Reconditioning a 50+ year old Olympus KHC microscope

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Part 1 – Fine focus recovery

I thought of giving my daughter a toy microscope, to let her know of some of the things that exist but go beyond what the eyes can see. But from searching in toy stores, I could not find any product that seemed to inspire proper optical quality. Some products seemed both expensive and very basic at the same time. Some products averaged 50 Euros retail, VAT included.

So I tried to take a look at what eBay had to offer. I quickly turned my attention to real lab grade microscopes. Some were obviously very expensive, but a very wide range of offer in price/age/condition could be found. After some extensive browsing, I managed to calibrate my price expectations and define a budget. My reasoning was that given I had an initial intention of buying a 50 Euro toy microscope, now that I was looking at real lab grade microscopes, I should at least relax my budget to be double that value. I even considered going beyond that, if I found an item that I could see, decide and obtain locally (decreased risk).

After some struggle with comparing and watching auctions and bidding on interesting microscopes, I decided to bid on one that was apparently left forgotten (I will go on that later) – an Olympus KHC binocular microscope.

It was still at 50 USD initial price. I bid a few hours before the auction ended, and to my content I won the auction for the 50 USD. It cost another 65 USD to ship to Portugal, but overall it was within the budget I had defined.

Of course there was some dimension of gamble involved: I was buying something for which I only had some photos and brief description saying that everything was ok, except for the missing 4× objective. However, comparing with the photos I could see that the 4× objective was there. Still I decided assuming that it would not be there and without confirmation of the seller if it was or not there.

After a couple of weeks, to my satisfaction the microscope arrived intact, in spite of being packaged simply in a cardboard box with some newspaper and air pillows. Surprisingly, it had the 4× objective mounted on it, just like in the pictures from the seller. Like all the other 3 objectives (10×, 40×, 100×) it was in perfect condition. Perhaps given the small profile of the 4× objective, the untrained eye of the seller led him to think the objective was missing.

Like I expected it was just the bare microscope, complete with all functional parts. It didn't of course have the wooden box and accessories these instruments were typically sold with back in the day.

The only issue I immediately noticed was related to the lubrication of the parts. The specimen XY movement mechanism was a bit stiff (especially the X axis), and the fine focus would simply not work, in spite of the corresponding knob turning.

I searched online for technical details and diagrams for this microscope, but with limited success. Essentially, the only information I could find was this copy of the instruction manual:

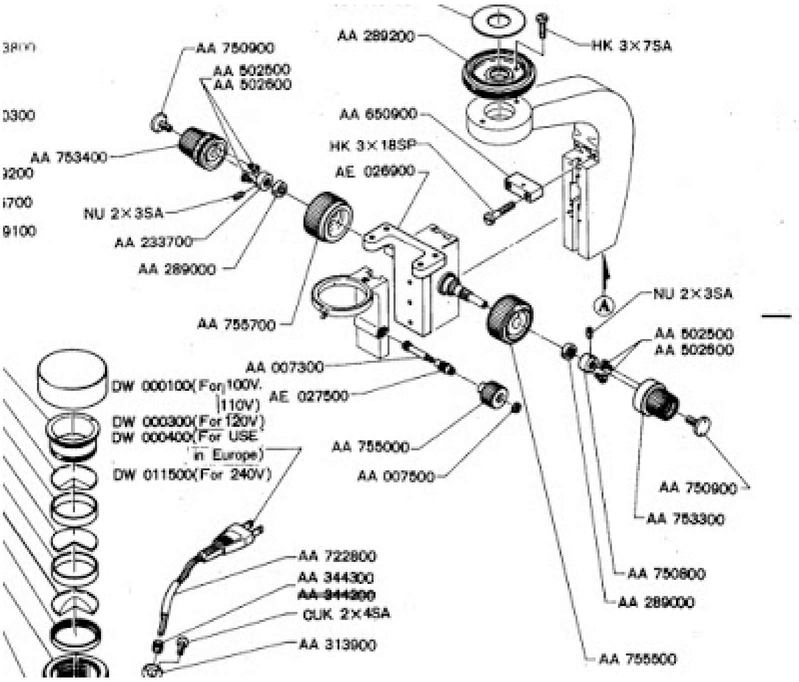
- http://www.alanwood.net/downloads/olympus-khc-instructions.pdf

And the exploded parts diagram:

- http://www.alanwood.net/downloads/olympus-kh-parts-diagram.pdf

Both in Alan Wood's web site.

