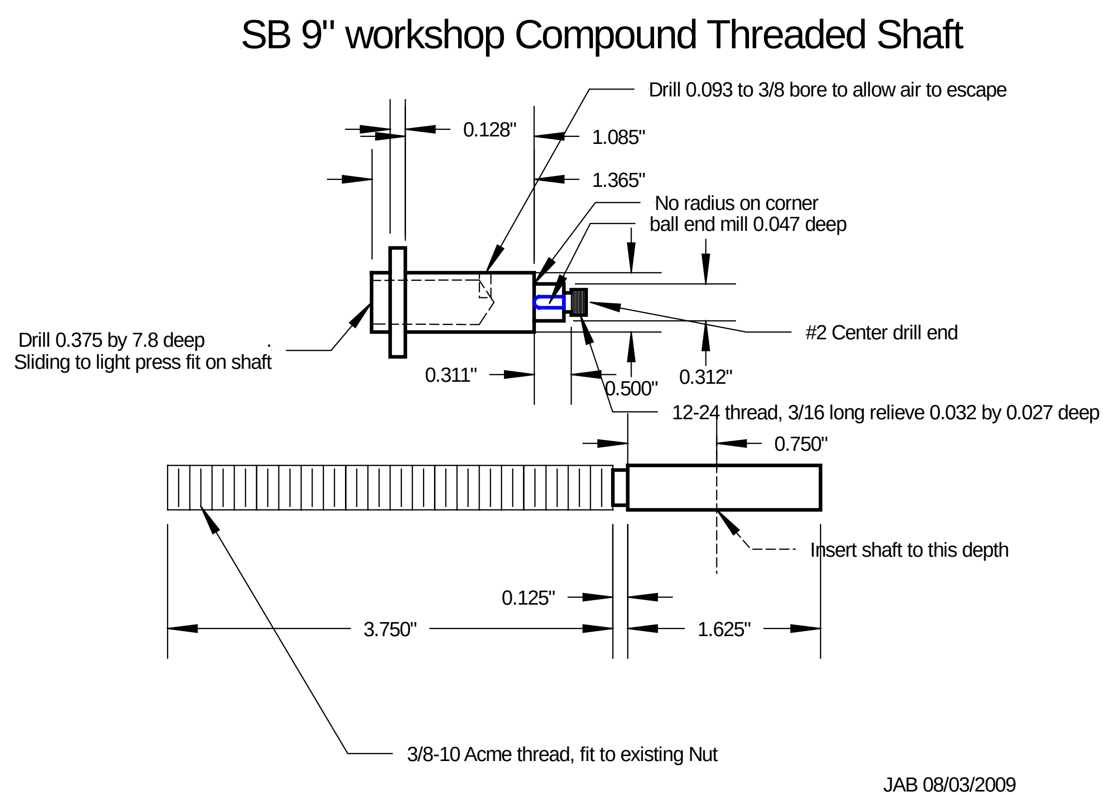

Figure 10 Dimensions for the Compound Feed Screw And Bearing Retainer Shaft

The dimensions for this portion of the project are detailed in Figure 10. The finished Bearing Retainer shaft is shown in Figure 11

This is a two part fabrication. The Insert part is fabricated from a piece of 1” water hardening drill rod. I used water hardening drill rod for two reasons. First I had a piece and second its high carbon content gives it good wear properties.

Figure 11 The Bearing Holder Insert.

Into the short end of the insert will be pressed and Locktited a chased 3/8-10 Acme threaded rod.

