

South Bend 9" Cross Slide Screw Fabrication For a Large Dial/Thrust Bearing Conversion

By

Steve Wells and Ed Godwin

3 October, 2007

Part 1

This series will document the machining and assembly of a South Bend Large Dial Cross Slide Screw with anti-friction thrust bearings. All parts were created from blank stock with the exception of a new-old stock 200 graduation South Bend index dial and an original South Bend crank handle. Bearings, SB index dial, precision ACME screw blank, and splined shaft blank were supplied by Steve Wells. Steve also will rework your existing cross slide screw or supply you with raw parts for you to do it yourself.

This work is part of an upgrade to a 1936-vintage South Bend Workshop (Model 415) lathe owned by Ed Godwin of Kissimmee, Florida. This work was accomplished in September/October, 2007.

Shown in the next two photographs is the way things will look when the project is complete. Note that this is for a large dial assembly. Small dial assemblies will have considerably different dimensions.

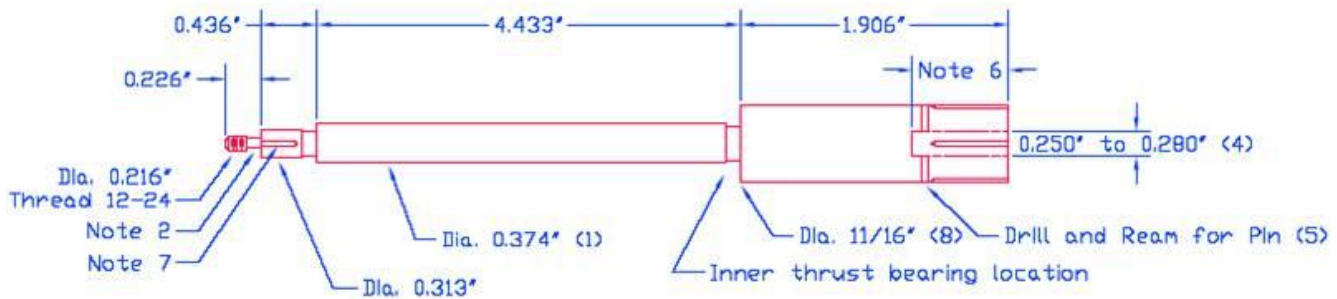




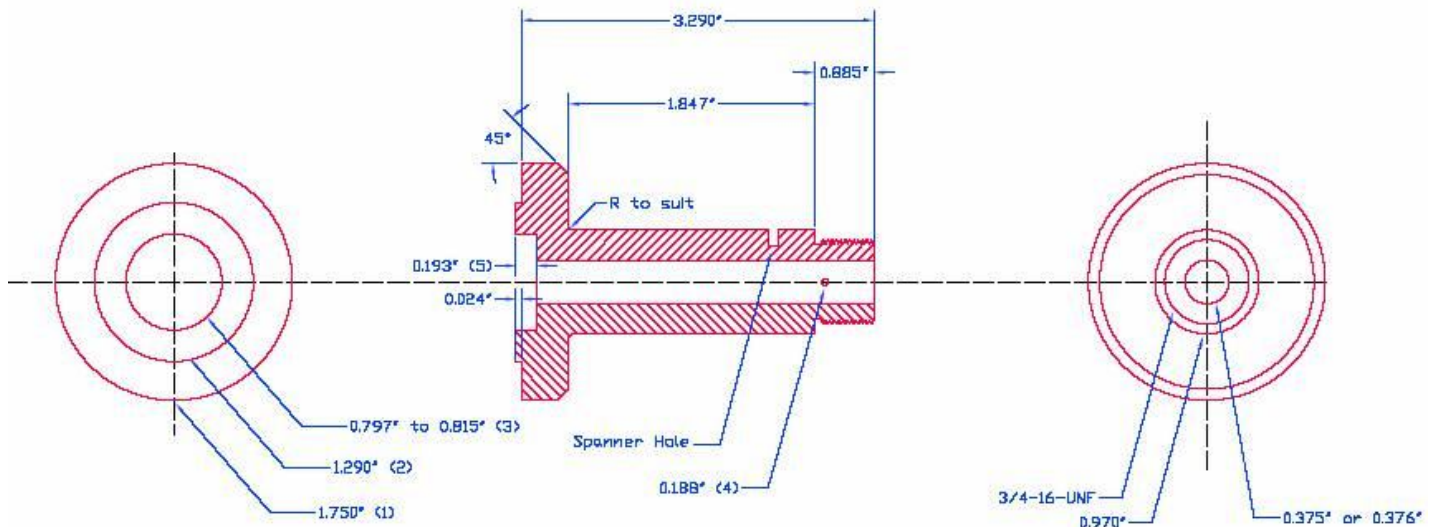
We will show you step-by-step how to construct this to achieve the kind of smooth and minimal-lash assembly you've been seeking. While dimensioned drawings are provided, be aware that there are only a few critical dimensions. We will point out where you need to be particularly careful for final fit-up. To some degree, the dimensions shown are an artifact of the 7" length of spindle blank that was supplied. One more inch of spindle blank would probably be worthwhile and would also give a little room for error, particularly when machining and threading the small steps at the dial end.

