

# A Quick Evaluation of Surface Finish of Pivots

## by Bob Whiteman

There have always been discussions regarding the effects and methods of polishing pivots. As with a lot of subjects, there are both facts and fiction presented. Since I am not, by any means, skilled in clock repair but have an inquiring mind and had some time on my hands; I decided to just try a few techniques and record the results in photographic format with the hopes of just adding a little more information on the subject.

I guess a quick disclaimer is in order. This effort was not intended to be, or represent any type of scientific study. Nor was it intended to prove that any technique or tool was good or bad. It was performed on samples as described below just so that I could get a rough idea of what finish was left on the pivot after certain operations. These finishes could easily vary when multiple pivots are polished using the same techniques; particularly with the variable skills that operators possess.

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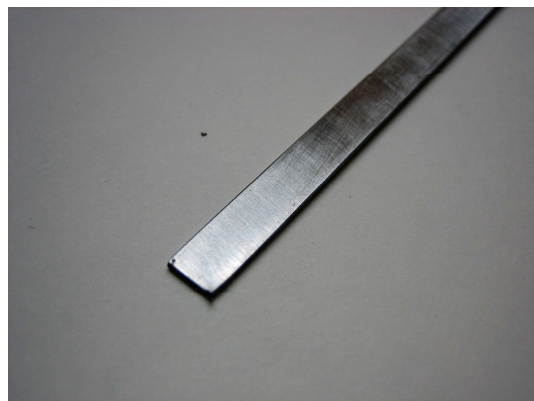
### Sample preparation:

Since I did not have a quantity of pivots with common dimensions and surface finish to start with; samples were made from a short piece of .125" diameter, annealed, O-1 drill rod. Using a very sharp tool bit, a pivot .100" long and .040" (1 mm) diameter was turned on the end of the rod. The combination of the sharp tool and hand feed left a finish that was fairly rough and might represent a 'worn' pivot. I made a total of six samples that all started using this method to keep them as similar as possible. Pictures were not taken of each of the pivots' initial condition so there is no way to know the exact condition of each pivot at the beginning of its respective process. However, sample 1 had no further operations and should be representative of these initial conditions. Each of the other five samples were finished using different techniques as described below with only the end results being photographed. No attempt was made to optimize each technique but more so to complete in similar time and effort.

The burnishing file used was made from an old rectangular needle file with cutting teeth only on the edges. The teeth were removed completely with a simple bench grinder, taking care to keep the edges straight. All burrs were removed after grinding. The top and bottom sides were rubbed sideways across a piece of 320 grit paper to create grooves (barely visible in figures 1 and 2).



**Figure 1**



**Figure 2**

Throughout the remainder of this document I will refer to the samples by number. Each sample has had a different process applied and is described below. Many more could have been done but would have required more time and effort than I wanted to put into this project. I tried to list just enough detail so that it would be clear how these steps were performed and what tools were used.

The samples were created as indicated in the steps below.

**Sample 1:**

- As turned

**Sample 2:**

- Turned
- Filed using a #6 cut Grobet knife needle file (MSC # 60235264)

**Sample 3:**

- Turned
- Filed (same as Sample 2)
- Polished with Cratex™ abrasive stick – X-fine grade

**Sample 4:**

- Turned
- Filed (Same as Sample 2)
- Polished with 320 grit wet/dry silicon carbide paper with oil

**Sample 5:**

- Turned
- Filed (Same as Sample 2)
- Polished with 320 grit wet/dry silicon carbide paper with oil
- Polished with 1000 grit wet/dry silicon carbide paper with oil

**Sample 6:**

- Turned
- Filed (Same as Sample 2)
- Burnished with oil

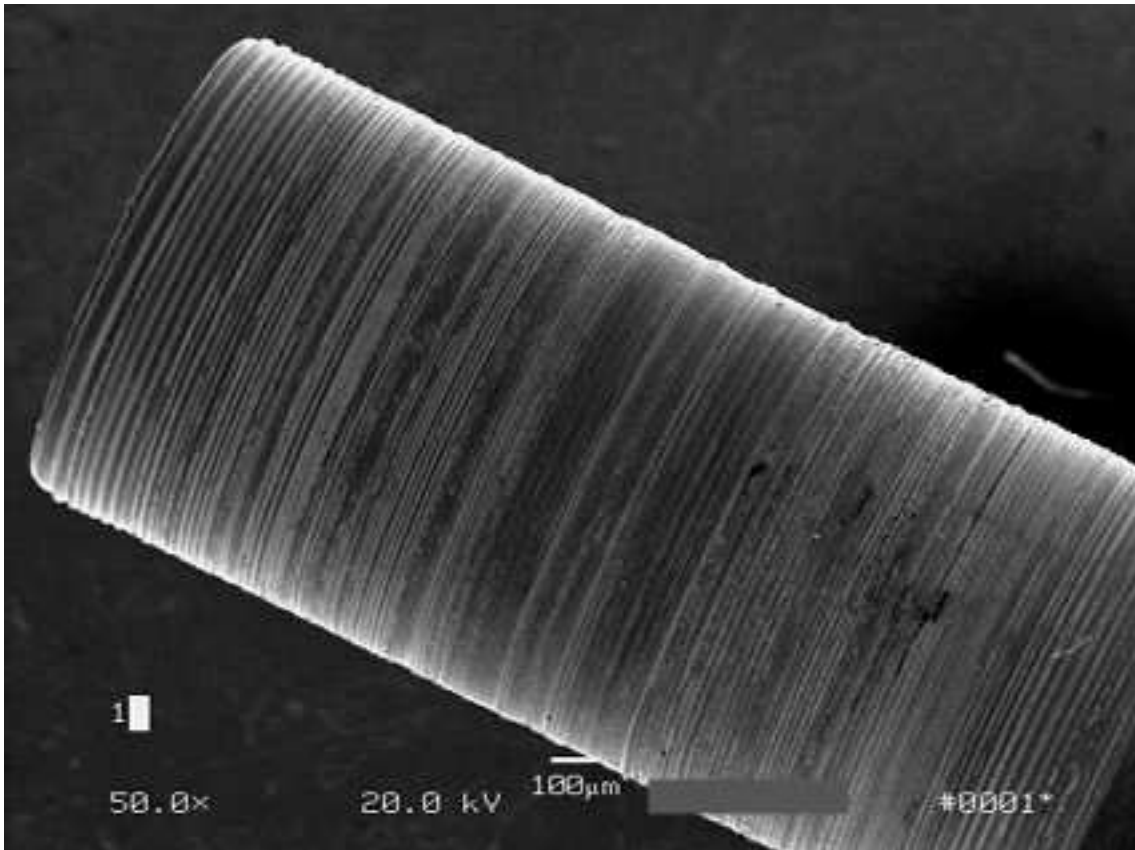
**Picture Descriptions:**

The following section contains the pictures and a brief comment as necessary. The first set of pictures were taken using a digital camera with a microscope attachment. The zoom level was kept at a point where it might be possible to see that some finishes may look good to the naked eye but actually are poor for what might be desired of reconditioned pivots. To best see the surface texture, four pictures of each pivot at increasing levels of magnification and orientation were taken using a Scanning Electron Microscope (SEM). The SEM provides a level of detail that obviously can not be obtained with optical microscopes. I hope that these help provide some knowledge and interest pertaining to pivot polishing. I will let you make your own judgments as to the process you like or dislike. Again, I am not a clock professional and most of you have done more repair work in one day than I have done total.

**Enjoy:**

### Explanation of Pictures:

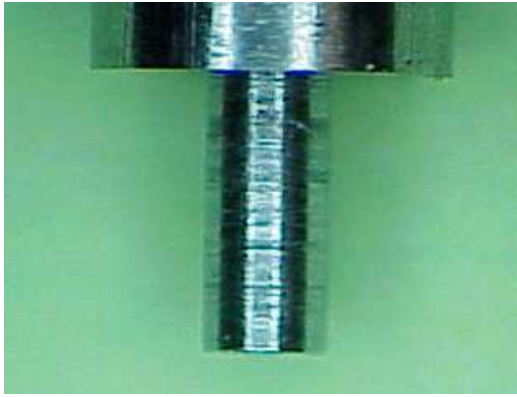
Each SEM picture is marked with the magnification level and a thin white bar indicating the 'scale', similar to what you would see on a road map. The example picture shown in Figure 3 was taken at a 50x magnification level with the scale bar indicating a distance of 100um (.004"). For this picture the short white bar would be the approximate length of the thickness of a sheet of paper. The fourth and last picture of each sample group was taken at a 1,000x magnification level with the scale bar indicating a length of 10um (.0004").



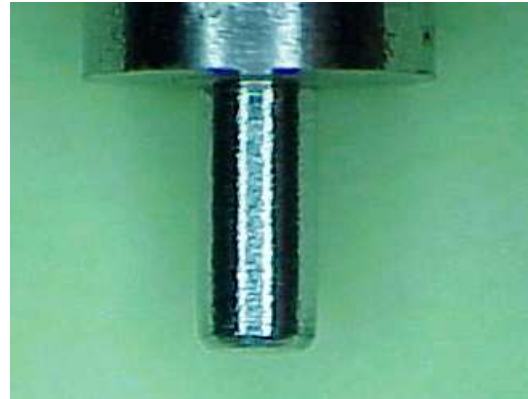
**Figure 3**

Magnification Level  
(50x)

Scale  
(100um)



Sample 1

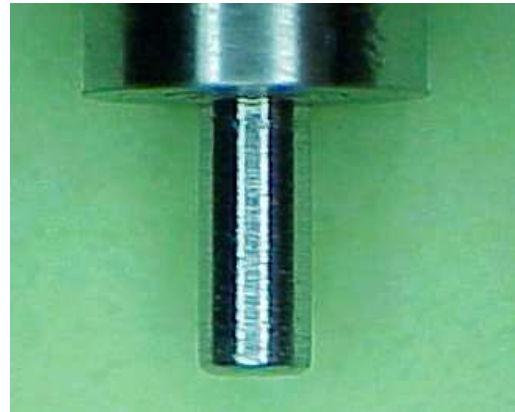


Sample 2

On Sample 1 you can see the scores left by the turning process and those are easily visible with the naked eye. In sample 2 the file has smoothed the surface to the point the pivot may look good without magnification.