I started by holding the 1” diameter rod in a collet in the Heavy 10 and center drilling both ends. . If I were using the 9” I would have used a 3 jaw chuck. I first turned the short end to 0.500 and drilled a deep hole 0.375 diameter and 1 ½” deep. I started with a 5/16 screw machine length cobalt drill and worked up to 23/64. I then used a jobber length letter U drill and finished with a Screw machine length 3/8 drill. The short screw machine drills, coupled with the larger angle found on cobalt tend to wander less when drilling and produce a more concentric hole. “Sneaking up” on the final size hole will result in a hole that is either “to size” or just a bit undersize.   I then lightly pressed a piece of 3/8 drill rod into the hole to use as a stub. The drill rod tends to be a bit oversize so it pressed well. The part was then turned around and held by a 3/8 collet using the handle. (Figure 12). The end to be machined was then supported by a custom dead center. I need to eventually put a 12-24 thread on this end, which requires a 0.215 diameter. A normal center would get in the way of the turning tool. The center was a piece of ½” drill rod held in a MT-2 endmill holder. This was turned down to ¼” for a distance of 1” and a 60 degree point was added. The turning was done in the headstock of the SB-9 using a MT-3 to MT-2 sleeve.
The part was not hardened but if care is used to keep it lubricated it will last quite a while. The large diameter was turned to 0.929. The next diameter, which is a bearing surface for the Dial, was turned to 0.500 and then there is a 0.312 step and a section 0.215 for the thread. All horizontal dimensions were set with a 2” dial indicator mounted on the ways.

Figure 12 Turning the bearing retainer

I have a 12-24 die so I did not chase the threads.
One word of caution. The 0.920 D. flange has a roller bearing on either side. The tool I use, shown in Figure 10 has a 1/32 radius on it to improve the finish on steel.

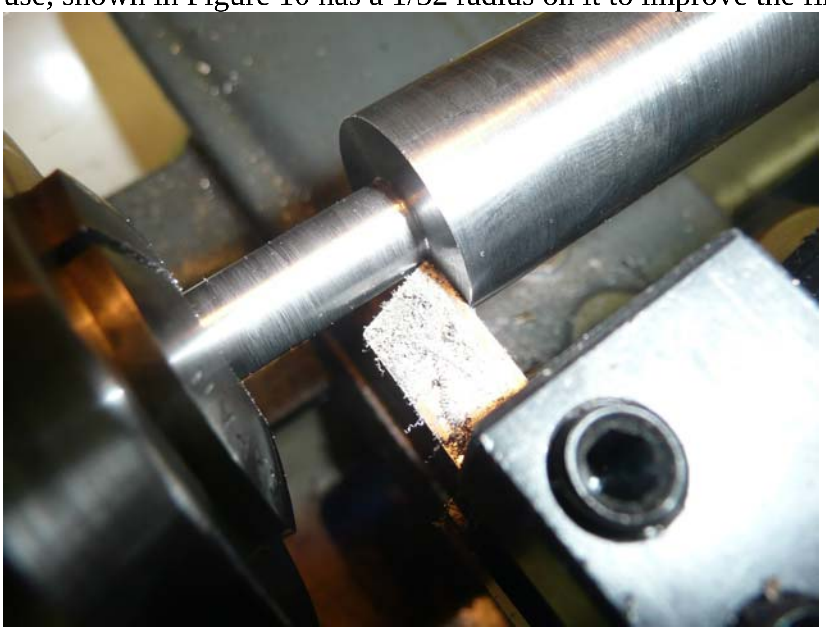

Figure 13 Removing tool radius and undercutting the diameter.

This radius needs to be removed where the bearing ID will sit and where the handle will but against the 0.312 step. I use a sharp knife like tool for this and actually under cut the diameter a few thousands (See Figure 11)

The next step is to chase the thread. This is a RH 3/8-10 Acme. This was the first Acme thread I had cut. I have cut a number of square threads however. I did not have an Acme thread gage tool so I bought one from ENCO. While usable it is very rough and appears to be primarily a stamping with little finishing. I would recommend another source. Get an old Starret or B&S from eBay.

In my box of HSS/Cobalt bits there was a ground Acme tool. It seemed to be for a 6 tpi thread. (Unlike a Vee thread each Acme thread requires its own tool) I hand ground the tool using the Thread gage to insure the correct form and end width.

Figure 14 The finished 3/8-10 Acme Screw Blank

The tool is shown in Figure 14 along with the finished screw blank. I ground the tool unhanded. One most allow clearance for the tool to follow the screw thread grove. This lead can be ground into the tool which makes the tool left or right handed. It is also possible the shim under the edge of the tool to provide the proper “tilt” to give clearance. In this case shifting the shim allows LH or RH threads.