This was a fun journey for Ed and we'll show you some fabrication and machining steps that will seem obvious to some of you but we had the photos so there you go. We are both happy to share this with you.

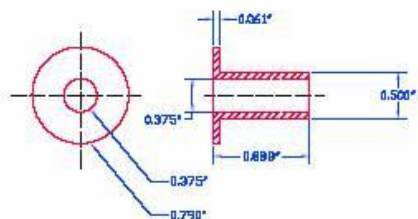
First, the drawings: They are not to scale.



- 1) 0.374" to 0.375" to allow 0.001" clearance in mating bushing.
- 2) Thread Clearance to minor diameter of 12-24 thread.
- 3) Relief Grooves ~ $\frac{1}{16}$ " to $\frac{3}{32}$ " wide.
- 4) To suit available reamers. Ensure that dia. is less than screw minor dia.
- 5) Pin may be $\frac{1}{8}$ " straight pin or #1 or #2 (max.) taper pin. D&R after Loctiting Screw into hole. If using straight pin, chamfer holes..
- 6) Screw blank insertion shank depth - 1.25" minimum to 1.50" recommended.
- 7) Ball End Mill - 0.095" to 0.105" diameter to fit existing handle pin.
- 8) Check saddle to ensure a slightly loose fit. After reaming saddle, trim shaft slightly if required.
- 9) Inner thrust bearing is 0.276" thick.
- 10) The screw blank will have a finished length of 6.80" after assembly. OAL of the screw blank with insertion shank is 8.05" to 8.30".

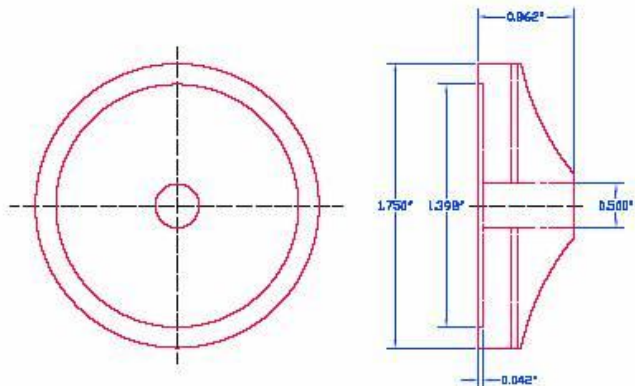


- 1) Match O.D. of the dial you intend to use.
- 2) Optional raised face.
- 3) Slightly larger than the needle thrust bearing being employed - 0.796"
- 4) Drill 0.188" through one side only to match oiling hole in saddle.
- 5) Bearing used in this design is 0.143" thick.