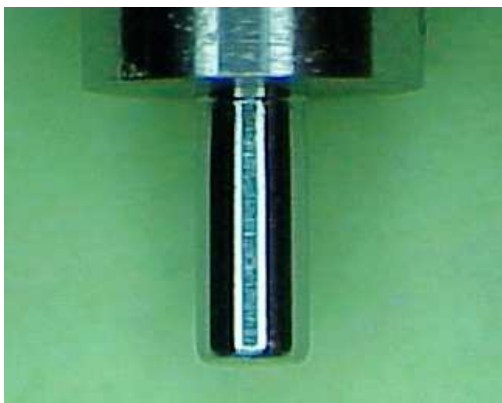


Sample 3

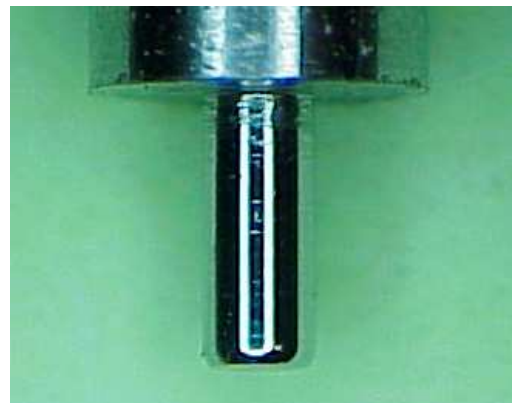


Sample 4

Sample 3, after being polished with the Cratex stick, has a nice shine and would look good to the naked eye, while Sample 4 shows some features left from the sandpaper, but still looks good.

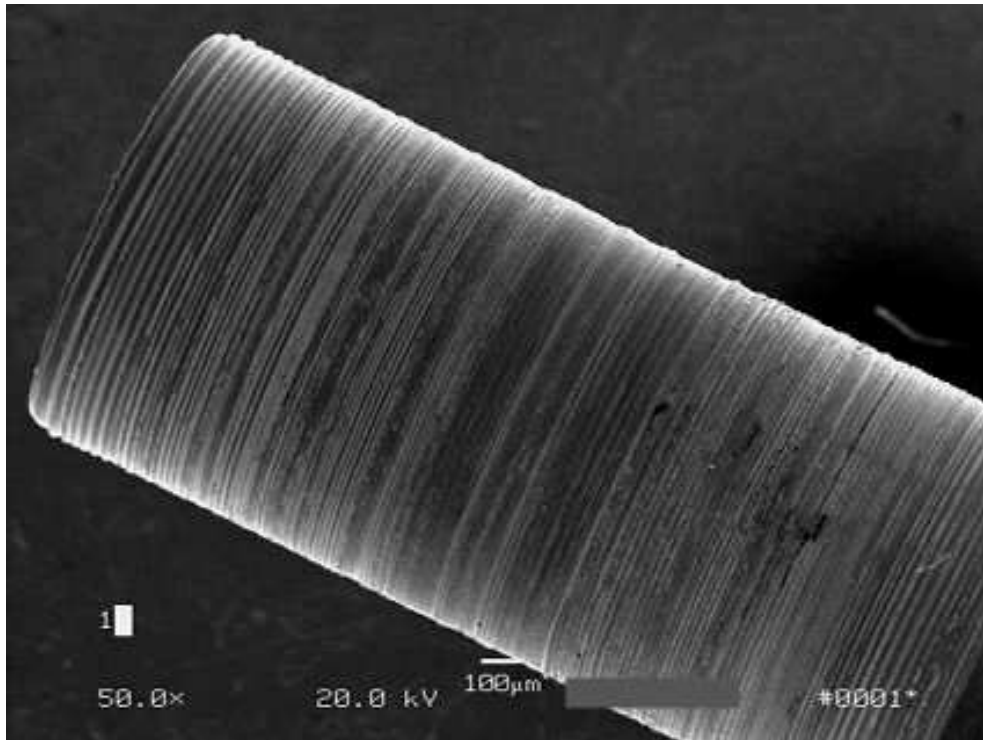


Sample 5

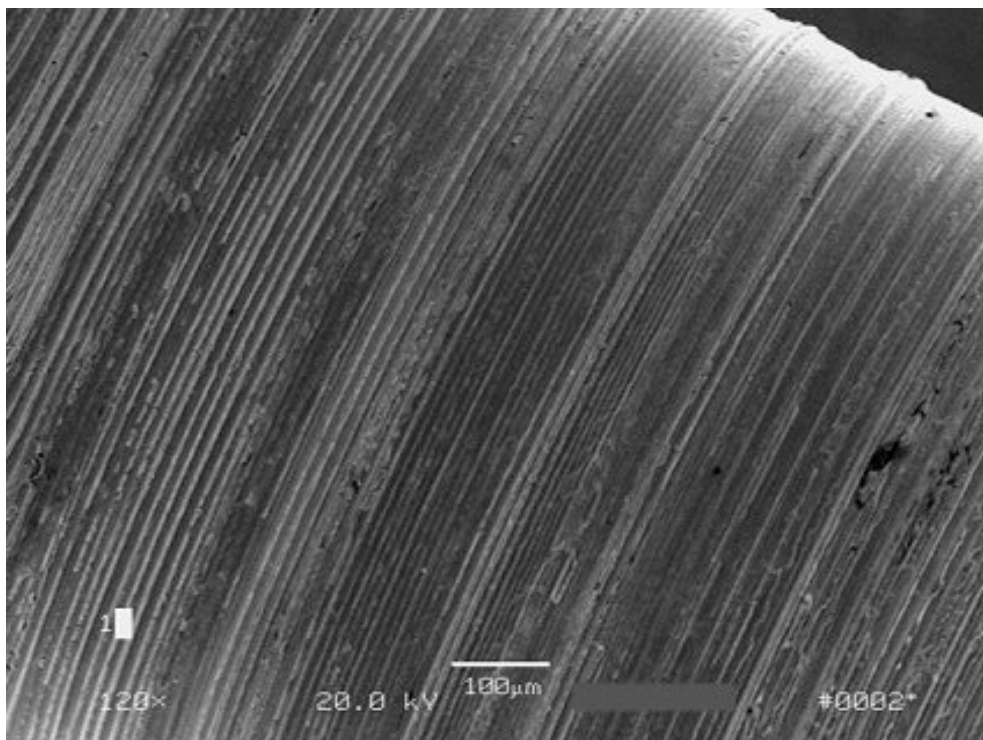


Sample 6

Sample 5 and 6 both look good at this point. The 1000 grit paper has done a pretty good job but SEM photos show the differences. Unfortunately the nice finish makes the photos difficult.