The material was 3/8 water hardening drill rod. I center drilled one end to allow a live center support. I added a section of thread relief at the right end using a cutoff tool and making two plunges and then chased the thread. First cutting 0.010 deep, quickly shifting to 0.005 deep and then 0.0025 and finally 0.001. After the first pass, which will throw up a ridge I used a smooth file to remove the ridge. Every third pass was a free pass and the file was used for the first three or so passes to insure the ridge removal. The compound was set at 14.5 degrees and the last several passes were advanced using the cross feed screw not the compound.

As the screw cutting progressed to the calculated depth (0.050”), I tested it for fit on the nut. The final five or six passes were free passes both to insure that there was minimal bowing effect in the threads and to get a clean a thread as possible. I also filed the walls of the threads, lightly with a knife file. The screw and nut are shown below in Figure 15


Figure 15 Compound nut on Shop made Acme Compound Screw.

Two final steps are needed, the bearing block needs a round bottom grove for the 0.093 key used to keep the handle from turning and the screw needs to be pressed and Locktited into the bearing block

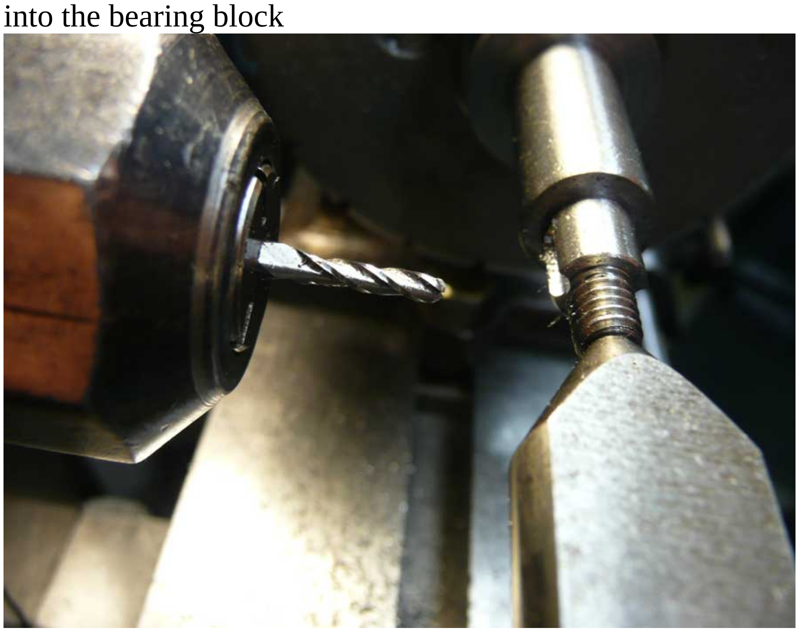
Figure 16 Milling the Key slot.

The slot was made using a 0.093 ball end endmill, and cut 0.047 deep. (Figure 16).The bearing block was held in a collet in the Burke Index head and the far end was supported by a footstock

Not shown is the bad slot that I cut when I forgot to tighten the collet.

The pressed in piece of drill rod used as a handle was easily removed with a flat bar working against the 5C collet. The shaft of the screw was cleaned well using lacquer thinner and coated with 603 Locktite and pressed into the bearing block . To insure concentricity I held the block in a collet on the Heavy 10 and pressed using a dead center and the tailstock with light tapping using a plastic hammer.   I had planned to pin it just to be sure but after curing pining was not needed. The finished screw is shown in Figure 15. Note that there is a cross drilled hole in the longer 1/2 “ diameter. This is to allow air and excess Locktite to escape during the pressing operation.

Figure 17 The completed compound screw and bearing block assembly.

