An Idiot's Guide to Rebuilding the 8520 head.

Background:

I bought my Clausing 8520 in October 2002 after looking semi-seriously for about a year. Most of the E-bay deals were well over $1000 so when I was able to get mine for $700 I was delighted. It looked to be in pretty good shape, but had a 3-phase motor without a handy power source where I bought it. So other than spinning the spindle by hand I couldn't really judge the condition of the rotating parts.

Flash forward a month during which time I cleaned up and painted the mill and did a few obvious minor repairs. After giving up on finding a good cheap VFD, I got a new single phase 3/4 hp 56C frame motor on Ebay for $25 (that morphed into ~$70 by the time I got it shipped to me and got a proper base welded on). I spent a little bit of time figuring out how to adapt the 3 phase switch to a single phase motor (another write-up) and then finally fired up the mill in late November. While quiet at 180 rpm, it got steadily louder as I increased speed, getting pretty unpleasant by 1900 and sounding like a freight train clattering through my shop at the 3250 rpm full speed.

So I took off the belts, spun the spindle pulley by hand again and now noticed some roughness in the rotation. Either I hadn't observed this carefully during my initial inspection or else just my few second of running the machine at high speed had dislodged some old crap inside the spindle. Regardless, it was clear that I needed to take the head apart and at least look at the spindle bearings.

Fortunately, I 'd been reading the Clausing group on Yahoo and was inspired by Dennis Pantazis' write-up of his own head rebuilding experiences. I had no experience whatsoever in machine tool rebuilding, but I'd been a gearhead for many years and had engines and trannies (and their various parts) out of my cars many times and figured that it didn't look all that hard. Ultimately, in fact, it wasn't all that hard. But there were several problems I encountered during the process that were outside my experience and not described in Dennis' text. I spent several weeks bothering many folks on the Clausing group trying to figure out how to proceed through these problems and wanted to summarize what I found out so that others might have an easier time of it.

Step by step Illustrated Guide:

This is a more detailed version of Dennis Pantazis' write-up on 8520 head rebuilding. It will be redundant for experienced machinists, but it may save some time for other hobbyists as clueless as I .

Note: All parts names will be as given in the Clausing Head Assembly Diagram from the 8520 manual and will be identified by their part number.

Required Tools:

1. Set of Allen wrenches (3/32" to 3/16")
2. Flat blade screwdrivers (large and small)
3. 2 or 3 jaw puller (can be gotten for $10 - $20 from your local auto parts store)
4. Snap ring pliers
5. Adjustable pin spanner wrench with 1/8" pins (these can be bought from tool supply houses, but most local stores seem to only have the kind with the more common 4 mm pins. I bought one of the 4 mm

kind and modified it. Or you can just build one from scratch as Dennis Pantazis describes in his write-up)

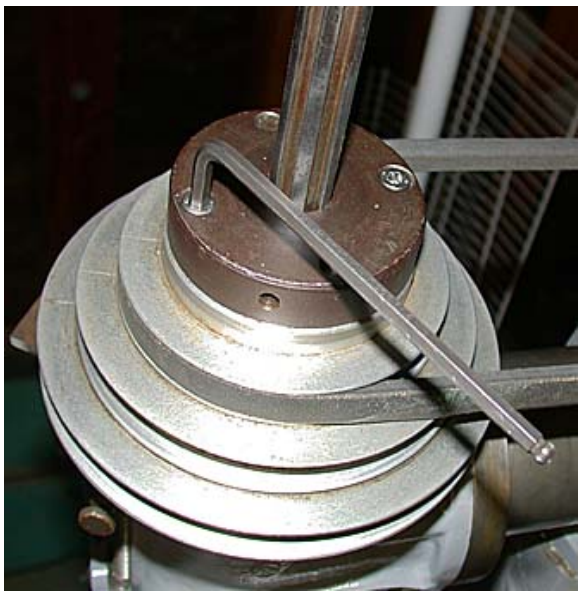
6. Hammer (any will do, I used a 10 lb. sledge)
7. Bench vise
8. Some 2x4's
9. Plenty of clean rags.

Part I: Spindle and Bearing Removal

These first few tasks were easiest for me with the head in its standard vertical orientation.

1. Remove drive belt from front pulley (560-009).
2. Remove drawbar from spindle.
3. Unscrew 4 screws attaching head guard (342-020) to head housing (386-020) and remove guard by slowly sliding forward. You can remove the brake shaft and handle (8520-15) first if you wish, but letting brake handle and brake band rotate, I was able to slide the guard off with the brake handle attached.

4. Use an Allen wrench to remove the two 1/4-20 cap screws from the drive plate (556-020) and a small flat blade screwdriver to loosen the two setscrews on the sides of the drive plate. Don't completely remove these setscrews as they hold in tiny springs that can be hard to find after they fall out. Now slide the drive plate up and off the splined shaft. My drive plate came off easily enough without binding anywhere, but if your splines have been damaged it may stick. (Note that the belt is still on in these two pictures only because I went back to take them after finishing the job)

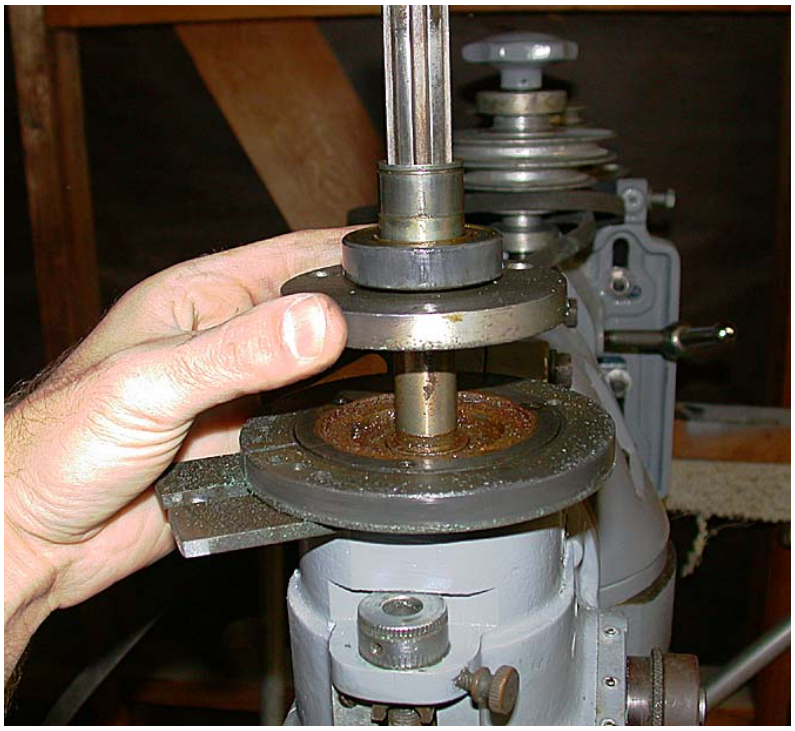


5. Use snap ring pliers to remove the retainer (641-011) from the collar on top of the pulley (560-009). This can be done with ordinary needle nose pliers but is much, much easier with the right tool - available for <$5 from your local discount tool store.