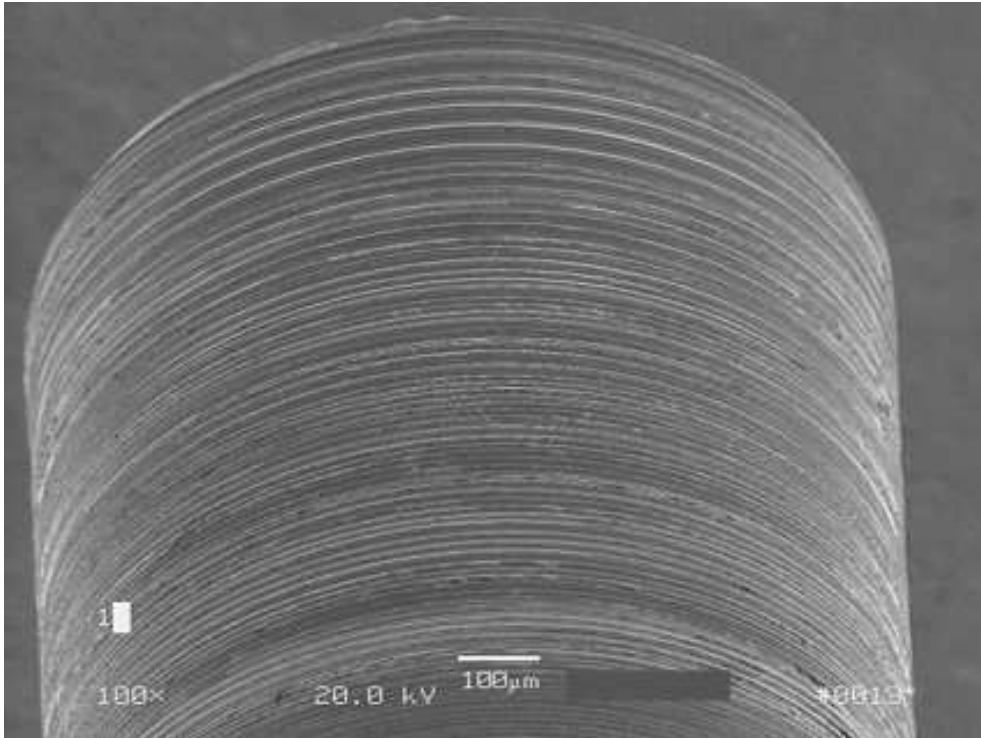


**Figure 10** – Sample 1 @50x

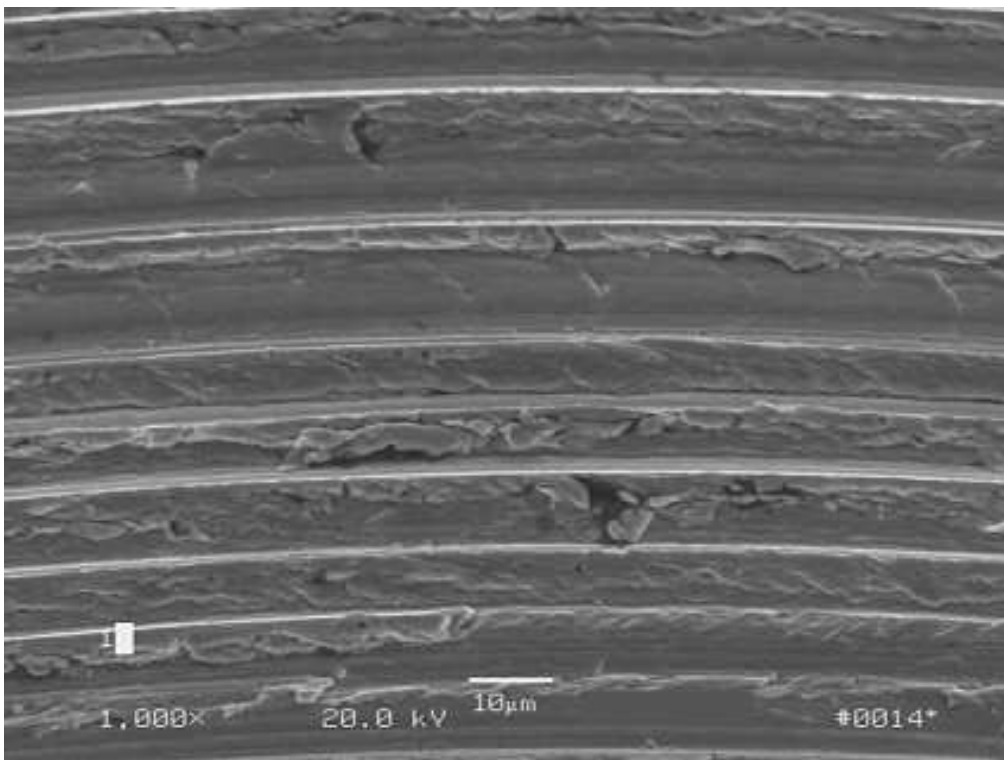


**Figure 11** – Sample 1 @120x

These photos show the surface of sample #1 in the “as turned condition”. This condition would represent the starting surface condition for all other samples. The scores are visible with even the slightest magnification, but the SEM photographs make the surface features very easy to see in great detail. At the lowest magnification, 50x in Fig 10, you can see this would be an extremely poor pivot.

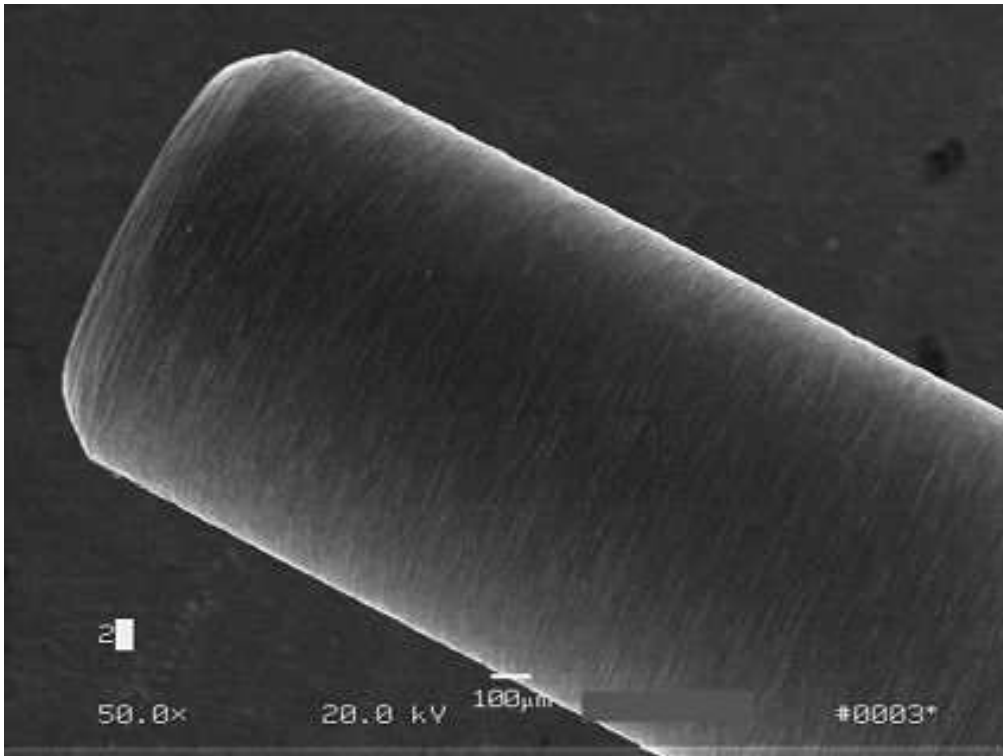


**Figure 12** – Sample 1 @100x

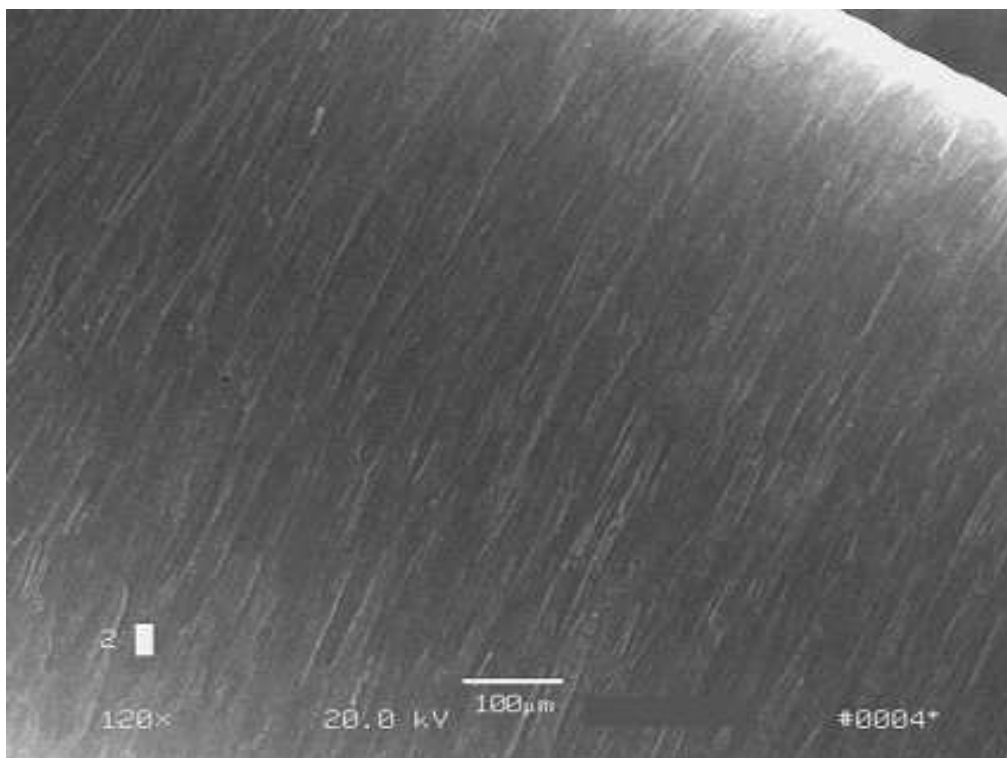


**Figure 13** – Sample 1 @1000x

These two figures are again of sample 1, but at higher magnification and orientation. You will see the surface details that would almost look like the surface of a record (remember those!). As shown at 1000x in figure 13 you can see the grooves created by the cutting tool and the tears and burrs present at the microscopic level. These are what you are trying to eliminate when polishing pivots (and don't forget the holes in the bushings and plates!!)