Bushing and Bearing Housing

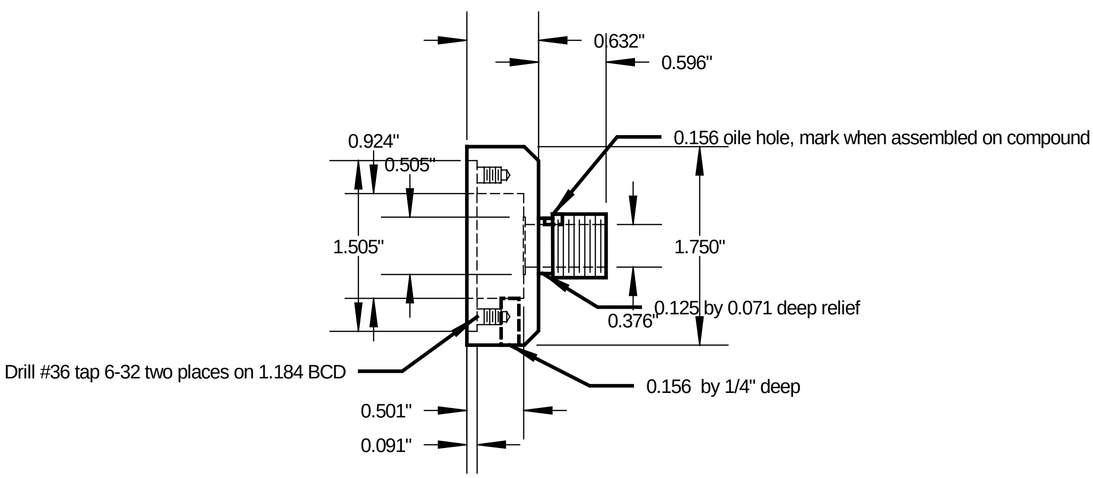

Figure 18 The Bearing and Bushing Housing Dimensions.

This portion of the project is one of the more difficult items. The finished part is shown in Figure 19, dimensions are in Figure 18.

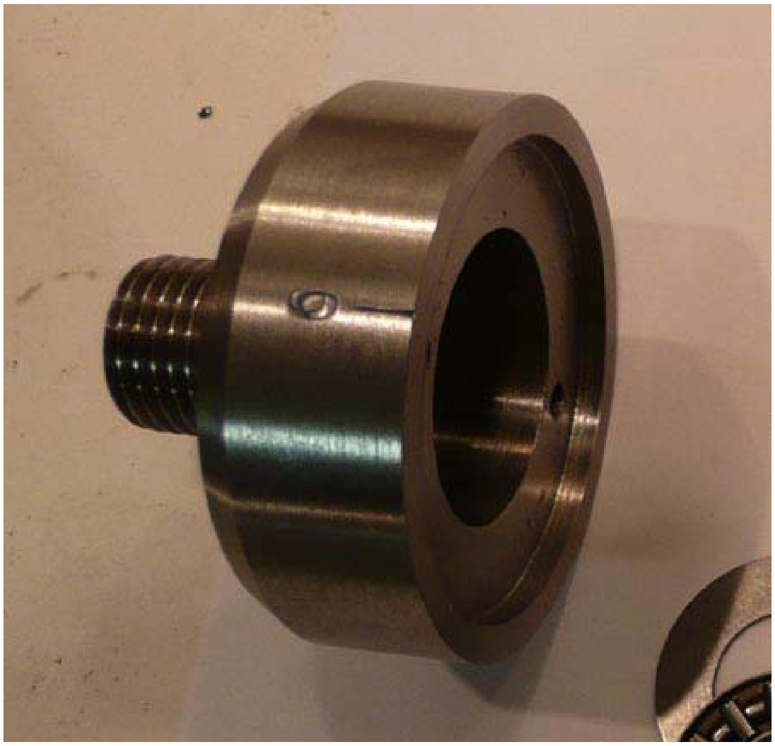

Figure 19 The Bearing Housing.

The large OD matches that of the dial. It has a 0.376 bore that acts as a radial bearing surface for the screw. It has an internal bore that houses the roller thrust bearings. It has a large step for the bearing retainer. It has a 9/16-18 thread that firs into the compound, a Zero reticule mark and two 6-32 tapped screw holes for attaching the bearing retainer. This version is labeled as the Alternate Housing in Ed’s note.

I started with a piece of 1 7/8 1144 steel 1 3/8 long. Actually I started to make this as a weldment but messed it up and bought the 1 7/8 stock.