Index Dial Bushing

- D) The length of this bushing is critical. It should be one of the last things machined and its length should extend about 0.002" past the end of the dial and also slightly past the handle-mounting shoulder on the shaft. When you tighten the handle nut on the shaft, the handle will bear on the narrow end of this bushing and press the bushing's flange against the thrust needle bearing. The 0.002" clearance gives enough space for the dial to rotate freely on the OD of this small bushing.



Standard SB Index Dial of 200 Divisions.

First, let's prepare the saddle.



Here you see an 11/16" chucking reamer turned by hand being used to clean up the thread crests and holes in the 415 saddle.

A new 3/4-16 tap is being used to clean up the threads. Run the reamer and the tap through a couple of times each. This will help to remove any burrs that might damage the plastic ball carrier of the inner thrust bearing.

I found that this plastic ball retainer has an outside diameter about 0.010" larger than 11/16", making it difficult to insert. Also, the ball carrier should be free to move during operation. I suggest you gently remove the excess plastic on the OD of the ball carrier. I used an abrasive flap wheel while the bearing was mounted on the shaft and it worked fine but I was very slow and careful about it.





Here are the semi-finished parts supplied by Steve (very high quality stuff, indeed):

- In the background is my original 415 Workshop Lathe cross slide screw. We'll use the handle, the handle nut, and the pin from this assembly. Everything else goes in the nostalgia box.
- The partially machined spline blank at 7" length.
- The screw blank waiting to have the insertion spigot machined.
- The NOS 200 index dial.
- The inner (ball) and outer (needle) thrust bearings.

We still have to make:

- The large bushing
- The small bushing
- Miscellaneous pins, screws, etc.



The spline blank is only seven (7) inches long. After careful calculation, it turns out the 7" is just barely long enough, no margin for error at all. You can see above that the splines are only just fully engaged with the apron gear. Steve says that the next batch will be an inch longer (8") and that will also make it a little easier to chuck it up for machining.

But if you get a 7" blank, be very careful and do a lot of measuring and cross-checking first.

Remember, you can always make your large bushing a little shorter if you need to, but you can't add length to the spline blank.



The original lead screw on the saddle. Take some measurements off your old one, if you have it. Such as length of screw, etc.

OK, we've made ourselves cross-eyed from taking measurements, calculating, making sure we understand how everything fits together and works. Time to have some fun.

Let's start making some chips. How about drilling and reaming the spline blank for the new screw blank. I drilled and reamed for 0.250". That's a stubby screw machine length drill. I like them for their rigidity on important and/or deep holes.

If it's a really critical hole, I like to use my Morse Taper drills directly in the tail stock. These drill chucks are convenient but they're none of them super accurate.





Reaming out the hole to 0.250". Dead-slow and lots of lubricant. Since the reamer only cuts on the leading edge, withdraw and clean out often. If the flutes fill up with chips, it will push the reamer off to the side and either overcut (most likely) or wander. I like to hold the dog in my hand because I get a really sensitive feel for how the reamer is cutting.

Now, let's turn down a 1-1/4" long section of the screw blank to 0.250" so it will just barely fit into the spline blank we just reamed. You can turn this section to 1-1/2" length and it will provide a little more space for your cross-pin. At 1-1/4" length, you have to put the pin almost into the splines, so I'd recommend 1-1/2".



OK, there's 1-1/4". Debur, do a little emery cloth and done. I chose to machine the spigot right up to the threads and butt the threads right up against the spline blank when assembled. You may choose to leave a section of unthreaded shaft exposed. If you choose the latter, however, make sure you don't limit your cross-slide nut travel due to lack of threads. Seems obvious, but thought it should be mentioned.

Since you're going to be Loctiting this spigot into a blind hole, you'll need to provide a little air relief, so gently file a small flat on one side the entire length of the spigot. Not more than about 0.005" deep, because the recommended Loctite 680 has a 0.015" gap-filling capability. Most of the other Loctites are only recommended for 0.005" gaps.



The 0.250" screw blank spigot has been trial fit into the spline blank. A #2 taper pin has been selected for the cross-pin simply because I like taper pins better than solid pins and #2 is what I had. #1 tapers are slightly smaller and would be more advisable. If a solid cylindrical pin is used, 0.125" is recommended.