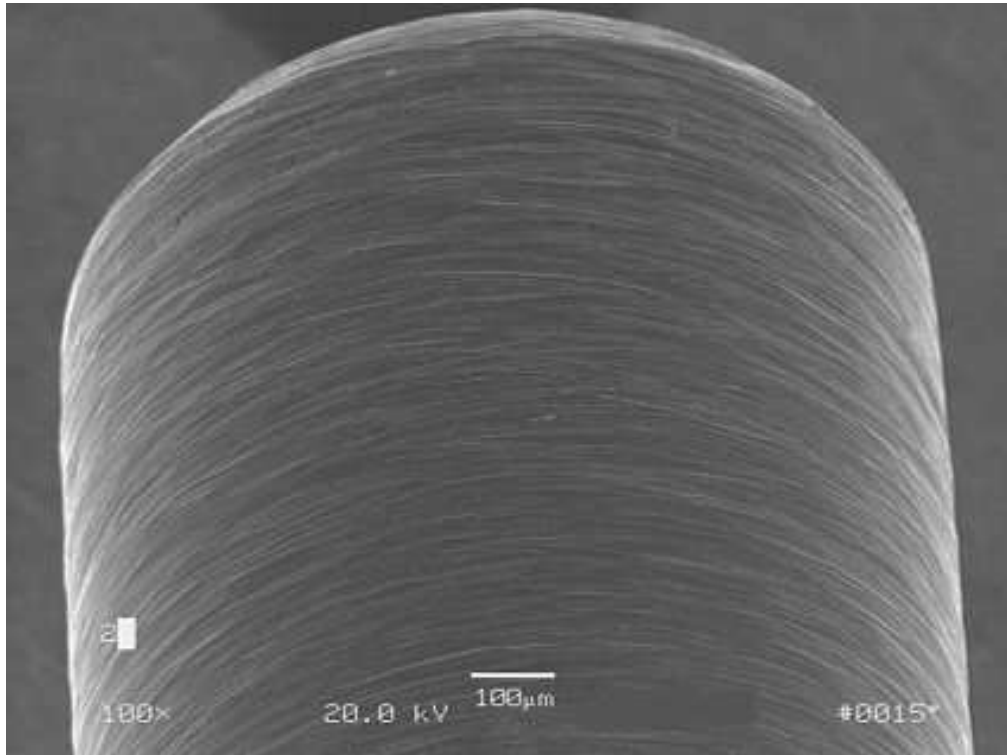


**Figure 14** – SEM Sample 2-1

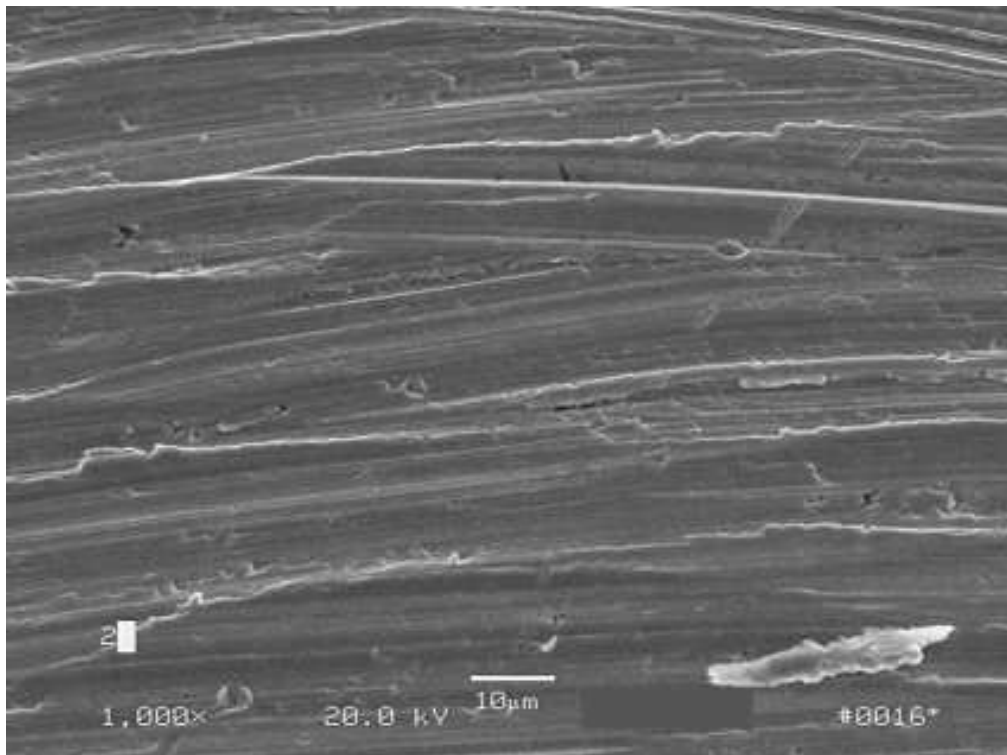


**Figure 15** – SEM Sample 2-2

This sample was filed to remove the majority of the roughness that was present in the initial condition represented by sample #1; and would also be done to restore a pivot to a cylindrical shape. In these SEM photos the surface doesn't look too bad but still leaves a lot to be desired for a workable clock pivot.



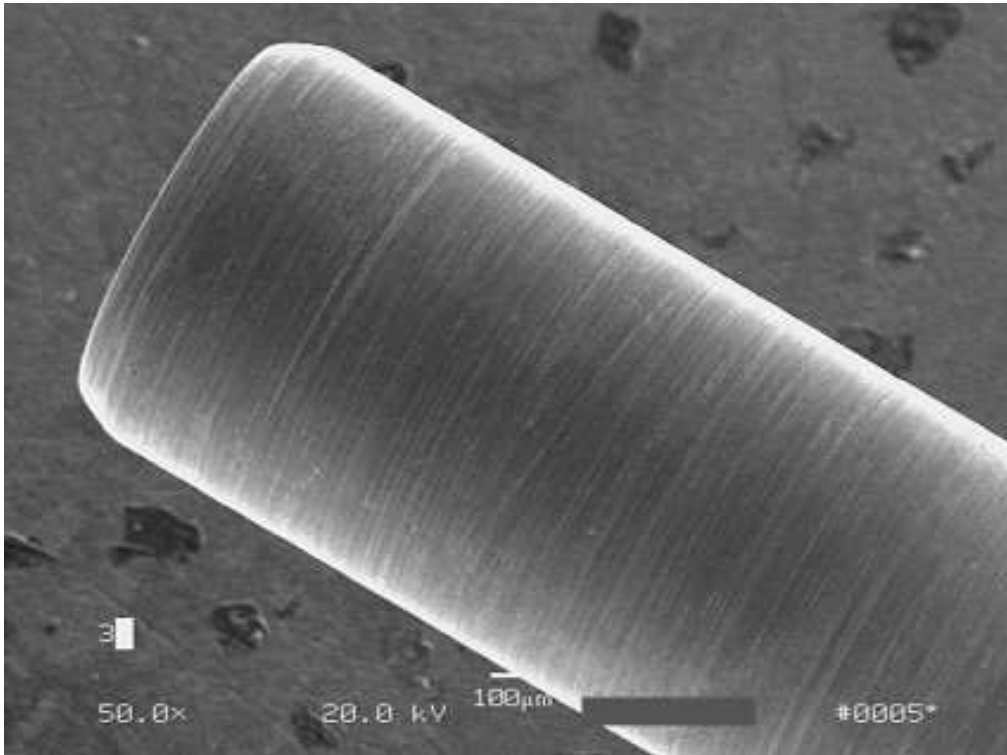
**Figure 16** – SEM Sample 2-3



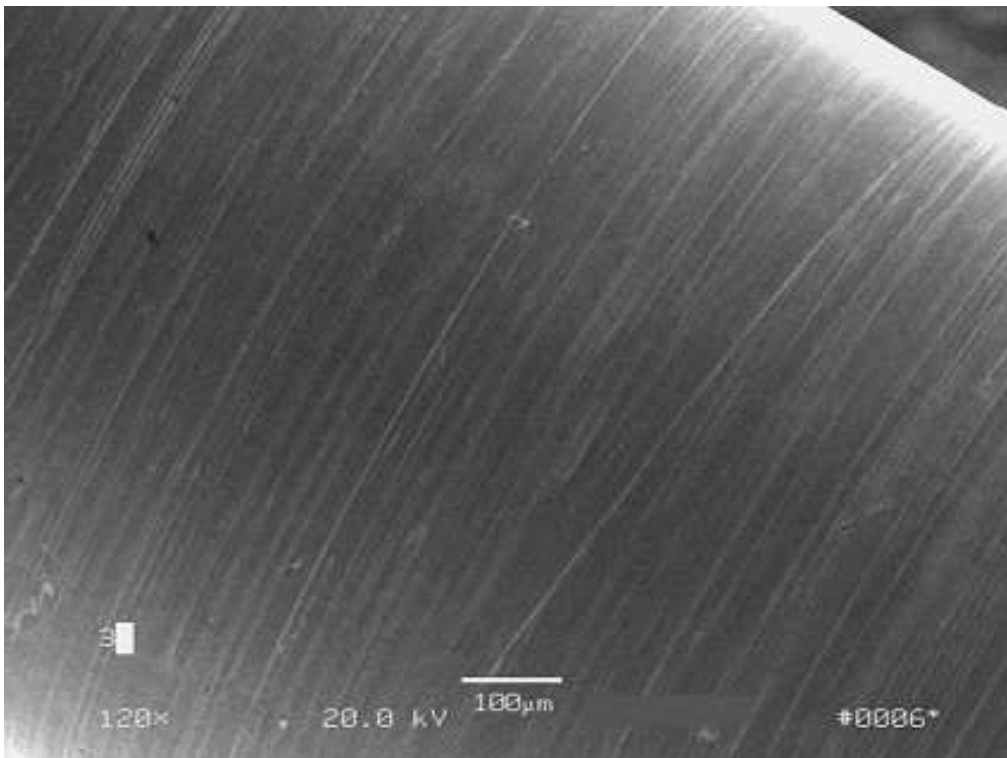
**Figure 17** – SEM Sample 2-4

At the higher magnifications and orientation, it is clear that the pivot is not as good as it first appeared at the lower magnifications. There are still grooves, tears, and burrs left in the surface and the roughness is very bad. You should be able to visibly see with slight magnification that more work is required on this pivot. The remaining samples had all been filed prior to their respective process.