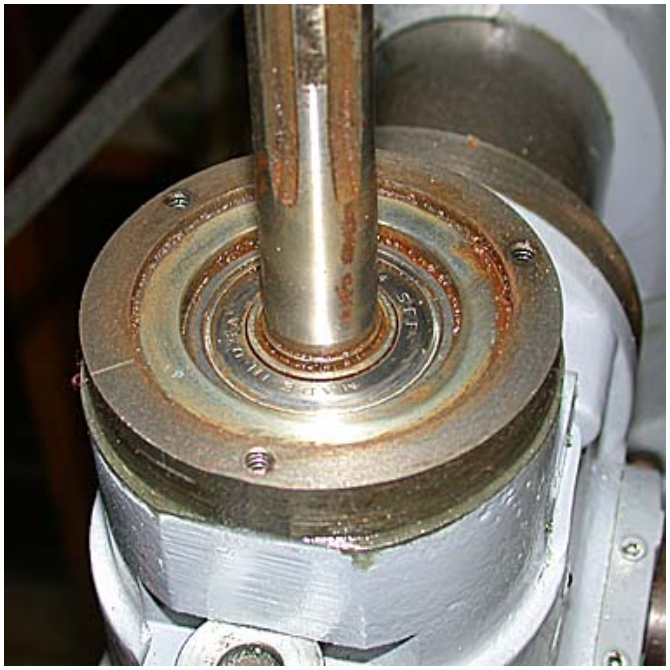

6. Use puller to remove pulley (560-009) from the spindle. You are sliding the inner hub of the pulley off of a bearing (044-007) and it should come off pretty easily. I tried Dennis' trick of using a hammer for this job and didn't have much luck. A puller provides steady centered for and worked much better for me.

7. Use an Allen wrench to remove the three cap screws from the pulley sleeve assembly (990-061), and lift it off the spindle. The pulley sleeve assembly has a bearing attached to its shaft that I never

removed, as it was still in good condition.

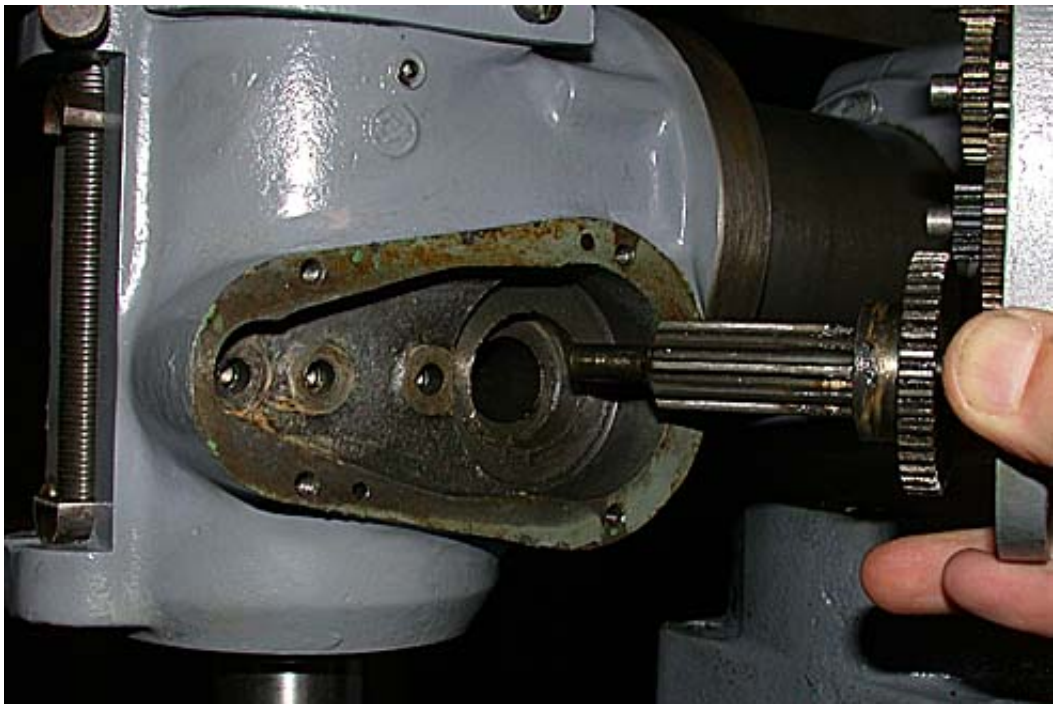


8. Remove brake band (which Clausing cryptically refers to as Plate Assembly (8520-10). It should lift off freely from the head housing.



Now the top spindle bearing (044-016) should be visible in the top of the quill (631-003). At this point you have two choices. You can either remove the quill from the head housing and work on it separately from the mill, or you can leave it in. Since I don't have any good methods of holding large pieces without marring them in my shop, I chose to leave the quill in the head housing.

9. Since you are now likely to subject the quill to some healthy forces, it's a good idea to remove the vertical feed assembly (the four gears and two knobs attached to housing (386-009) in the head diagram).



10. Rotate the head on the ram about 90 degrees and tighten it back down. This is to get easier access to the bottom of the quill.
11. If necessary build an adjustable pin spanner with 1/8" pins. I did this by taking a store bought adjustable pin spanner with 4 mm pins, drilling a 1/8" hole in each arm near the pins and inserting 1/8" drill bits. The base of the bits sticking out the back side of the wrench now served as the pins of an 1/8" pin spanner.
12. Put the pins of the pin spanner wrench in the two holes in the retainer (641-008) in the bottom of the quill surrounding the nose of the spindle. Find and remove any retaining pins or setscrews near the bottom of the quill and then unscrew the retainer.