All cross drilling and reaming for all parts will be left to the end of the project so that they can all be done with one setup on the vertical mill in the v-blocks.

If you don't have a vertical mill, or a really good drill press, then now might be the time to build a cross-drilling rig for your lathe. They are mighty handy sometimes. Bob Wright at the Yahoo Group "South Bend 10K" has a nice design and photos.

Moving on to the large bushing, start by securing a suitable piece of solid hot or cold-rolled steel. For this project a 2" diameter piece would be good. The 3" section shown being sawed off was used because that was what was available. There are lots of different ways to handle the machining of this bushing but remember that you will need to machine both ends and things need to remain concentric as you swap ends. So you might want to think of using a four-jaw chuck. I was able to use my 3-jaw but you'll see later that I checked it first before making that decision.



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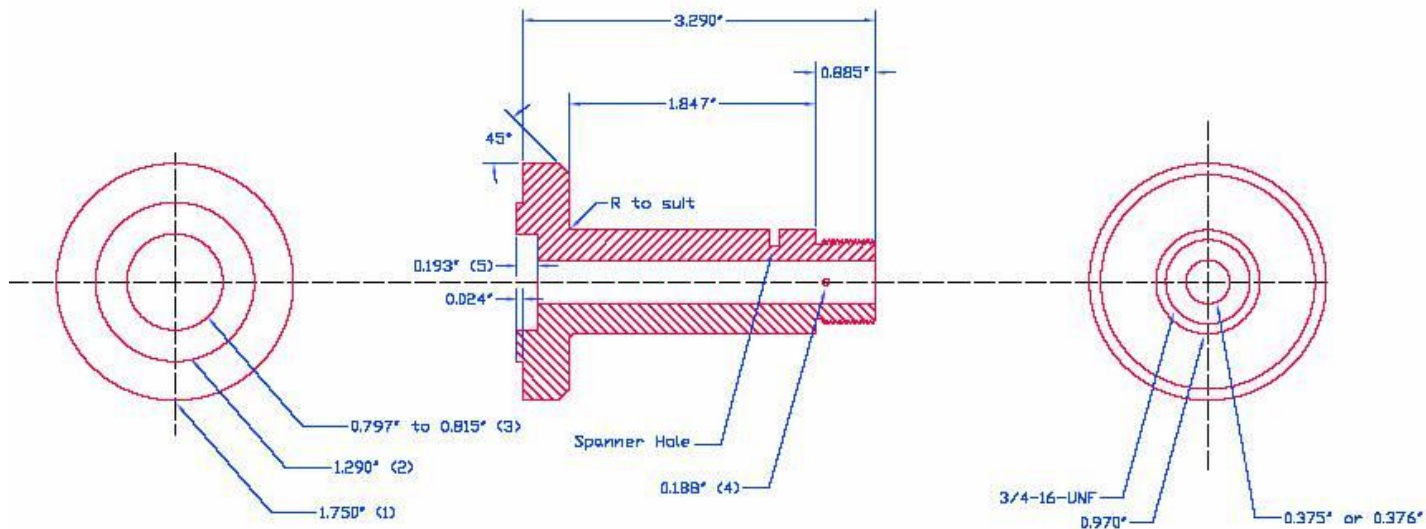
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Part 2

We left off cutting off a section of 3" round stock to make the large bushing. 2" stock would be adequate since the index dial we're using is 1.750" OD. If you're going to be working with a 2" OD dial use appropriate stock. And, of course, a small dial assembly which we're not documenting here will have considerably different length and diameter dimensions.





- 1) Match \square of the dial you intend to use.
- 2) Optional raised face.
- 3) Slightly larger than the needle thrust bearing being employed - 0.796"
- 4) Drill 0.188" through one side only to match oiling hole in saddle.
- 5) Bearing used in this design is 0.143" thick.