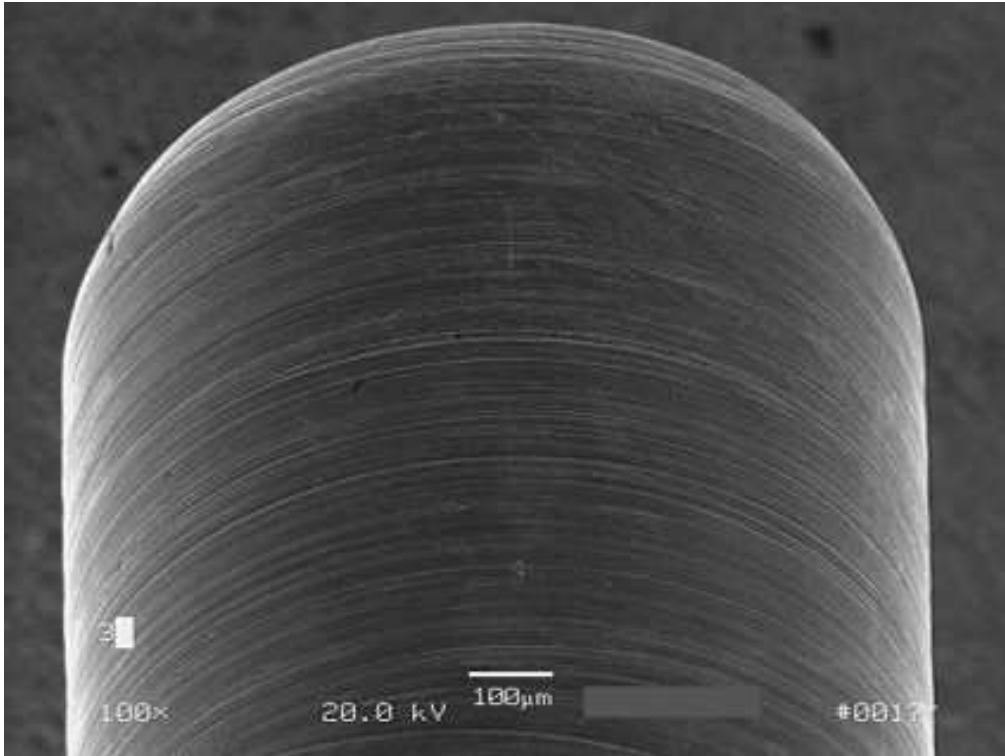


**Figure 18** – SEM Sample 3-1

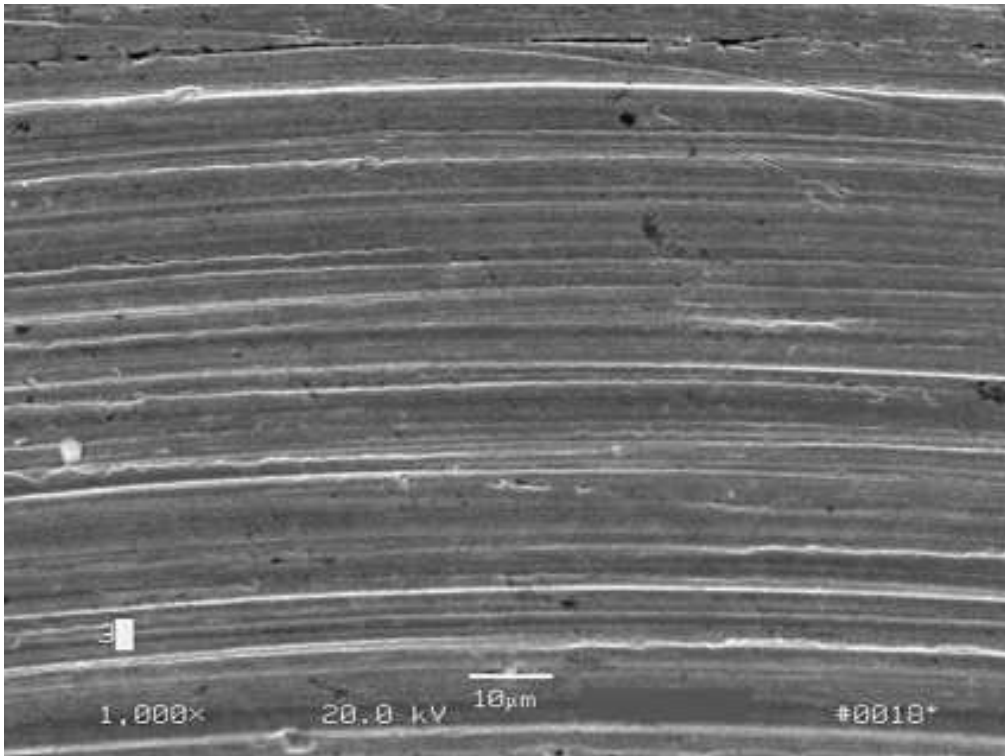


**Figure 19** – SEM Sample 3-2

Sample 3 was the first sample that received a polishing operation. In these pictures the surface finish is starting to look a little better. Some grooves and features are still barely visible. The Cratex stick did tend to break the sharp edges and begin to leave a visually polished surface.

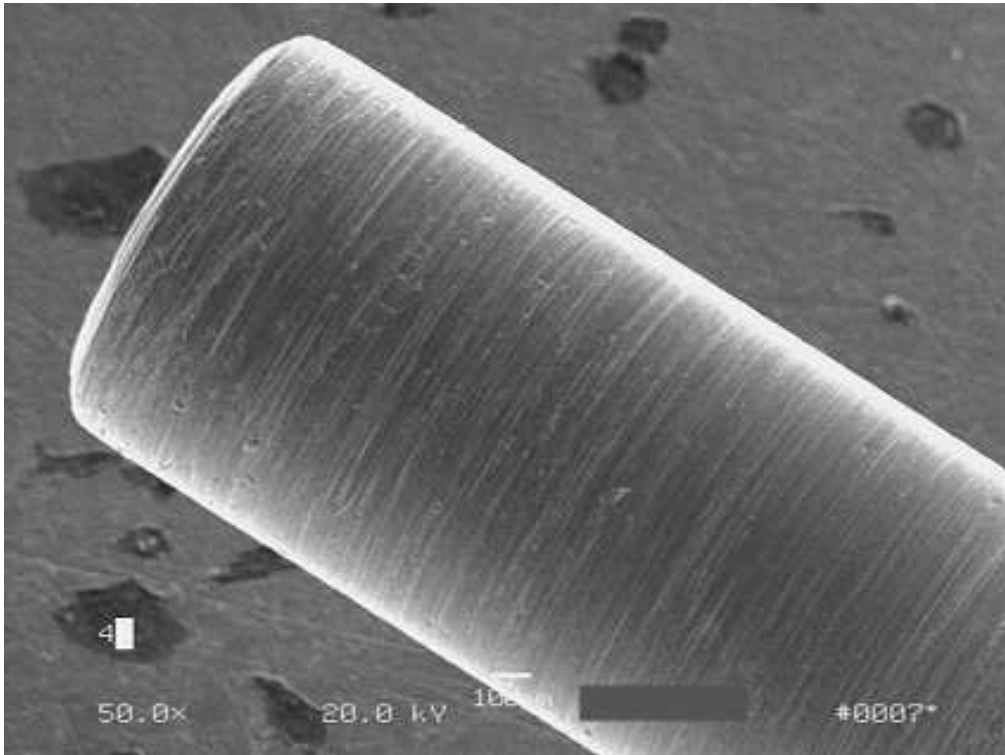


**Figure 20** – SEM Sample 3-3

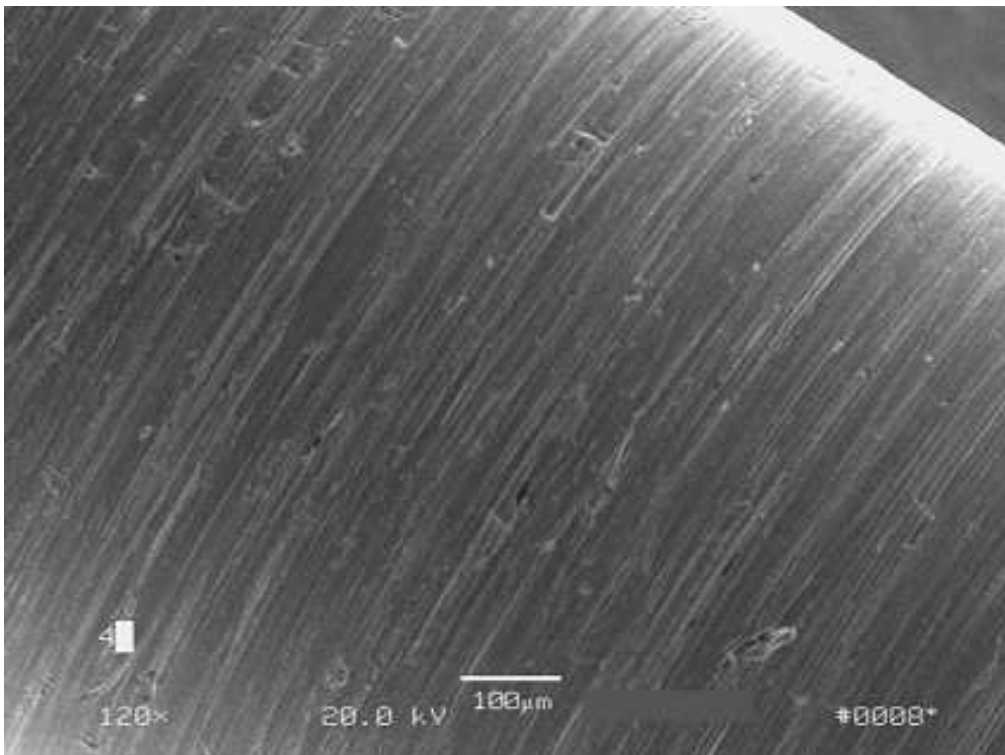


**Figure 21** – SEM Sample 3-4

At the higher magnification it is clear that polishing with the Cratex stick left the grooves and only seemed to smooth the sharp edges and remove some of the burrs left from turning and filing. Polishing for a longer time may have improved the surface a little, but would still not be an acceptable finish. This would lead to rapid wear and friction in the newly bushed and burnished holes.