Figure 20 Drilling through the blank

This was OD ground from the vendor. The blank was held in a 3 Jaw chuck and faced off and center drilled on both ends. (Since the od was to be turned I did not pother to protect it with copper shims.) It was then drilled through starting with short cobalt screw machine drills 5/16 in diameter. (Figure 20) The hole was increased in size by 1/64 up to a letter U drill and then reamed oversize with a 0.376 reamer. As noted before this process minimizes drill run out and produces true to size holes. While the part was in the chuck

Figure 21

The 9/16 boss was turned and the thread relief cut. (Figure 21) Since this is the end where the drilling was started the potential for the hole to wander was small. The relief is small and there is a large blank wall just after the relief. This required a new threading tool. I usually use a symmetrical one, but in this case the edge of the tool would hit the face before I cleared the last thread. I ground the tool shown in Figure 22 which has a very short lead and threaded the boll without incident/

Figure 22 Asymmetric Threading tool

Finally before removal a large bevel needed to be put on the OD (Figure 23).

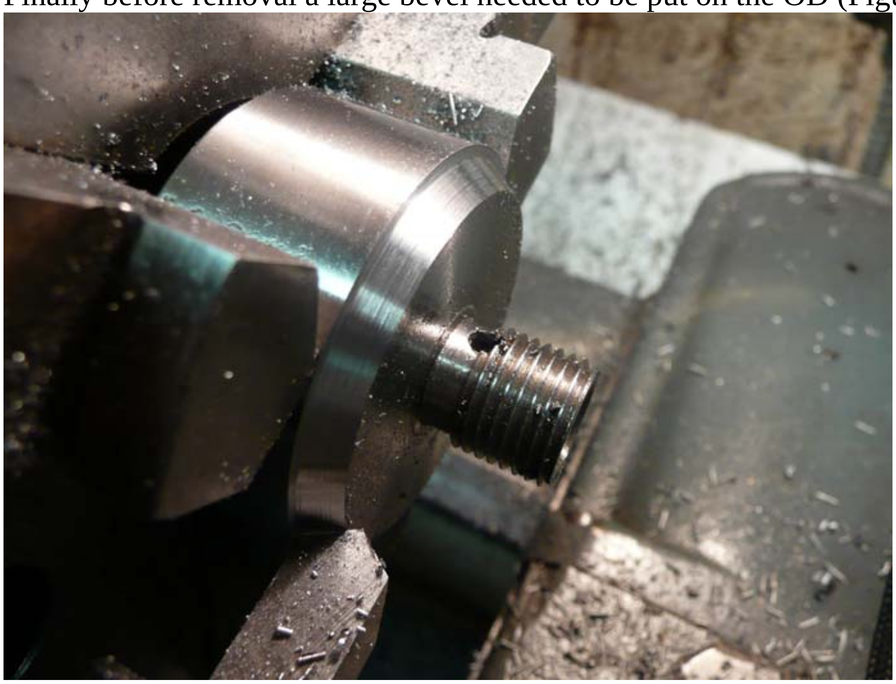

Figure 23 The step on the bevel is there since 1/8" is to be removed from the OD and I wanted the bevel to remain. The same tool was used to put a bevel on the face of the threaded boss.

Note that an oil hole has been cross drilled in the boss. During the threading process the compound was tested on the threads to insure a good fit. At the point where the final fit was obtained the position of the oil hole was marked, without removing the part from the chuck and then drilled in the lathe with the shop made cross drilling fixture. (Figure 24)

At a point just opposite the oil hole a 5/32 by 1/4 deep hole, ¼" back from the face is also drilled.

Figure 24 Cross drilling the Oil hole

This hole is used to lock and remove the housing in the compound body. Note the constant use of shorter length screw machine drills. These both reduce wandering and are more suitable for use with the chop made cross drilling adapter.

The part was then removed from the chuck and Super-glued to a piece of 3/8 drill rod which was used as a mandrill for the rest of the job. (Figure 25)

Figure 25 Mounted on the Mandrill, the OD is turned and the part faced to length.

The depth of the mandrill must be set careful since several counter bores are to be made and you do not want to have to machine the drill rod.

At this point the OD is turned to 1 ¾” (to match the previously made dial) and the part is faced to length. (Figure 26). Three counter bores are now bored. The largest is 1.510 by 1/16 deep, the next id 0.925 by 0.407 and the last is 0.505 by 1/64” deep. See Figure 23 The depth of the 0.925 hole is critical. I suggest measuring the bearings while mounted

Figure 26 Boring the counter bores in the housing.