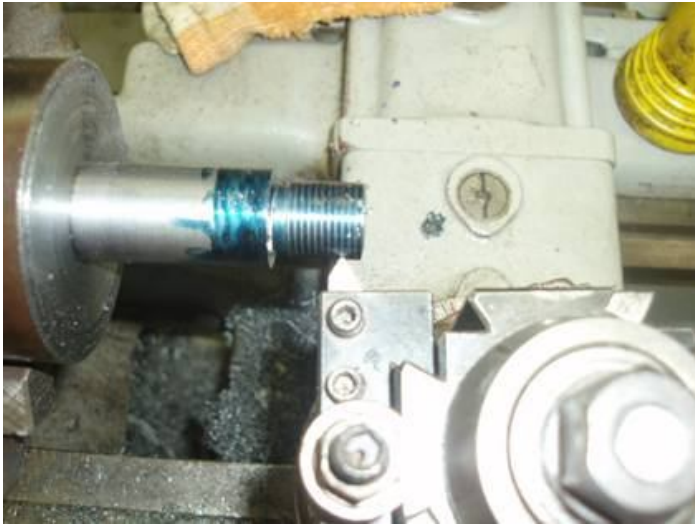
Chuck it up securely, face it off and start hogging off the extra material. The chips from this filled up a five-gallon bucket.



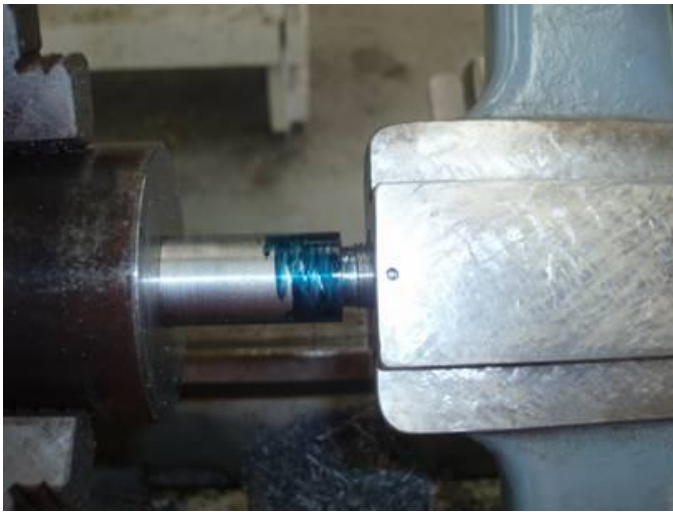
The bushing blank is turned down to the 0.970 dimension and the thread relief groove is being cut.



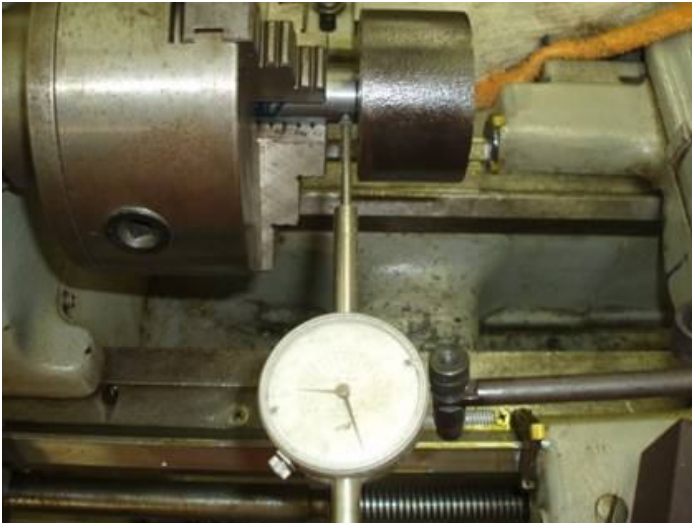
Threading $\frac{3}{4}$ -16 UNF. You'll want a nice thread here so take your time and use a nicely honed tool. You should aim for a close-fitting thread in the saddle, smooth but not loose.