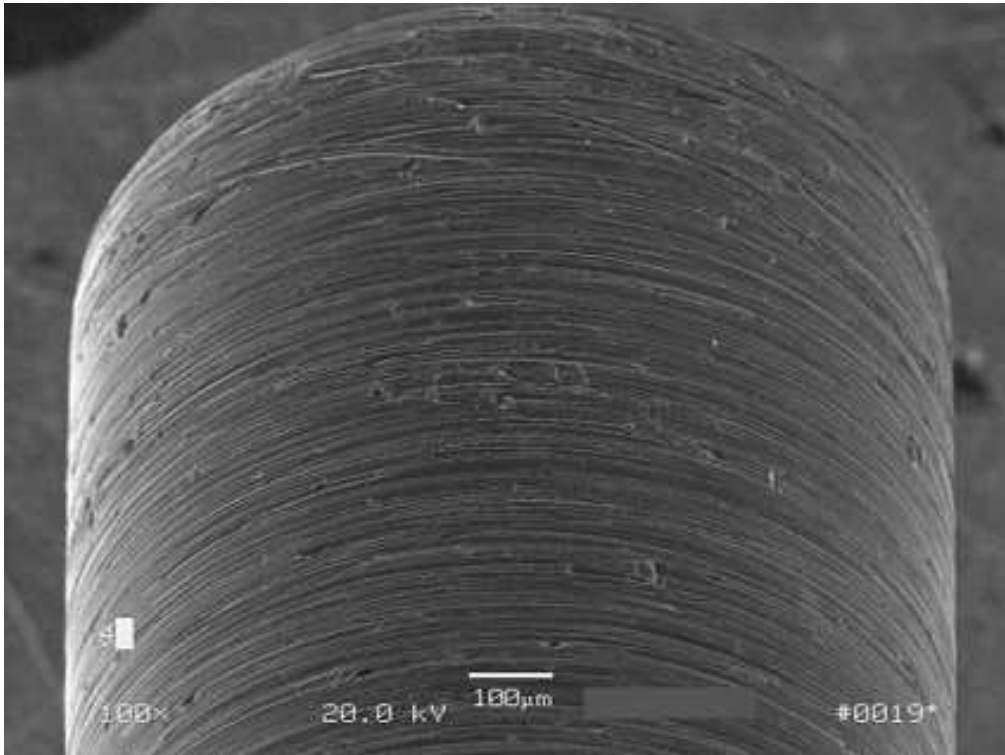


**Figure 22** – SEM Sample 4-1

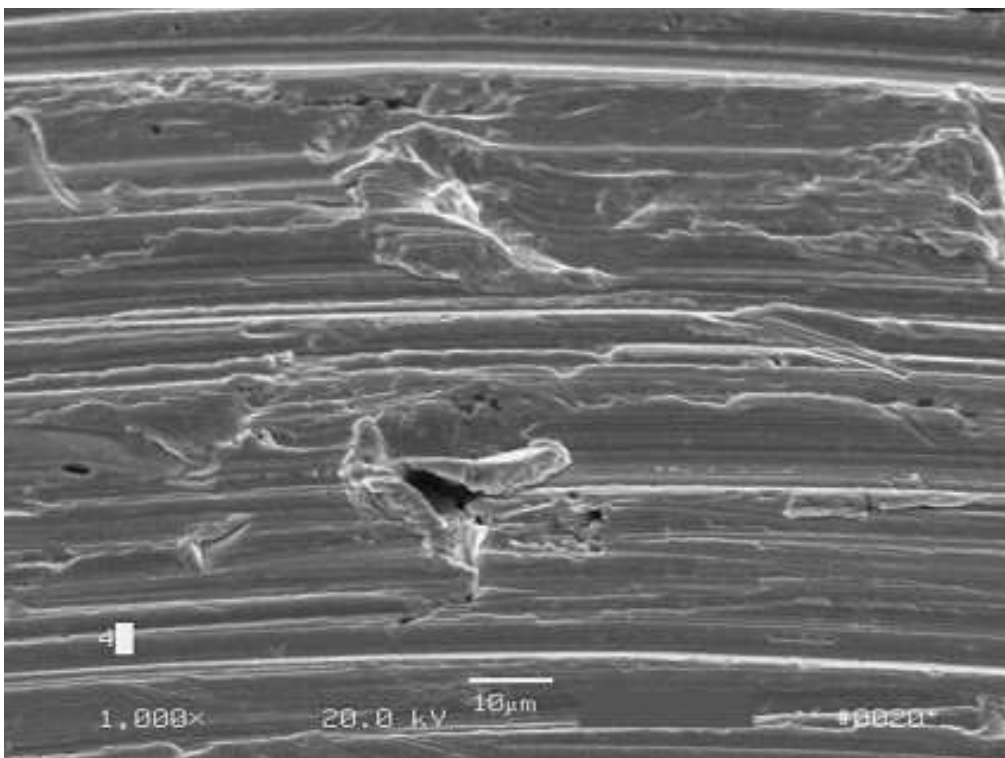


**Figure 23** – SEM Sample 4-2

Sample 4 was filed and then ‘polished’ using a 320 grit paper. Visually it starts to look like a method that would produce an acceptable pivot. But at these low magnifications you can still see that we were only taking the high spots off of the previous finish. Leaving a rough surface with irregular features and traces of the original machining.