On the shaft, and subtracting 0.002, for bearing preload

Here I used a short stout carbide boring tool, which I polished on a diamond hone just before using.

At this point two holes need to be drilled on a 1.184 bolt circle to hold and clamp the roller bearing retainer ring. This could have been done, with a bit of fixturing, in the Burke mill. I chose to use the cross drilling fixture and the lathe. (Figure 27)

Figure 27 Drilling holes for the Bearing retainer.

This approach required remounting the cross drilling fixture so that it point axially to the bed. The lathe is put into back gear to lock it in place. I checked first and found that I could rotate ½ turn and lock again. Using this procedure the back gear is becoming a dividing head. It is important that the backlash must be taken out of the back gears in a consistent direction or future holes will not line up (I found that one out the hard way).

The center of the Housing was then found and the drill was moved 0.592” from center. I first center drilled the hole and then drilled #36 5/16 deep and then tapped with both a plug and a home made bottoming tap, all in one setting, without rotating the part.

The bottoming tap was made from a broken plug tap, with the end ground flush.

The final step is to scribe/mill the Zero reticule on the body. I use the same approach of sawing the line in using a thin, 0.010 saw on the horizontal mill. The first step is to position the mark. I remounted the compound on the cross feed, screwed in the housing, tight, and blued the housing in the general area. (Figure 28) I clamped a parallel into the compound and, using a 6” steel rule, centered it. I then lightly scribed the housing, to mark where the deeper line should go.

The next step is to move to the Mill and set the scribe line at Top Dead Center in the Index head.

Figure 28 Positioning the Zero Reticule line.

Figure 29 Setting the scribe line to TDC on the Mill

Here I use a test indicator to, first find TDC and then rotate the housing so the scribe line directly under the indicator. (See Figure 29)

The line is then milled into the part, similar to the lines made on the Large dial shown in Figure 5. Finally housing was put back into the lathe, the line was picked up using the point punch the Zero number was stamped.(Refer to Figure 6).

With that the housing is finished. The Superglued 3/8 plug, which is being used as a stub arbor is removed by tapping with a small ball peen to break the bond and the bore cleaned with acetone/finger nail polish remover/lacquer thinner or just hand reamed.

<u>The Bearing Retainer Ring</u>.

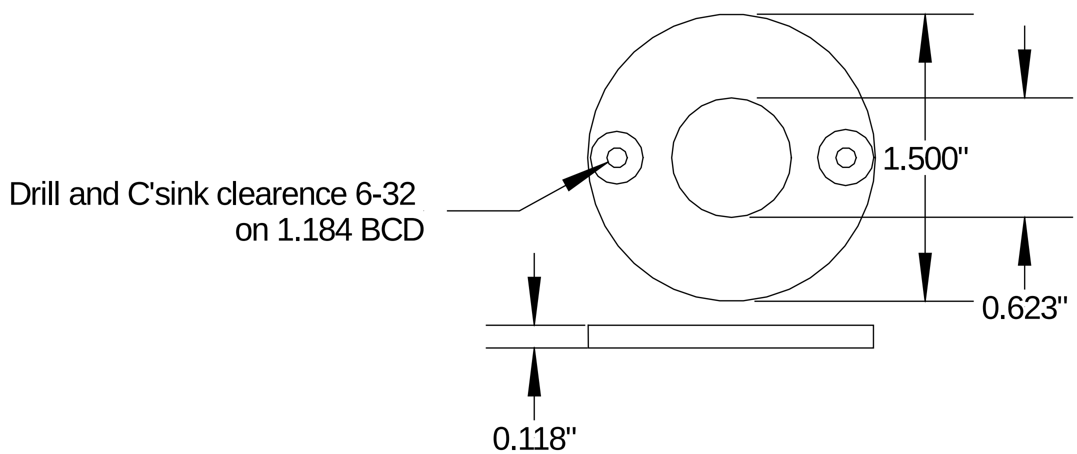

Figure 30 The Bearing Retainer Ring Dimensions

As simple as this part appeared to be holding it proved to be difficult, primarily in the holding of the relatively thin part.