Trial fit. Thank goodness it's a 9" lathe and not a 13". Maybe a trial female plug would have been useful as a thread gauge?



Threads are finished. So is the facing for back side of the large diameter section of the bushing. Time to reverse the work and machine the other end. Since you have to maintain concentricity, you'll need to decide if you're moving to the four-jaw chuck or not.



Work is reversed in the 3-jaw chuck and checking for runout. In this case, the TIR was less than 0.001" and adequate for this class of work. But I just got lucky – My Bison 3-jaw is pretty good. Many are not. Here's where you need to take some extra care in your setup.

The work has been turned to the OD, faced down and the face step cut-in, drilled and now reaming for 0.375". Work closely to your dimensions. As you set up work in the chuck, ensure that you will have enough space to get your micrometer or dial calipers in to take measurements. Basic stuff, but worth mentioning.

Now, instead of drilling to an ID that would allow reaming, you could drill and then use a boring bar to get to reaming ID. I chose to carefully drill and ream simply because a boring bar small enough to get into a hole that's, say, 0.325" diameter is going to be slender and long for this piece of work. Your choice.



While the stock is chucked up, the initial counter-bore for the needle thrust bearing will be made. If you're really confident in your dimensions and machining, go ahead and bore to final depth. If not, then just counter-bore to a depth that is about 0.002" more than the thickness of the needle bearing. Final depth of this counter-bore will be part of the final fit-up.

The diameter should be a little larger than the OD of the bearing. Don't measure the bearing's washers, measure the needle carrier, it is always larger than the washers. The diameter is not critical, but if it's too much larger, the bearing can skew to the side and then the needles won't roll so much as skid. So anywhere from 0.002" bigger to 0.020" bigger should be OK.

Don't forget to grind the underside of the cutter for sufficient clearance from the edge of the hole. I prefer to do this kind of work with a stiff tool bit rather than a more flexible boring bar.

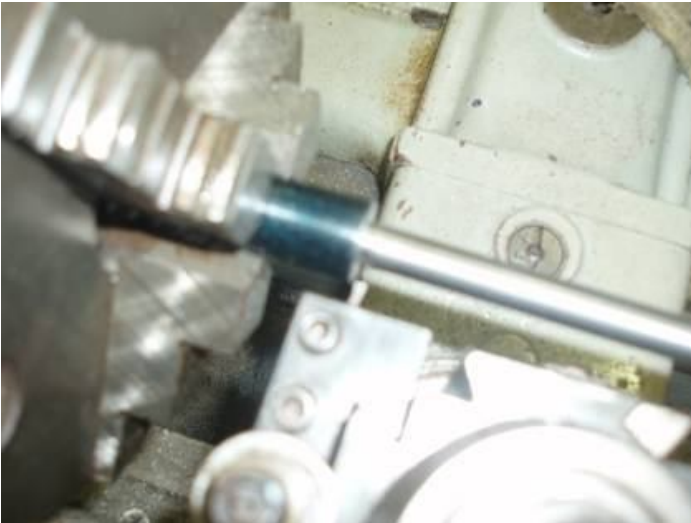
And, here's the bushing with a trial fit on the saddle. If you tighten it up with a strap wrench, you can centerpunch through the oil hole for the future drilling of the oil hole in the bushing.



With spline blank chucked and supported in the tailstock live center (check runout for this setup and use a different work-holding setup if you cannot achieve $< 0.001''$ TIR), turn to $0.374''$ to $0.3745''$. You want to get a smooth but close running fit to the large bushing. I like to run a piece of 1000 grit emery over the work before testing the fit. Use your already machined bushing as a gauge.



Cut the two relief grooves where indicated on the drawings. Depth and width are not too critical but they are primarily to allow places where dirt can collect and to allow a square shoulder against which the thrust bearing washers can bear.



It's worth checking your build-up dimensions at this point with the inner ball thrust bearing and large bushing installed.