I had no pins or setscrews holding in this retainer in my 1968 era 8520 while Dennis Pantazis did in his 1955 machine. You will need to check yours carefully to be sure. It required a lot of force initially to unscrew my retainer (probably 100-150 lbs. applied by hand to the end of the pin spanner wrench). Be very careful that the arms of the pin spanner are flush with the face or the retainer. I was not and broke one off in the retainer hole. I was able to drill this out, repeat with the pin spanner set properly and get the retainer out, but not before trashing the face of the retainer enough that I chose to replace it. This is a $50 part from Clausing, so don't make this mistake.

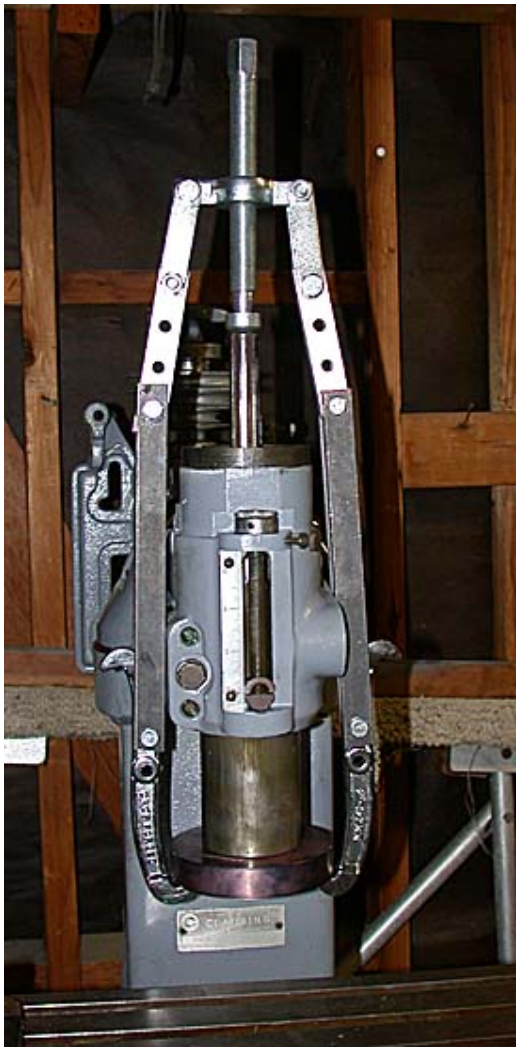
With the retainer out you will be looking into the quill at the bottom of the spindle bearing. The only

thing now holding the spindle in the quill is friction between the quill and the outer races of the lower spindle bearings and between the spindle and the inner race of the upper spindle bearings. The upper and lower bearings both sit in slightly larger sections of the quill. So the lower bearings can only go out through the bottom of the quill and the upper bearing only through the top.

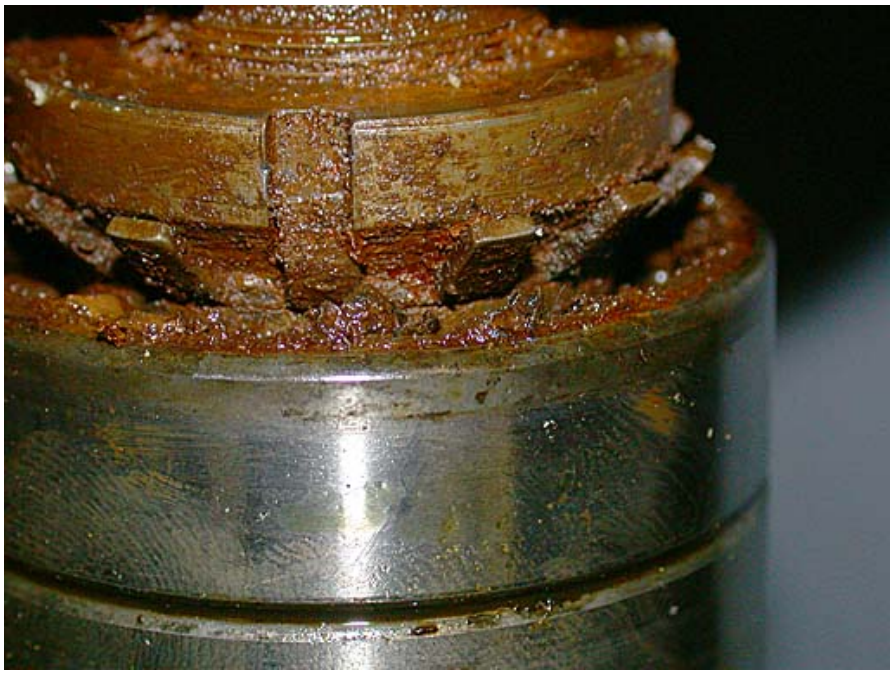
What we now need to do is press the spindle along with the lower bearings out the bottom of the quill. The top spindle bearing will remain with the quill. This was the most difficult step in the whole process for me. Taking some good shots on the top of the spindle with the sledge hammer didn't budge the spindle in the quill. A better approach (both easier and less likely to damage the spindle) is to use a puller. The problem is that the puller must press on the bottom of the quill and the top of spindle to force the spindle out. These two points are nearly 15" apart and store bought pullers (of any reasonable price) don't have nearly this reach. So you'll need to build one. I chose to modify my $10 auto parts store puller by mounting extenders on the puller jaws as shown below. In my case a 6" length of 1/2" x 3/4" Al bar stock (sawed into two 3" lengths), a 3' x 1/4" length of steel bar stock (sawed into four 7.5" lengths) and a few miscellaneous 1/4-20 nuts and bolts provided the need extension.

The following steps can be performed in any head orientation, or even with the quill removed from the head, but I found them easiest with the quill in the head and the head in its standard vertical orientation.