The exploded parts diagram lacks enough detail, with most of the individual parts of the focus assembly not represented in this document.



So I decided to start disassembling, being careful to keep track of what I was doing. First, I started by removing the focus knobs. At this point I truly had no idea how to reach the focus mechanism.

To remove the fine focus, I used a set of pliers of the type used for installing retaining rings. docking its pins to the pair of holes in the face of the fine focus knob:

This exposed the fine focus shaft and the cylindrical part populated with 5 screws in different areas of the part (from the parts diagram, parts AA 233700 and AA 750800, from left and right side of the microscope, respectively).

After its removal on the right knob, it exposes a nut that retains the coarse focus knob:

For removing it, one must turn the coarse focus knob counter-clockwise, while keeping the coarse focus knob for the other side fixed. After that, the coarse focus knob can just be pulled off:

Later I found that I could control the friction of the fine focus knob by adjusting the screws in the bearing removed right after the fine focus knob:

This part has an O-ring which is in contact with the fine focus shaft. Apparently it is made of nylon or eventually Teflon. This is one of the very few plastic parts I could find in this microscope.

I must admit I was fascinated with the robustness and precision metal machining work present in this 50 year old instrument. I can only assume this was a very expensive product back in its day.

Considering that CNC, precision automation and a lot of the things we take for granted today were still experimental technologies, at a distance from the mass production arena, it is remarkable to see this piece of precision work, that most certainly had a large share of manual labour.

It worth to remember that this was manufactured in a period only a couple of decades away from the end of WWII, in a Japan that had to struggle to put itself back together.

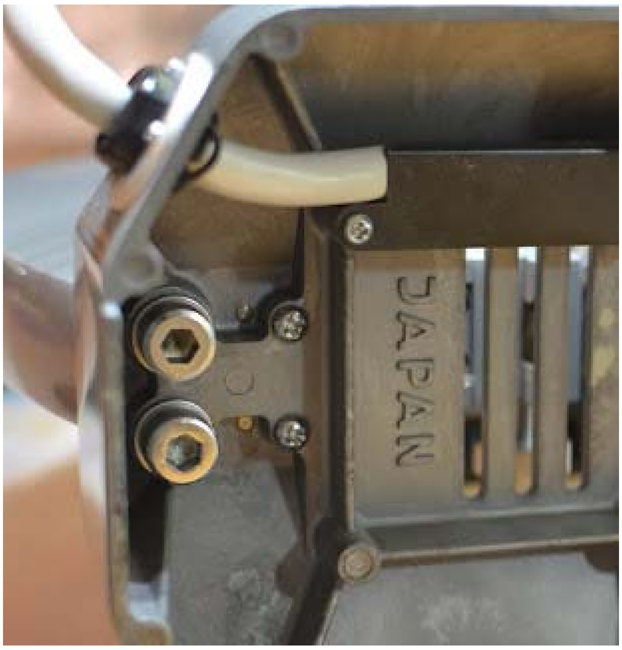
In this particular bearing, the O-ring is fractured. Given that the damage does not seem to affect the function, I kept there, instead of searching for a replacement ring.

On the other side, the ring was in good condition:

Then in the left side knob, I got stuck with the coarse focus knob retaining bolt. Unlike the right side one, this has the two holes for removal with a special wrench.

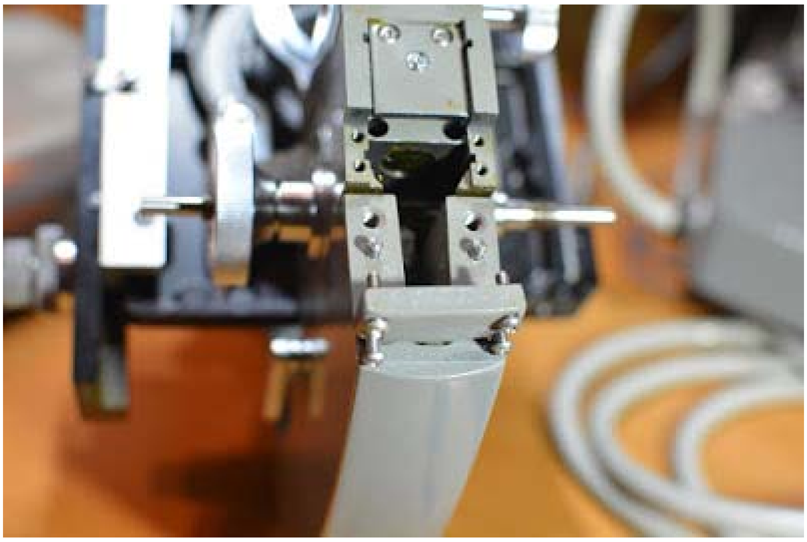
As I only had the tweezers, I attempted to remove with these. The part was quite stuck, and I only realized I was applying too much torque on the tweezers when this happened:

So I gave up going in this direction, and decided to disassemble the base of the microscope, in order to have a different angle for accessing the focus assembly. Removed the four screws that keep the base attached to the body of the microscope:



And could now have access to the bottom of the focus and condenser elevation control assemblies:

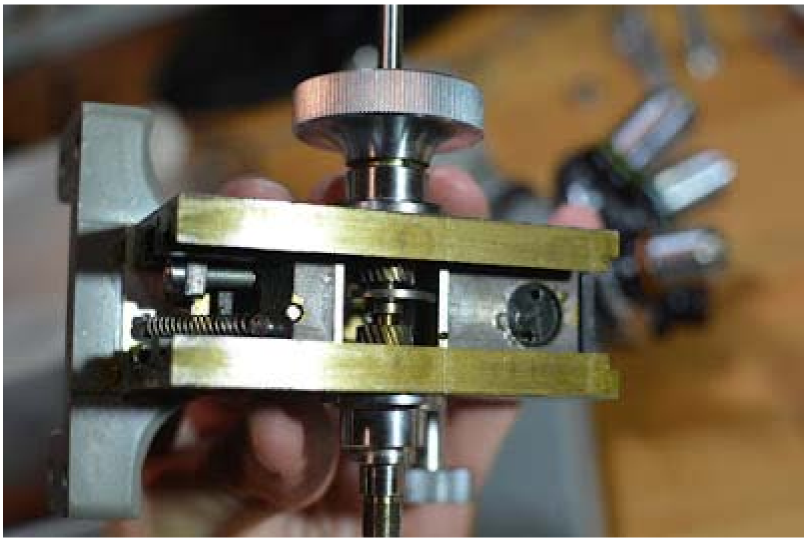
The bottom rectangular part held together by four screws, have behind two springs. After removing the screws, to avoid having to remove the springs (and later having the challenging task of placing these again), I simply moved the part to the bottom, keeping the springs under tension:



In order to remove the focus assembly, I had to remove the specimen stage by removing the four Allen screws that keep it attached:

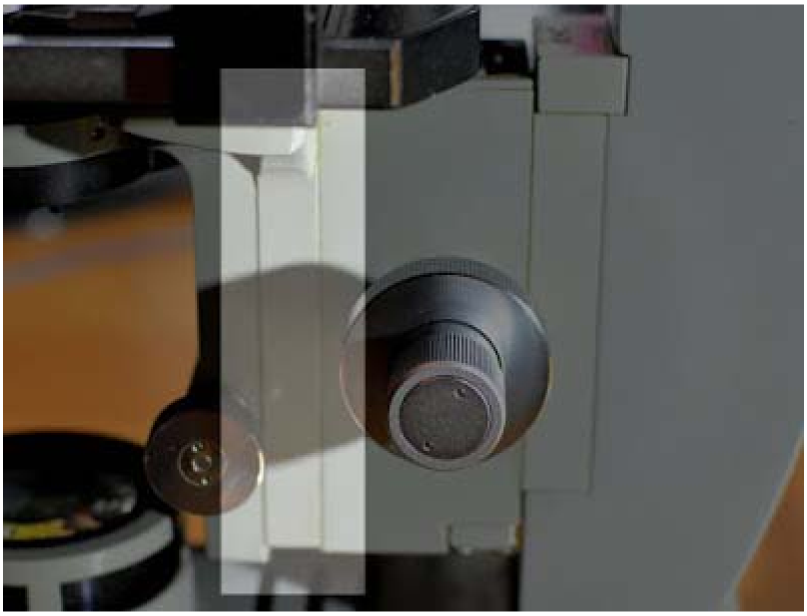
A cover in the top of the assembly must also be removed in order to allow the focus assembly to slide out of the microscope body:

Then by sliding towards the bottom the part comes off easily:

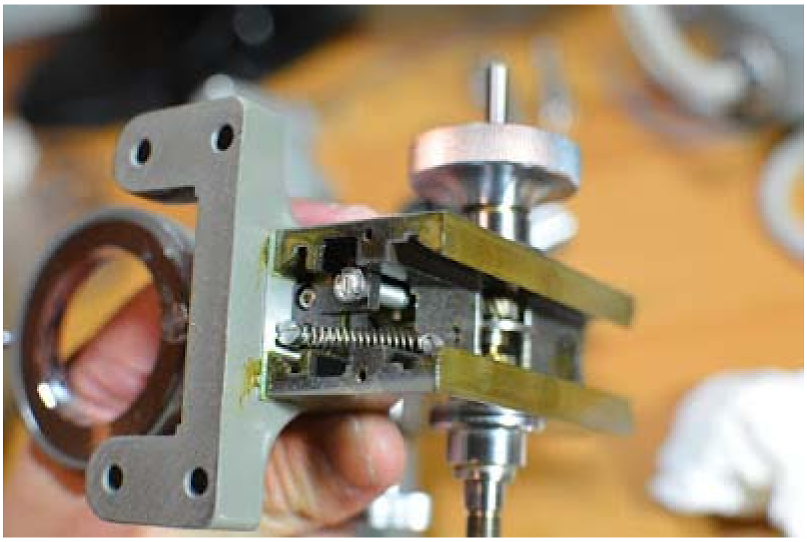


At this point I still did not understand how the fine focus mechanism worked. There was indeed a disc that would move to the left or right as I would turn the fine focus shaft, but I could not see any relationship between that happening and the moving of the focus assembly.

That is when I gave attention to the fact that there was an intermediate moving part (sorry for my lack of microscope morphology knowledge, up to this point). So I thought that the spinning disc had to play a role in respect to this part:

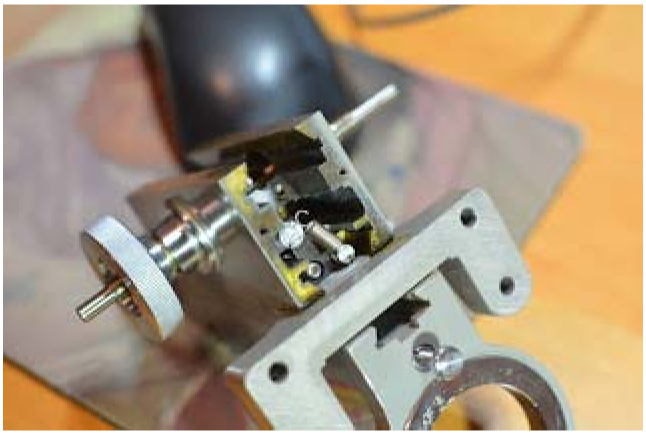


So I found that there was a lever that would cause this intermediate part (to which the specimen stage actually is attached) to move, based on the position of the disc. The lever is hidden behind the disc and the pinions, so that it was difficult to identify it at first. As it moves, it pushes against the long, adjustable screw that can be seen on the photo, causing the assembly to be moved up or down:



So, at this point the problem seemed obvious: the dampening grease aged and became sticky (as in most joints in this microscope), and the disc mechanism was no longer able to move the fine focus body. The short travel length the fine focus rail has to move clearly must have contributed to cause the part to become stuck.

So I removed the spring that can be seen in the photo, and the cap that encloses another spring.

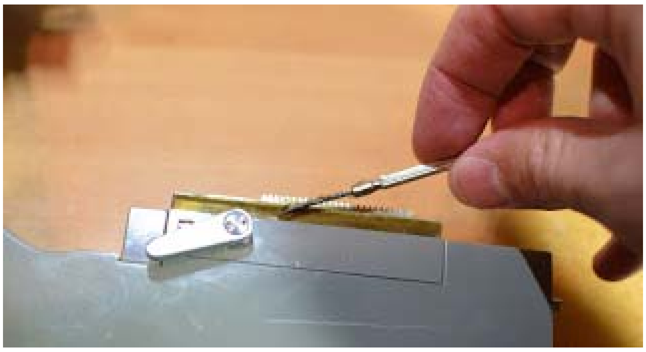


After applying considerable force, I managed to slide out the fine focus body:

With the fine focus body removed, it was now a matter of cleaning very well all the dampening grease bearing parts, and apply fresh grease (I used standard lithium-based grease, which should be ok, even though there are more specialized greases). The cleanup was a particularly time-consuming task, as the grease was persistently attached to the metal surfaces.