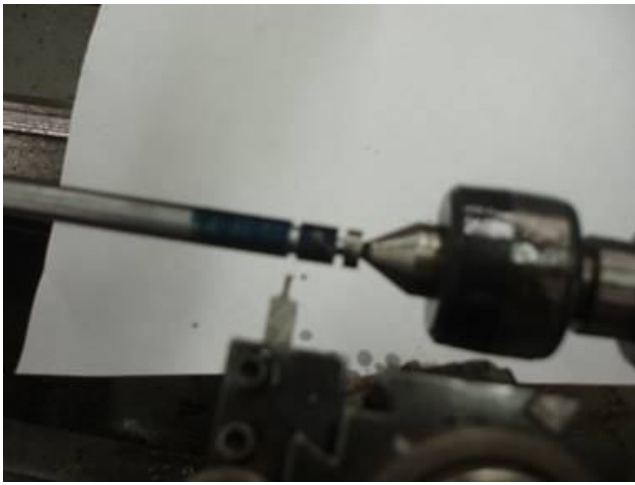


Outer needle bearing tool!



The second relief groove is shown at the left in the below photograph and the threading relief groove is on the right. Since the thread is only 12-24, the center hole at the end of the shaft is very minimal. Needless to say, all machining on this shaft is performed at very low stress levels. This was necessitated due to the 7" length of the spline blank. With a slightly longer blank, the setup could be a little stouter.

Do not try to do these relief grooves with a cut-off tool. Grind a sharp, short groove cutter for this.



The finished spline blank is shown. I suggest doing some partial threading of the 12-24 thread on the lathe and cleaning it up with a die. That way you'll assure a thread concentric and square to the shaft. With only one shot at this, it's worth the extra effort.

This photo shows all the finished parts ready for assembly.



The small bushing is a straightforward piece of work with the caveat that it's final overall length must be left to final fit-up machining since it has to extend past the dial hub by just about 0.002" to 0.004". At this point it's also worthwhile to polish up the face of the dial. Some 1000 grit and oil on the surface plate or a mirror will do the job. Just enough to make it smooth.



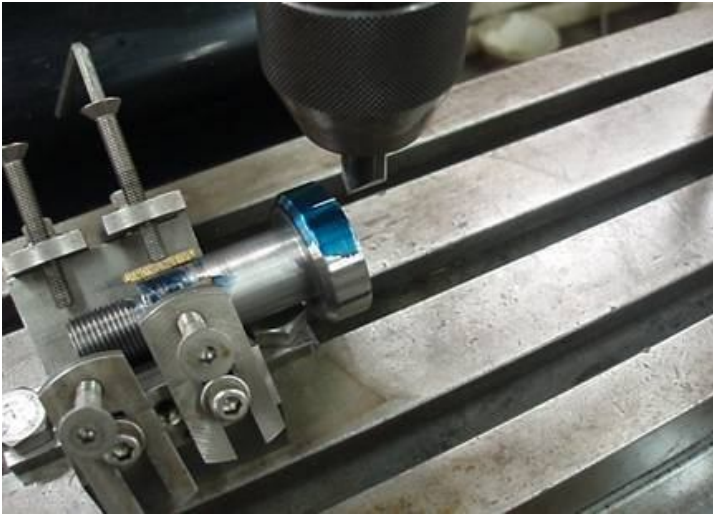
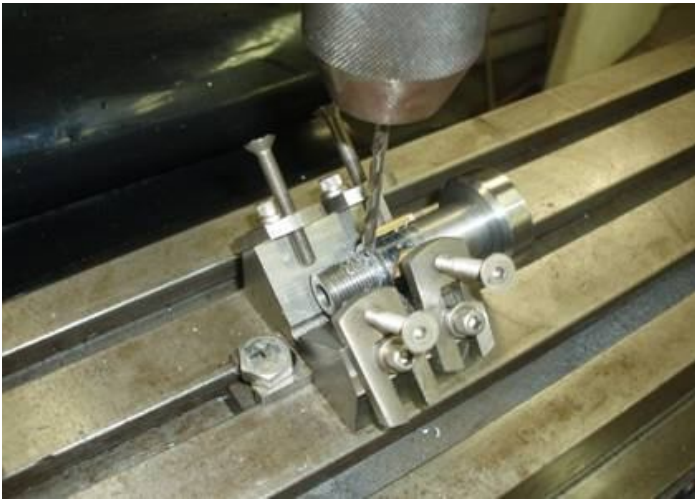