13. Set up the extended puller with one end on the top of the spindle and the other on the base of the quill. If doing this with the quill inside the head, slide the quill to the top of its travel and tighten the quill locknut securely. Place a 2x4 on the table immediately below the spindle, so if the spindle shoots out the bottom it won't damage either the table or the spindle nose. Crank on the puller until the spindle comes out the bottom of the quill. This required significant force on my mill - about 50-75 lbs. on the wrench turning the top of the puller, which corresponds to 1-2 tons down the spindle axis. When the spindle finally let go, it was with a very loud crack or thunk and jumped down about half an inch. Thereafter substantially less force on the puller was required to slide the bottom spindle all the way out. Rotate the head again to remove the loose spindle without having to crank your table way down.



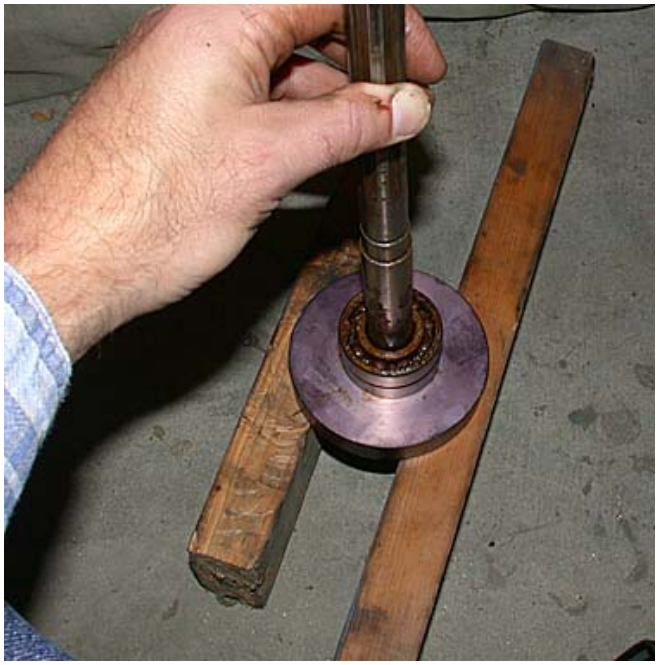
Now we get to inspect the mess that is our spindle. If yours is anything like mine you'll find decades old grease on everything and even some rust on the surface of the shaft between the upper and lower bearings. We'll clean this up later.



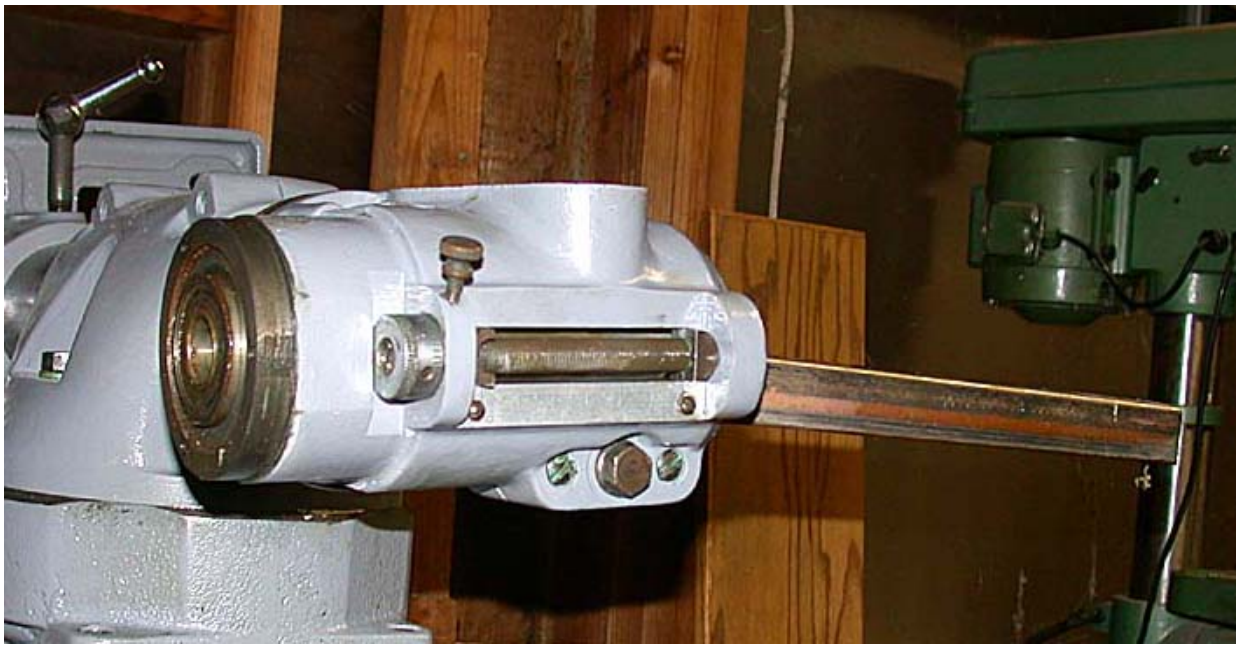
14. Look closely at the star washer (932-011) and retaining nut (537-020) holding the lower bearings on the spindle. Note that one of the star washer tabs is pressed into a notch in the retaining nut. Take a small flat blade screwdriver and pry this tab clear of the notch. The retaining nut can now be unscrewed from the spindle.
15. The retaining nut (537-020) is likely to be on pretty tight. To unscrew it, it is necessary to hold the rest of the spindle securely. I did this by screwing the drive plate (556-020) back onto the head housing and passing the splined shaft of the spindle up through the quill and ito the drive plate. I then held the drive plate with a big wrench in my left hand. Once the spindle is kept from rotating, use your other hand on the pin spanner in two opposing notches of the retaining nut to unscrew it from the spindle. If you get one of the common pin spanners with 4 mm pins you will find that the stock pins

fit perfectly in the retaining nut notches. You can now remove the retaining nut and star washer.

16. Place the spindle nose between two 2x4's with the bottom surface of the bottom bearing resting on both wood blocks. Raise the blocks enough so that the spindle nose is at least a couple of inches above the work surface then place a rag or a thin wood board immediately below the spindle nose. This way you'll have room to drive the spindle all the way through the bearings and won't damage the spindle nose when you do so. A few raps of the sledge hammer on the top of the spindle will now force the lower bearings (044-005) up off the spindle. I'm sort of a stickler for applying balanced forces, so I found an Al plate with a 2" hole bored in it, placed it between the 2x4's and the spindle with the nose in the 2" hole. The whole diameter of the lower bearing now rested on the Al plate and it was very easy to drive the spindle through the hole leaving the lower bearings behind.