Another view of the lever that contacts the disc and raises the fine focus body:

Applying grease to the surfaces. In respect to the pinions and toothed rails, I used standard lubricant oil:

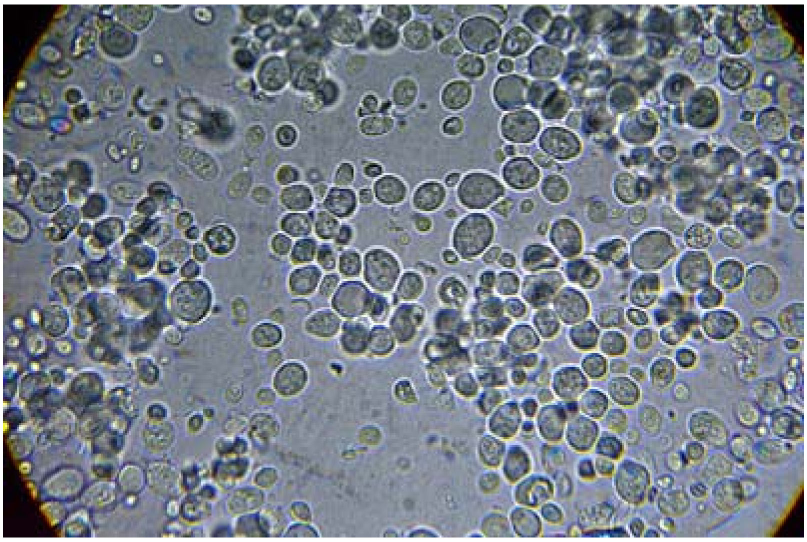


After lubrication was done, it was time to assemble everything again, and prey for no leftover parts appearing on the table :)

After assembly and testing the focus knobs I was quite happy with the smooth operation, like if it was brand new. I also had to clean and apply grease to the fine focus shaft friction bearings, and adjust the screws for the appropriate level of friction (not too tight nor not too loose).

The friction level of the coarse adjustment knobs was done as described in the manual, by turning both knobs in opposite directions.

A small test, having as specimen a colony of yeast cells, from a beer yeast pill. Test was performed at 1000× magnification (10× eyepiece + 100× objective) under oil immersion. Fully closed condenser iris for optimal contrast. Photo captured with Nikon D5200 DSLR in manual mode, with a 35mm lens in close proximity to the eyepiece:

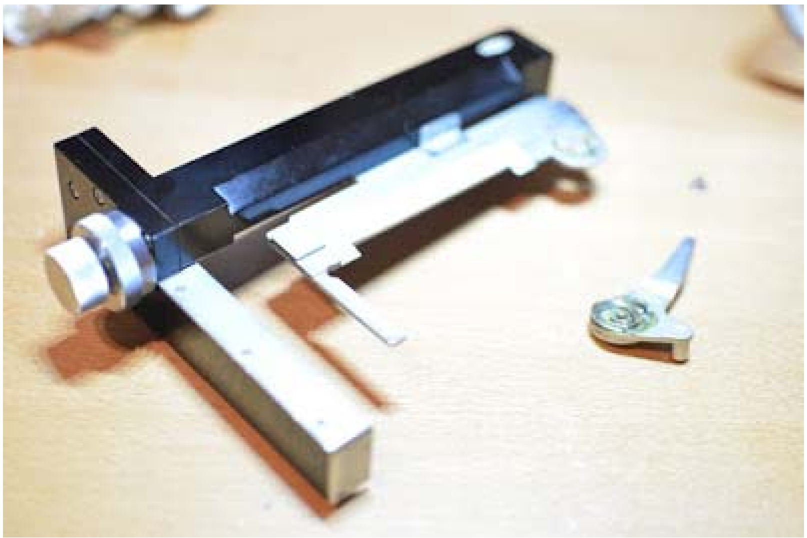


Part 2 – XY specimen stage mechanism lubrication

Like pretty much every moving part in this microscope, the XY specimen stage mechanism also suffered from dried/sticky grease, preventing the X axis from moving at all. As such like in the previous case, the only solution was to tear it down, clean it and apply new grease and oil.