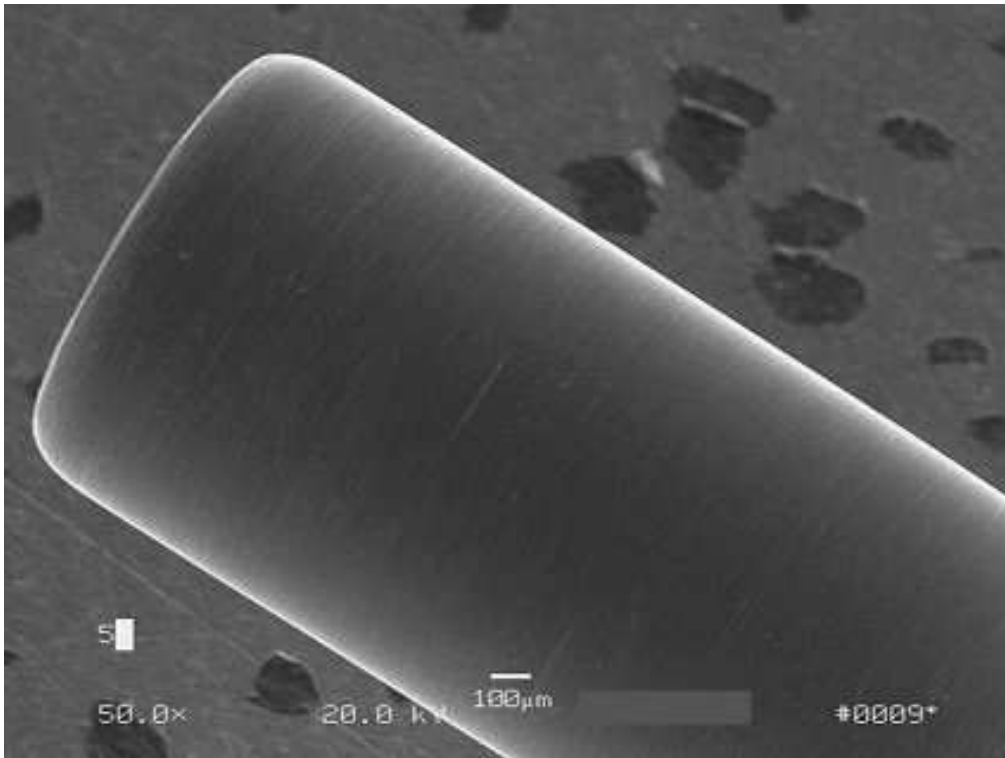


**Figure 24** – SEM Sample 4-3

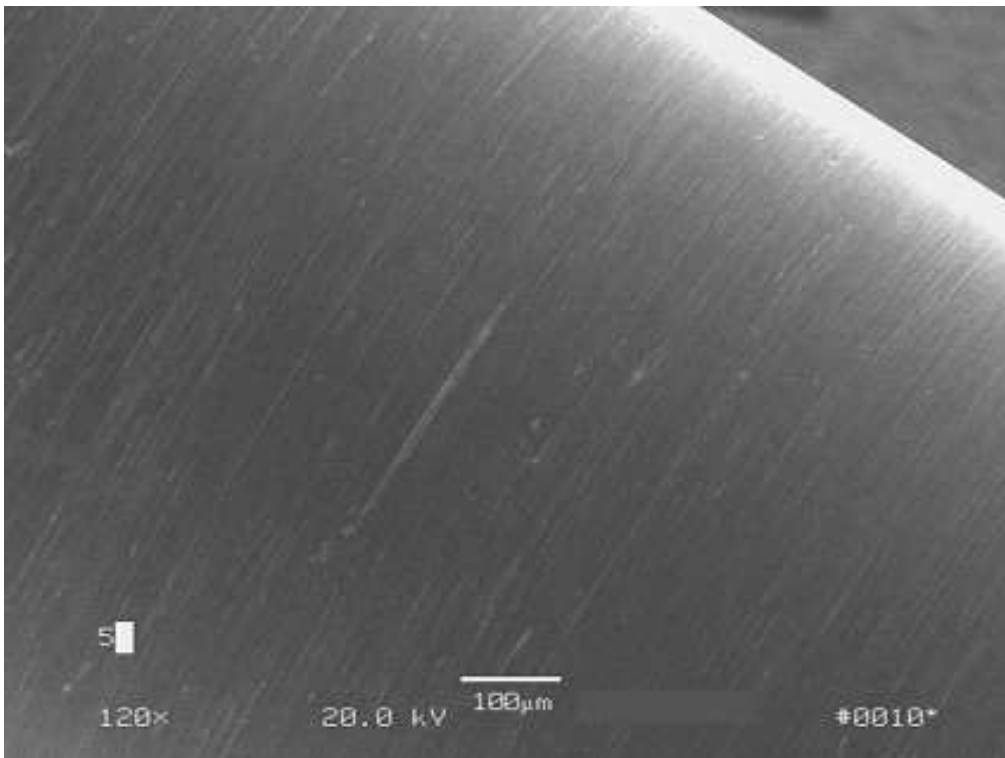


**Figure 25** – SEM Sample 4-4

Again at the higher magnification it is even more apparent that resulting surface finish is really not acceptable. New features have now appeared that seem to be the result of the fine grains of abrasives working on the surface of the pivot. In some respects this even appears worse than the ‘as filed’ condition represented in Sample #2.

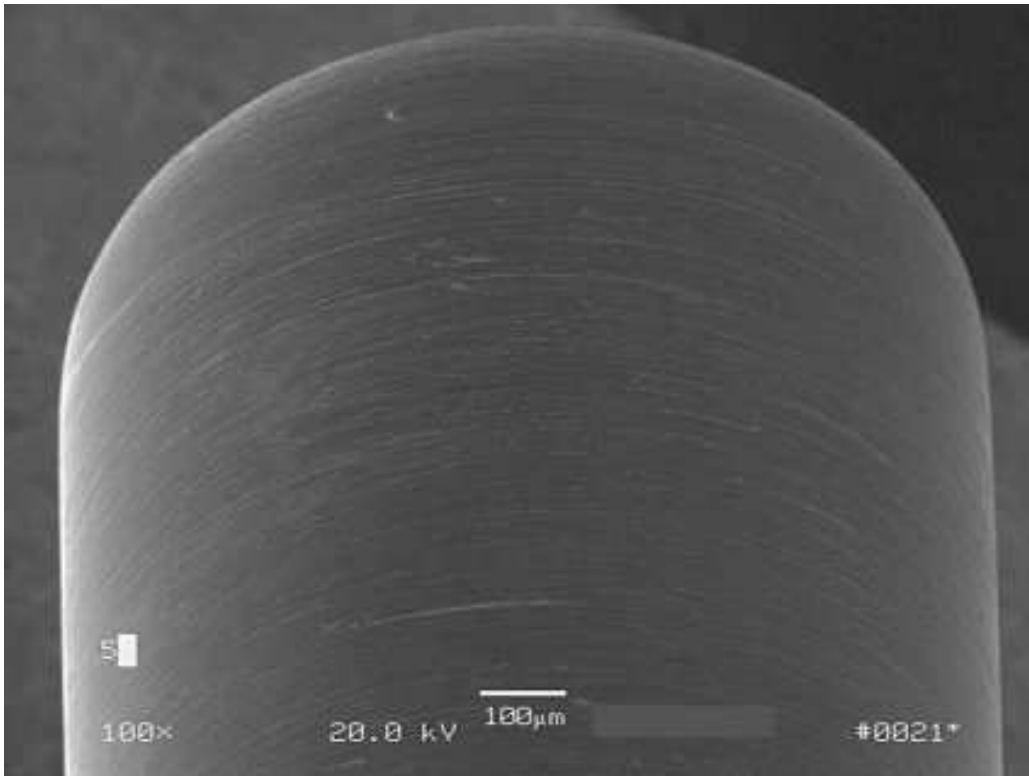


**Figure 26** – SEM Sample 5-1

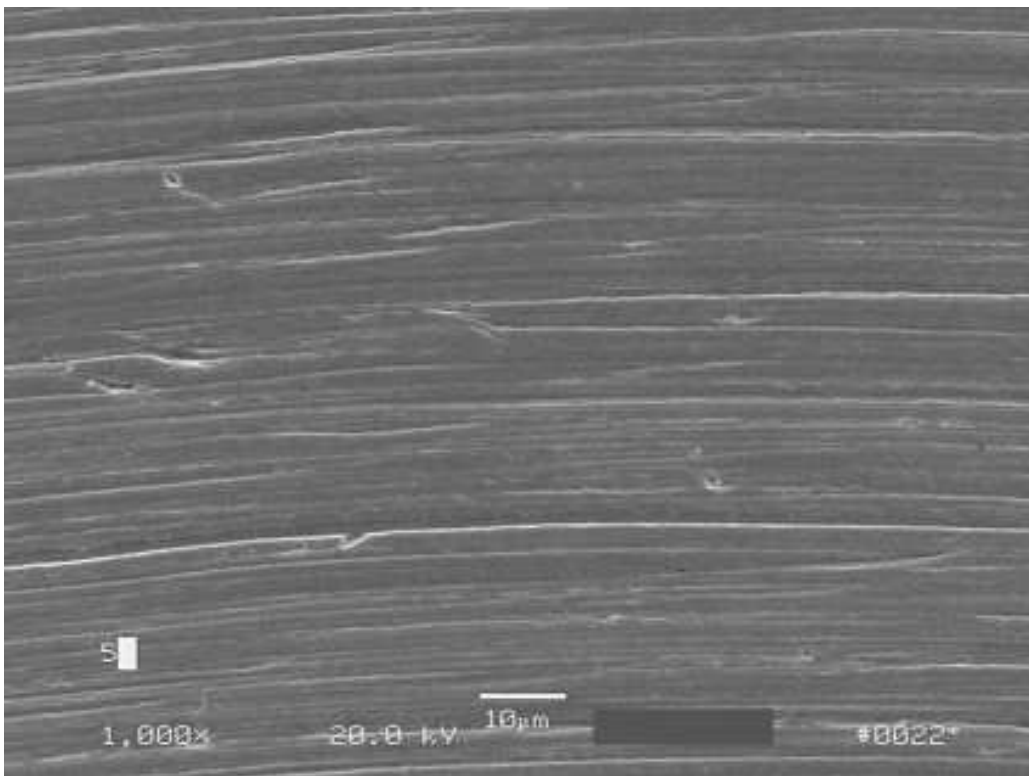


**Figure 27** – SEM Sample 5-2

Sample #5 is the same as Sample #4 except the I continued to polish with an abrasive paper of a finer grit. A 1000 grit paper was used to further improve the surface left from the 320 grit polish. The finish of this pivot is probably acceptable and could be considered ready for re-assembly. The finish shown in Figure 27 shows that most surface defects have been removed and that a large bearing area is present; both desirable to reduce friction and wear.