17. Finally you can now pound the upper spindle bearing (044-016) out of the quill. I rotated the head to horizontal again and found a 2' steel pipe I could stick through the quill to touch the bottom of the upper bearing. A few shots on the other end of the pipe with the sledge hammer will drive out the bearing. Be careful when doing this that you don't mar the inner bearing surfaces of the quill.



That's it for the disassembly.

Now everything's out and you can assess how much you want to replace. I chose to replace the upper and lower spindle bearings (044-016) and (044-005), but keep the pulley bearings (044-007) which still seemed fine. In addition I chose to replace the retainer plate (641-008) and oil seal (708-001) from the bottom of the quill. Finally, my mill like Dennis Pantazis' was missing the spacer (699-153) that goes between the star washer and lower spindle bearings.

Ordering all this from Clausing would cost about $300 - including a whopping $100 each for the two lower spindle bearings. Nevertheless I tried ordering everything from Clausing service, both because I wasn't confident about finding proper subsitute parts and since I'd like to at least somewhat support a service center good enough to continue supporting a machine they haven't manufactured in 30 years. As it turned out Clausing were almost out of stock and only sent me one of what should have been a matched pair of lower spindle bearings. Rather than wait upwards of a month for its mate, I used the information on the single unmatched Clausing bearing to obtain an appropriate matched pair of bearings from a local bearing supplier. I returned the single unmatched bearing to Clausing (but even without it, still ordered $100 in parts from them so I don't feel too guilty).

For what it's worth Clausing sent me a Fafnir 7205 WN bearing. The bearing supply house sold me a pair of SKF 7205 BYG's, and I've heard from others on the Clausing list that they received a matched pair of 7205 WN-SU's when they did their head rebuild. So I gather there's some small freedom to choose among the 7205 series matched angular contact bearings, but I'd still get the advice of a bearing professional in choosing replacements. These are what the new bearings looked like (rear on the left, face on the right).

Part II: Cleaning

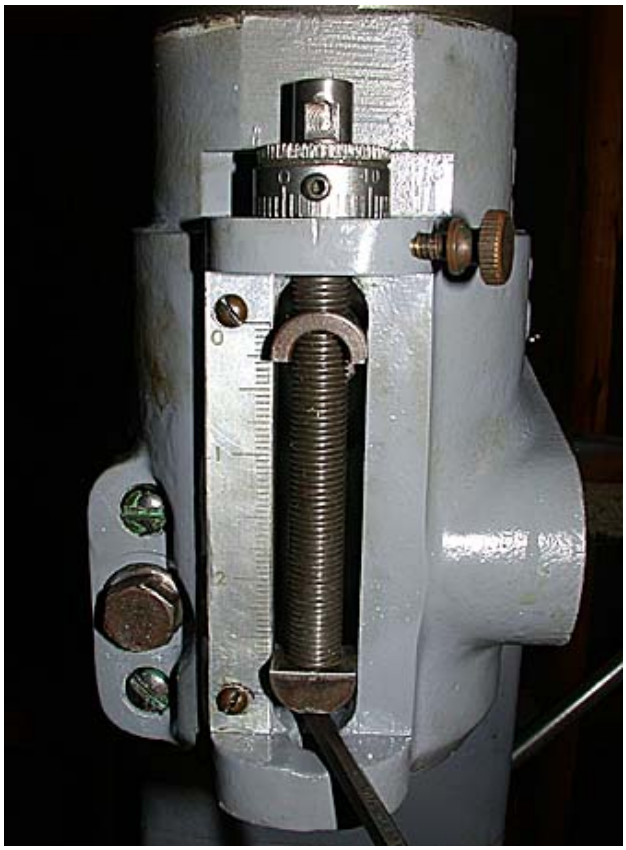
While waiting for Clausing to send parts is a good time to clean up the innards of your mill. As you can see I found corrosion on the surface of the spindle as well as on the inner surface of the quill. Fortunately the critical bearing surfaces of the quill and spindle were protected by bearings and were pristine. The splines, though discolored, were also clean. The remainder of the spindle shaft surface is largely cosmetic (i.e. not a precision surface) so one can more aggressive with its cleaning.

The cleaning steps I took were:

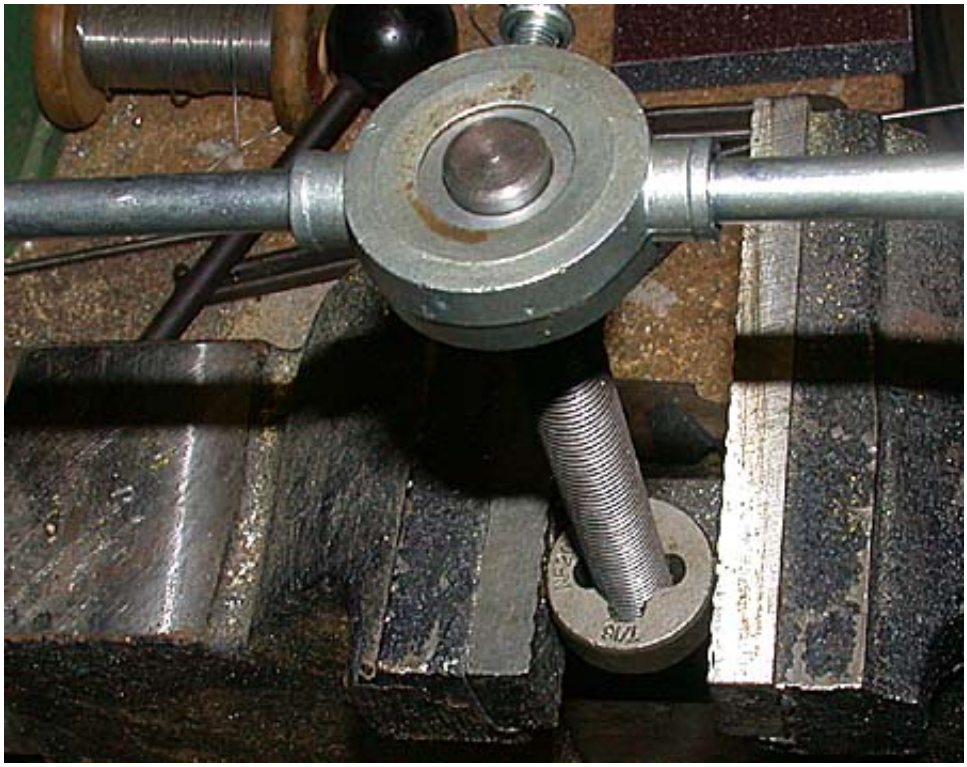
1. First put the retaining nut back on the spindle just to the top of the threads. This protects the delicate threads and bearing surfaces from any aggressive cleaning measures taken on the rest of the spindle.
2. Spray with WD-40 and rub with scotchbrite pads on the dirty and mildly corroded portions of the spindle. I used scotchbrite on the splines, but gently and only along the axis of the splines. Scotchbrite will take off material (but not much) and this seemed an appropriate level of cleaning for the splines. Keep scotchbrite and any other abrasive AWAY from the bearing surfaces. Several repeated applications of WD-40, scotchbrite and cleaning rags got the upper portion of the spindle pretty clean, but the region between the upper and lower bearings - which probably hadn't seen the light of day in 35 years - had more than just light surface corrosion. Scotchbrite and even hand sanding would have taken days in these areas, so I ended up cleaning them up using a wire wheel mounted on my hand drill. The result was a clean spindle shaft with some regions between the bearing surfaces now visibly, but not deeply, pitted. I didn't remove nearly enough material to affect the structural strength or balance of the spindle and this part of the spindle is completely sealed away from view, so this seemed like a reasonable level of thoroughness.
3. Now remove the retainer nut from the spindle and clean the nut, star washer and remainder of spindle with WD-40 and clean rags. I still avoided the bearing surfaces of the spindle, but did clean off the relatively delicate spindle threads this way. Make sure to carefully inspect the threads for any left over bits of your rags when you are done as you really want to avoid future contamination of the spindle bearings.

After doing this clean up and still waiting for parts, I decided to clean up the quill down feed limiter assembly. (A big thanks to Rich Dean for letting me know how to do this). The upper stop nut (709-001)

had always rattled a bit and this seemed like a good excuse to get to it. Even with the setscrew removed from the fine adjustment dial (233-001) I'd never been able to get the main adjustment screw (696-007) out. With Rich's encouragement I got the screw out by inserting a large flat blade screwdriver between the bottom half-moon nut (537-013) and the bottom of the housing where the base of the adjustment screw sits.



When the adjustment dial setscrew is removed, prying on the screwdriver forces the main adjustment screw up through the top of the dial. Once it has slid the first few mm it should slide the rest of the way freely by hand. The half-moon nut can then be unscrewed and the main screw pulled out the top. Rich told me that the reason it was so hard to get the screw out through the dial is that a small burr tends to form at the top of the screw shaft. Once I had the screw out I lightly filed down this burr and sanded the upper shaft smooth again. Then, just for completeness, ran the screw through a 7/16-20 die to clean up the threads - just like new.



With the adjustment screw and half moon nut out, what's left behind is the upper stop nut (709-001) that holds the quill in the head housing. Just for fun I removed the nut and pulled the quill out of the head. This made it easier to get to the inner surface of the quill for some additional spot cleaning. Again, being very careful not to mar the upper and lower bearing surfaces at the top and bottom of the quill, I reached deep inside the quill with some small sanding pads and cleaned off a little bit of corrosion that had formed near the threaded bolt hole. When done I carefully wiped the inside of the quill with a clean rag to prevent any contaminants from getting to the bearings.

With everything cleaned up and our parts now arrived from Clausing (and the local bearing supply house, we're ready to put everything back together.

Part III: Reassembly.

1. The first thing to do is replace the oil seal (708-001) in the screw-on retainer plate (641-008). In general you'll need to pull the old oil seal out first. I so munch my old retainer plate in the removal process that I bought a new one didn't have to bother with this step - but I paid for the privilege. In any case, place the flat side of the new oil seal in the retainer plate as evenly as you can. It will only go in a little ways by hand. Sandwich the retainer plate and seal between two metal plates (I used some handy 1/4 thick Aluminum I had lying around) and put the sandwich in your bench vise. Compress until the oil seal is completely inside the retainer. This required relatively little force. Put the retainer aside in a clean place until step 5.

2. Next we must grease the lower spindle bearings. Some sources have told me that just completely filling the bearings with grease is OK, but another source claimed that after doing so his bearings overheated and he had to re-do the job only filling 30-40% of the bearings. I then another reference stating the manufacturers typically recommend that 50-55% of the bearing should be greased. What I gleaned from all of this was to grease about half of the bearing. After doing so, the rotation of the bearing will spread the grease evenly to the rest of the bearing.

   Not knowing anything about greasing bearings I found an excellent write-up from Forrest Addy on the Home Shop Machinist forum. To paraphrase him: Wash your hands first and set up a clean work

area. Place a sausage shaped blob of grease in the palm of your subordinate hand and grab the bearing in your dominant hand. Force the face of bearing across the palm of your hand through grease and into the base of your thumb. This will force the grease through the bearing. Repeat until grease starts to squeeze through the back side of the bearing (this took two blobs of grease per bearing for me).

I followed this advice and after greasing about 50% of each of the two 7205 spindle bearings I used a clean rag to wipe off any excess grease that had gotten onto the inner or outer diameters of the bearings. I then spun the inner races of each by hand to spread the grease around the whole circumference. The picture below shows one of the bearings 50% greased before I spun the bearing around to distribute the grease.