I started with a scrap piece of 1” diameter material. Holding it in a 1” collet, I drilled and bored a 0.510 hole through. It could have been held in a chuck. The diameter next needed to be turned and the thickness faced to size. I happen to have a set of expansion arbors so the OD was turned on one of these. (Figure 31)

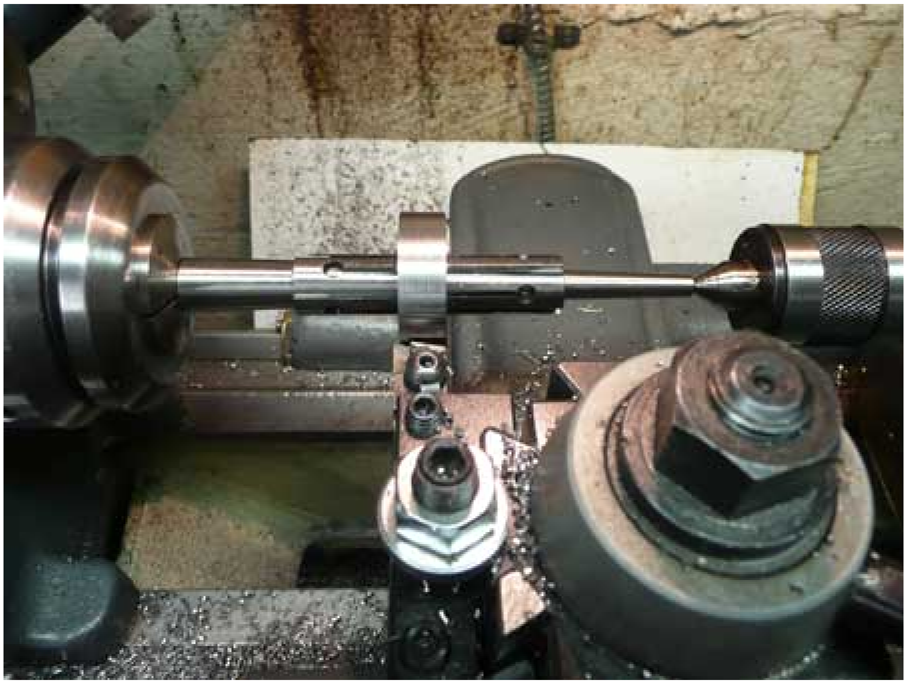

Figure 31 Turning the OD of the bearing retainer.

Next both faces needed to be turned and the thickness machined. I had two pot collets for the 9” lathe. So I put the 9” compound back together and remounted it. One had a step that was close, in size, to the retainer OD. I machined it to fit and held the part in the collet. First one side was faced, the part turned around and the second side faced to the proper thickness (See Figure 32).