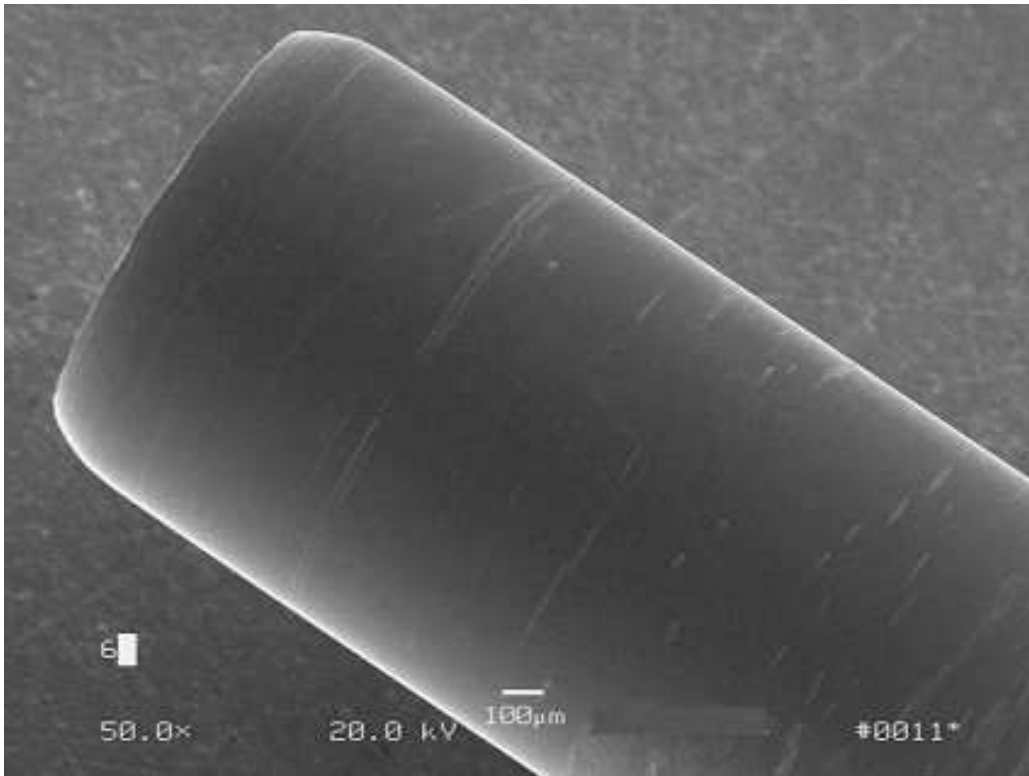


**Figure 28** – SEM Sample 5-3

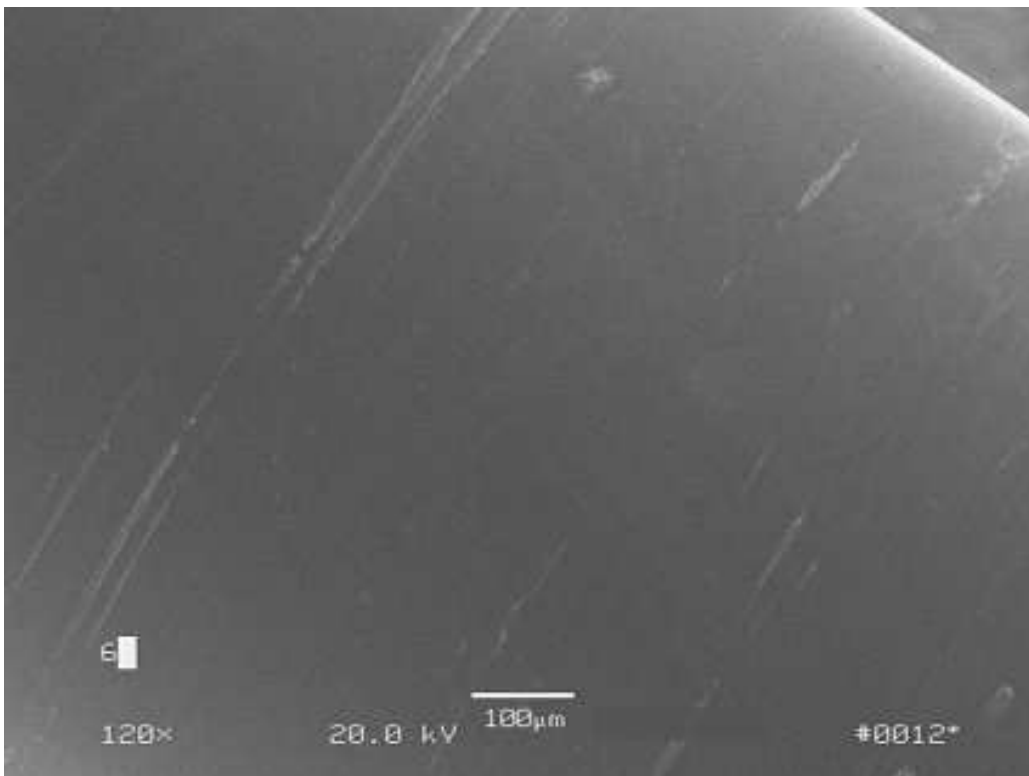


**Figure 29** – SEM Sample 5-4

At the higher magnifications the surface finish does not appear too bad. Some irregularities such as scratches and tears are visible but the overall bearing surface condition is reasonable. By spending a little more time polishing, this method may result in even better conditions but was not tested.

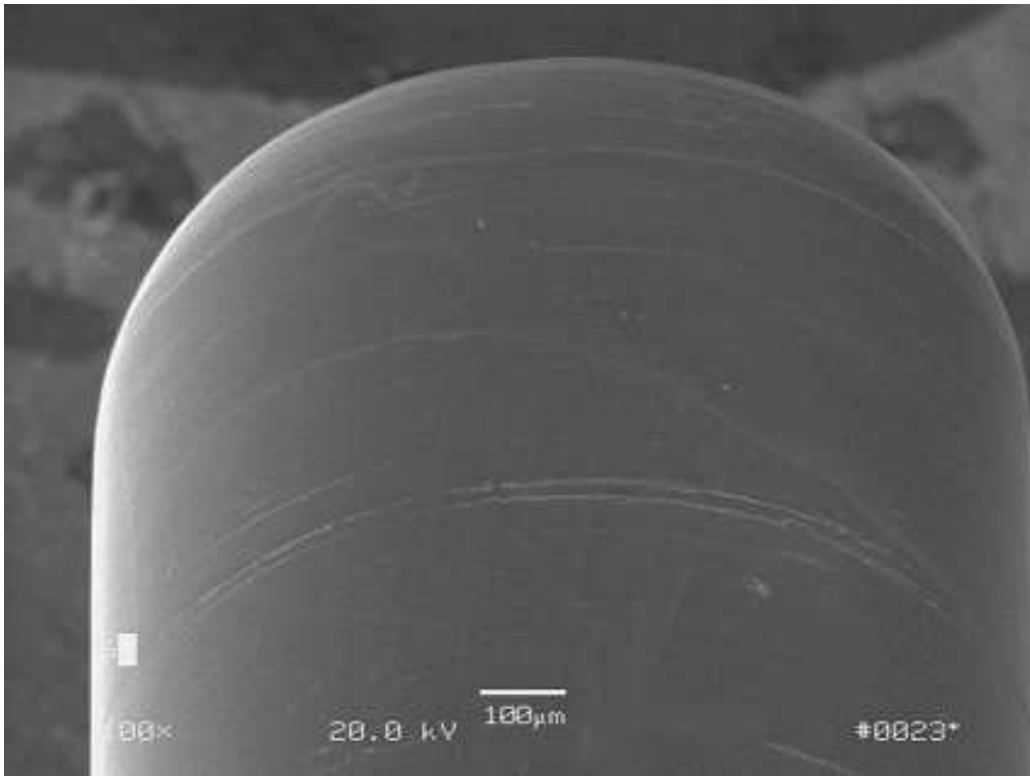


**Figure 30** - SEM Sample 6-1

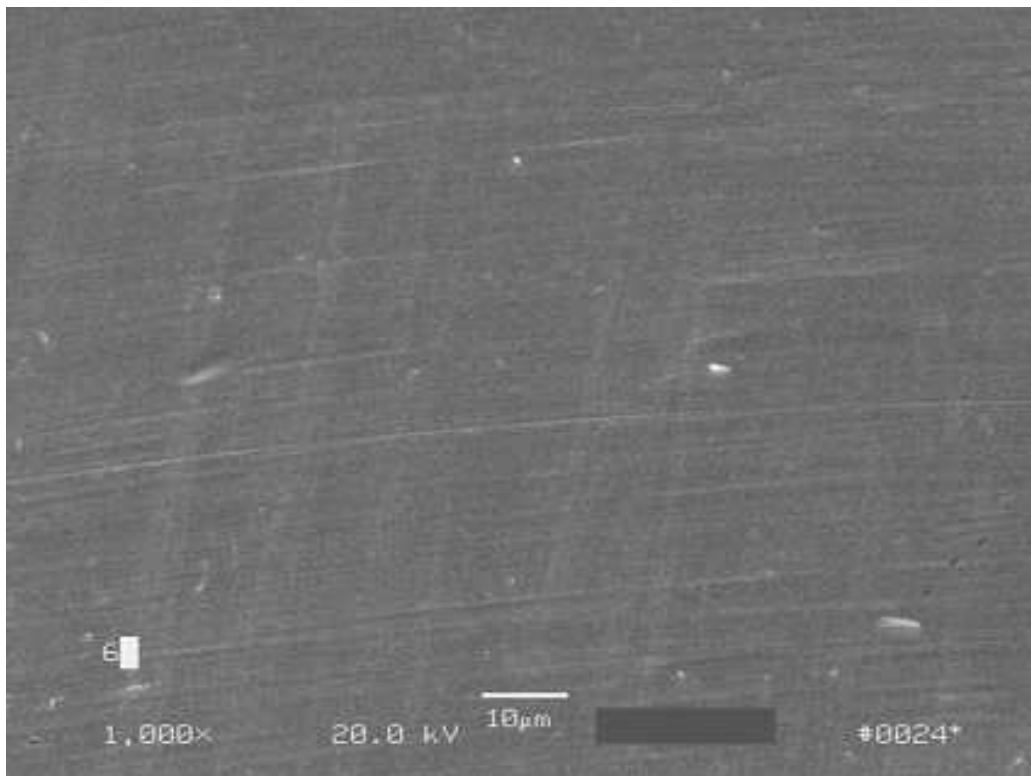


**Figure 31** - SEM Sample 6-2

Sample #6 was turned, filed and burnished with a definite improvement seen. With little effort most defects were eliminated and a very smooth surface with almost the maximum bearing area produced. It is difficult to determine if the imperfections seen in these photos are remnants of the previous operations or a result of the actual burnishing.



**Figure 32** – SEM Sample 6-3



**Figure 33** - SEM Sample 6-4

Even at the higher magnification the finish looks very good. Some scratches and marks are visible but their effects on the performance of a clock are left to further debates. The condition and cleanliness of the burnishing file and fixtures may also have an effect on the finish over the time that they may be in use.



I hope that this has been educational if not entertaining to all those that have taken the time to read and understand what was presented. Again, this project was undertaken as a simple exercise to help me understand what different pivot polishing techniques are capable of producing. As explained earlier I have only repaired a couple clocks as a hobby and would not want the reader to assume that I have a lot of experience in the area of polishing pivots or anything else for that matter. I was hoping to be able to get surface hardness measurements but it was expected that any data that I obtained would not be accurate enough to draw any conclusions regarding the effects of burnishing so it was not done. But for me, just seeing the finish produced in the short time taken to burnish was enough to convince me that burnishing was the method to use.

Regards;  
Bob Whiteman  
4 October 2005