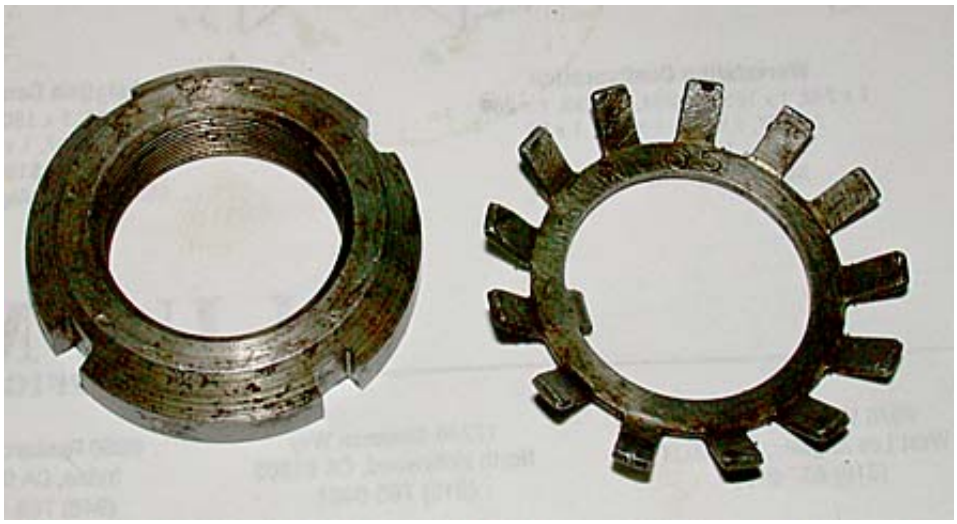
I got several different answers regarding what grease to use for the lower spindle bearings. Since everyone seemed to have a different opinion, I just went to the local machinery supply house and asked what they used. They gave me a red Lithium grease from LMX (NLGI grade 2), but I suspect a whole lot of greases of this grade would work.

Now to press the bearings on the spindle. The bearings need to be installed back to back on the

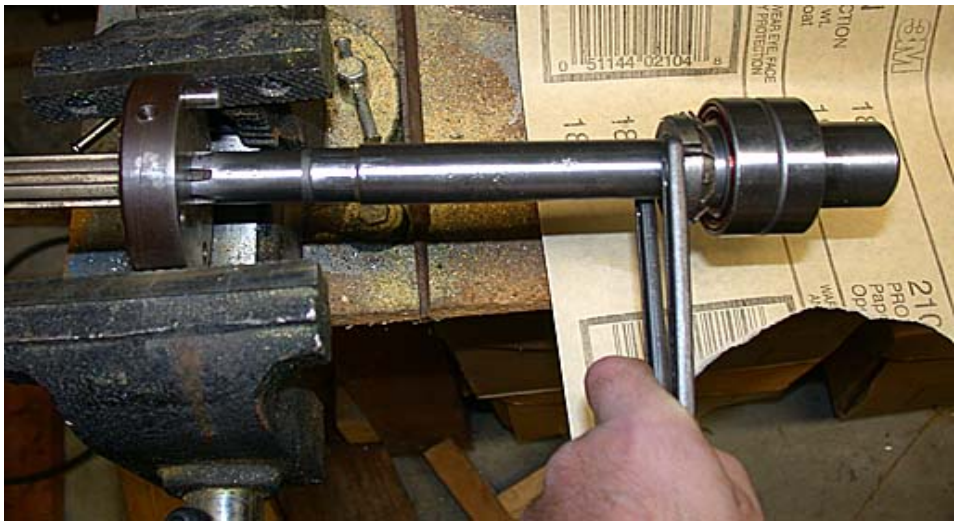
spindle to get the proper preload. Dennis Pantazis has a nice description of this in his write-up. Embarrassingly enough it took me a while to figure out which side of the bearing was the front and which the back. Once you realize that the inner bearing races need to load against each other in the back to back orientation, though, it becomes clear; the face of the bearing is the "open" side with the individual balls visible.

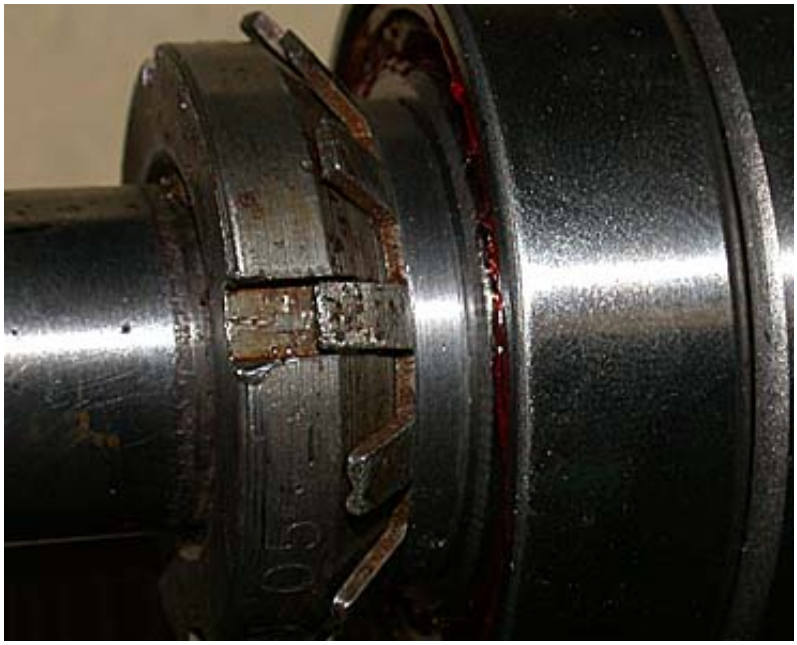
3. Start the first bearing on the spindle with its face pointed down toward the nose. Follow this bearing with the spacer (699-153). Clausing and the bearing manufacturers insist that force be applied only to the inner bearing race. By pressing on the spacer we ensure this is so. I used the puller (in its original unextended configuration) for this, but put an aluminum plate with a 1.1" hole bored in it on the spindle after the spacer to even out the loads. Only moderate force on the puller was required to seat the bearing (lots less than it took to get the spindle out).

4. Pull the Al plate and spacer off the spindle and start the second bearing on the spindle with the face pointed up toward the splines. Put the spacer, Al plate and puller back on and seat both bearing almost all the way onto the spindle shaft. Pull the Al plate off and slide the star washer (932-011) and retaining nut (537-020) back on the spindle.



Screw the retaining nut down hand tight. Now hold the spindle securely and use the pin spanner wrench to tighten the retaining nut all the way down, completely seating the bearings on the spindle and properly preloading them. I again used the drive plate held in the bench vise to hold the spindle splines during this process. When the nut is all tightened, seat one of the star washer tabs into a notch in the retainer nut.