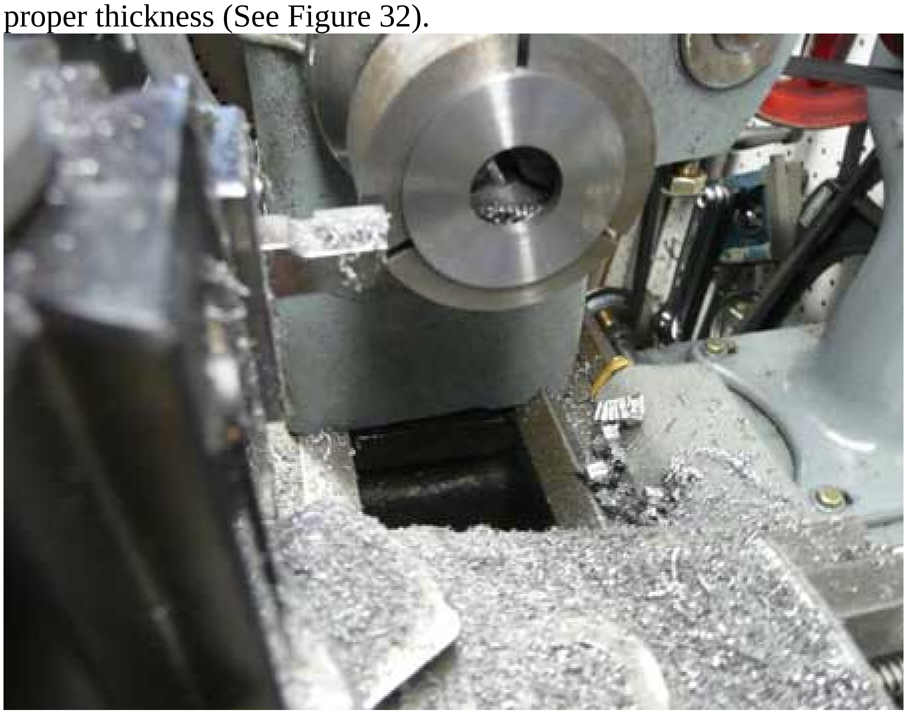

Figure 32 Facing the bearing retainer.

Next I needed to drill and countersink two holes for the 6-32 screw holes that hold the retainer and removes all the axial play in the shaft. I used the same approach as in drilling the housing but in switching lathes, since I have no pot collets for the 10L. Something did

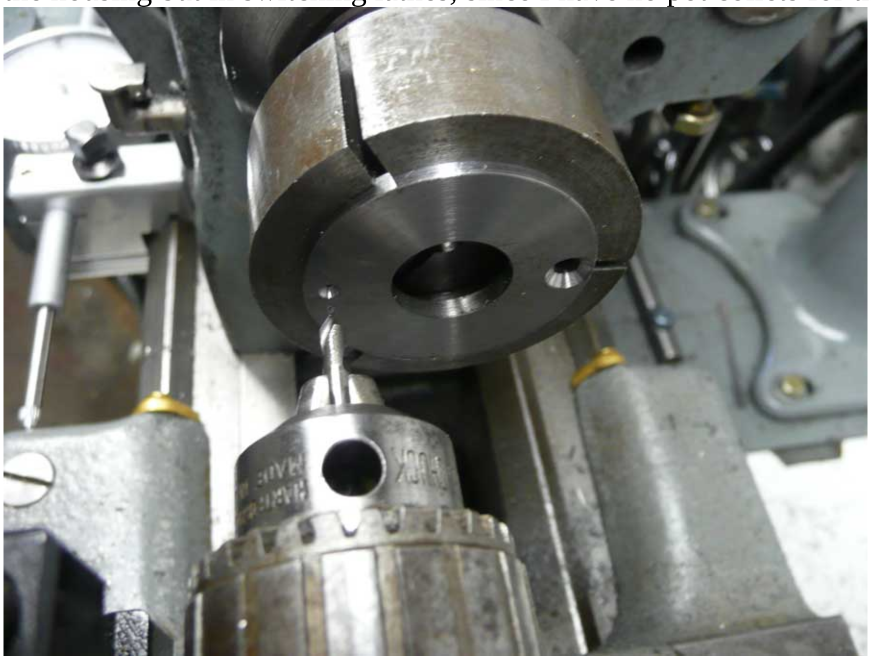

Figure 33

get lost in the translation. Figure 33 shows the center drilling of the second hole. Unfortunately this hole was neither opposite the first or on the proper Bolt Circle.

It took three try's to get things to line up. I had not measured the holes in the Housing and it turns out they were not on the proper BCD and I neglected to get the play out of the 9"

Figure 34 The finished large dial assembly mounted on the compound.

backgears. However since the retainer is covered by the Large Dial no one will see the goofs. (Except me and you if you look closely at Figure 1)

That finished all of the machined parts There was some fitting needed.
While the bearing retainer clamped properly the large dial had a bit more gap than I would like to see. I measured it with a set of feeler gages and took the proper amount off the face of the 0.500 step to provide 0.003 to 0.005” clearance.

As a final note one of the first projects after finishing the dial was opening up a larger pot collet to machine a 2 ½” od 0.110 thick washer. It interrupted cuts caused a slight vibration but it was enough that the, now almost frictionless, compound dial would not stay put. I therefore added a thumb screw on the compound Gibb, seen above in Figure 34, so I could lock it in place.

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