Now we start finishing the job. First, screw the large bushing into the saddle and tighten it down as much as you can. A strap wrench is good for this. Using a center punch of the correct size, reach down through the oiling hole at the front of the saddle and centerpunch the large bushing. While you're at it, you can also blue the large OD and mark the line for the witness mark.



Transfer the large bushing to the V-Block on the mill, center and drill the oil hole through one side only. Run a reamer through the bore by hand to clean it up from the drilling burrs.

Mount a scribing cutter and scribe the witness mark to suit your own tastes. When done, emery the OD to remove burrs and polish. Check to make sure you didn't raise a burr on the face where the dial bears. I did so I removed it with a needle file and a little emery paper.



Rotate the bushing 90 degrees in the V-block, and drill the tommy bar/spanner wrench hole. Do not drill through to the ID. Location is not too important but it should be closer to the threads rather than farther away. Check the spanner wrench clearance to the saddle before you make a final decision.



Loctite the screw blank into the completed spline blank. Leave undisturbed for 24 hours to cure.



After curing, transfer the assembly to the V-block and drill for the cross-pin. Shown here is post-drilling and checking taper pin for fit after the first reamer pass.



If you used a straight pin, choose one shorter than the OD of the work and make sure you chamfer the edges of both holes. If a taper pin is used, make it longer than the work's OD and grind/sand it flush after its been seated.



One final task is to mill the round groove for the handcrank pin. This groove does not extend all the way through to the shaft's relief groove. My pin measured 0.094" in diameter. The closest ball end mill in my box was 0.105" so that's what's shown. It worked fine. Before tightening the handcrank nut, there is about 5 degrees of rotational motion in the crank due to the oversized groove. But it sure makes assembly a lot easier.



If you're working with a new handcrank that doesn't have the pin hole already drilled in it, you can mount the handcrank on the shaft (superglue would work here) and drill the pin hole in handcrank and shaft simultaneously. Break the superglue bond with light heat when you're done.

Here are all the parts laid out and ready for final fitting. Assemble the shaft, inner bearing, large bushing, outer bearing, small bushing and dial. If there is a gap between the dial face and the face of the large bushing, then return the large bushing to the lathe and deepen the outer bearing pocket by an appropriate amount. It is better to sneak up on this.

Reassemble and you should find the end of the small bushing extends out from the small end of the index dial and past the shoulder on the shaft. You will now start shortening the small bushing with the goal of leaving about 0.002" between the hub of the index dial and the end of the small bushing. This is clearance space to allow the dial to rotate when the handcrank is secured on to the shaft. Once this is complete the end of the small bushing should slightly extend past the shoulder on the shaft so that when the handcrank is secured on, it is pressing against the small bushing not the shoulder of the shaft. This fitting ensures that the assembly pressure is compressing the needle bearings completely and the small bushing should be turning with the shaft.

The locking screw for the index dial will bear on the OD of the small bushing. A brass (or nylon/delrin) shoe between the screw and the bushing will reduce marring and if you file a small arc on the shoe it will make better contact with the bushing.



If you haven't already done so, take a slot file and clean up the screw slot in the handcrank screw. Now's the time to make a split screwdriver for this nut. There are lots of ways to do this but here's a quick and dirty one. Take a 5/16" socket with a hex drive (the kind that always come with those kits of hexdrive screwdriver bits) and grind away everything that doesn't look like it belongs. Takes five minutes and it is very serviceable.

After all final deburring, polishing, painting, etc. perform final assembly. It should look about like this and its rotation should be as smooth as a baby's behind.



Steve and I hope you had fun with this project and we hope it works well for your lathe.

END