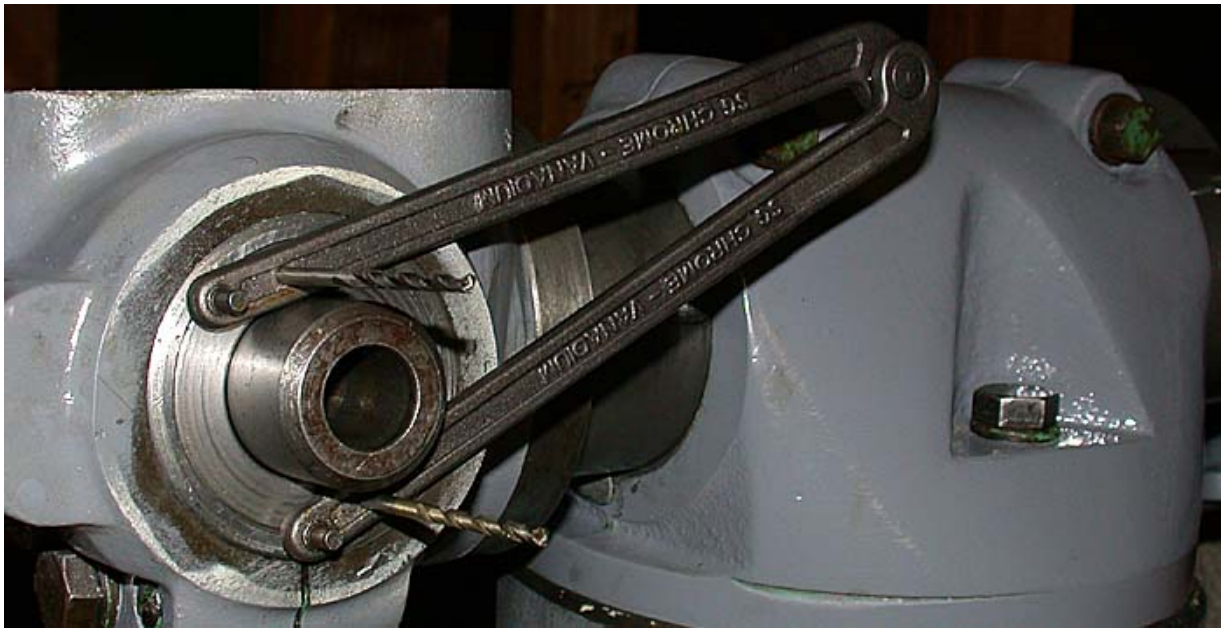




During steps 3 and 4 try to keep the work area as clean as possible as the greased bearings can easily pick up grit leading to premature wear. Also note that it isn't really necessary to put on the bearings one at a time as I did, but was a bit easier for me to keep things from slipping around during setup this way.

5. Make sure one last time that the quill and bearings are clean and then insert the spindle up into the bottom of the quill, seating the lower bearings as far as you can (it won't be far. It's easiest to get clearance to insert the spindle either by rotating the head to horizontal (or else by working with the quill outside of the head altogether). Assuming you're keeping the quill in the head, now rotate the head to vertical while supporting the spindle nose with one hand. Place a 2x4 on the mill table immediately below the spindle nose and crank the vertical table feed up until the 2x4 just touches the spindle nose. Tighten down the quill downfeed locknut and then slowly crank the vertical table feed upward. The bearings will slowly seat in their bore in the quill. I've seen some folks recommend lightly oiling the OD of the spindle bearings to make them slide in smoother. I didn't do this and mine seated in a series of clunking fits and starts, but ended up going smoothly enough.

6. When the spindle has gone far enough up the bore so that some of the threads at the base of the quill are clear of the bottom bearing, start the retainer plate (641-008) in the threads. Turn it using the pin spanner (gain using the 1/8" drill inserts) until it is stopped by the bearing. Don't force it, contact with the bearing will be obvious. Now return to the procedure of step 6 and continue cranking up the table and seating the bearings. Whenever you think you may have fully seated the bearings, try screwing in the retainer and see how far it goes. When you can get it flush with the base of the quill without binding on the lower bearing, everything is seated and you are done. I approached things in this incremental fashion since I couldn't be sure otherwise when I had the bearings all the way in and wanted to avoid gratuitously putting a few tons extra force on the spindle nose just to make sure.



7. Now install the upper spindle bearing (044-016). Slide it down the splined shaft of the spindle into its seat in the top of the quill. It won't go in far by hand. Place the pulley sleeve assembly (990-061) on top of the bearing and lower the quill enough so that the threads of the three screws can be started in the top of the head housing. Tighten the quill downfeed locknut and then tighten the three pulley sleeve assembly screws 1/2 turn at a time in a radial pattern (1,2,3,1,2,3.....). When you've tightened the pulley sleeve assembly all the way down, remove it, raise the quill up and repeat. I found that even with the quill raised all the way I couldn't quite get the upper bearing to fully seat - maybe 1/16" still projected out of the bore. To get this last bit in I put a 1/2" thick by 2" diameter Al plate with a 1.1" hole in its center on top of the bearing and then repeated the procedure with the pulley sleeve assembly. After this the bearing was seated flush with the top of the quill. If an Al spacer plate isn't handy, the old top bearing you're replacing should work.

8. The rest is quick and easy. Remove the pulley sleeve assembly and any spacer you used and reinstall the brake band (Plate Assembly (8520-10)) on the head housing. If you removed the downfeed limiter assembly, remember to reinstall the main adjustment screw (696-007) and fine adjustment dial (233-001) before the brake band goes back on. Put on the pulley sleeve assembly and screw it down firmly. Put the pulley (560-009) on next. I drove it onto its bearing by driving a 2x4 onto its top plate with a few taps of the sledge hammer. The pulley is fully seated when the groove for the snap ring is exposed above the inner diameter of the pulley. Reinstall the snap ring in its groove using the snap ring pliers. Seat the drive plate (556-020) on top of the pulley. Tighten the two Allen head cap screws and the two setscrews. Hook up the drive belts...

And you're done. With any luck your 8520 will now run quiet at all speeds, just like mine.