The separation of the mechanism from the stage is simple: in the bottom of the geared side (where the knobs are) this forelock is moved as shown in the picture, and by moving the Y axis to the end of its travel range, the mechanism is removed:

Then it is possible to separate the parts that compose the mechanism:

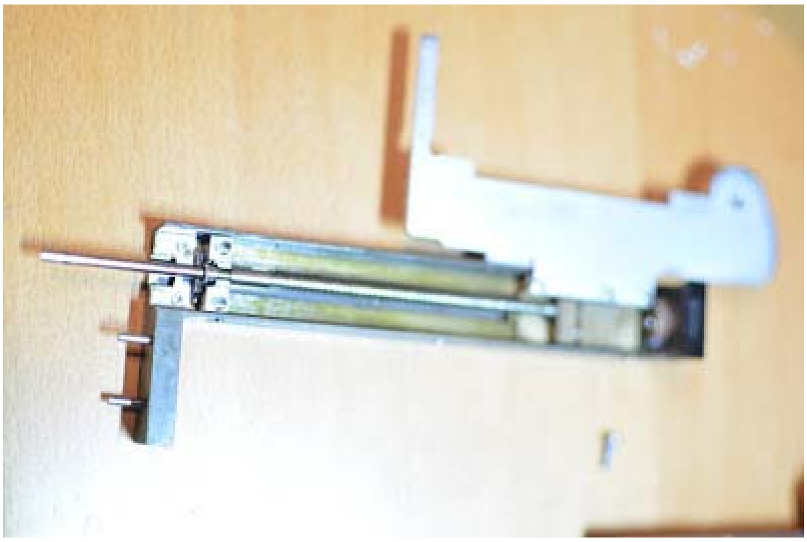


For cleaning of the stage, it is also interesting to be able to remove this part entirely:

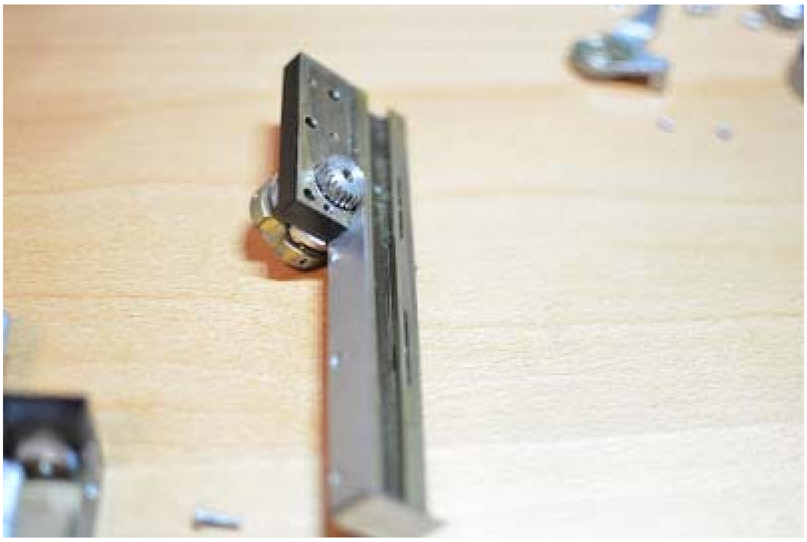
The first thing to remove are the knobs. An Allen and a Philips key are sufficient to remove the two knobs:

As seen above I have also removed the slide retainer tweezer to also clean and lubricate with grease.

The X movement is simply driven by a long worm gear turned by the inner knob. To better clean the worm gear and have access to the sliding rail underneath it, I dislodged it from the casing by removing the two screws of the holder part (left side of the worm gear):



The Y movement is simply a pinion that rolls against the geared rail in the stage. I cleaned and lubricated both parts with standard mineral oil:



After all the cleaning and lubrication was done (gears with oil and contact rails with grease), it was time to put it all back together and start doing some observations.

Part 3 – LED conversion

The microscope came with what I believe must have been the original illumination system:

- a 30 Watt / 110 Volts tungsten bulb (in this case a GE branded one):

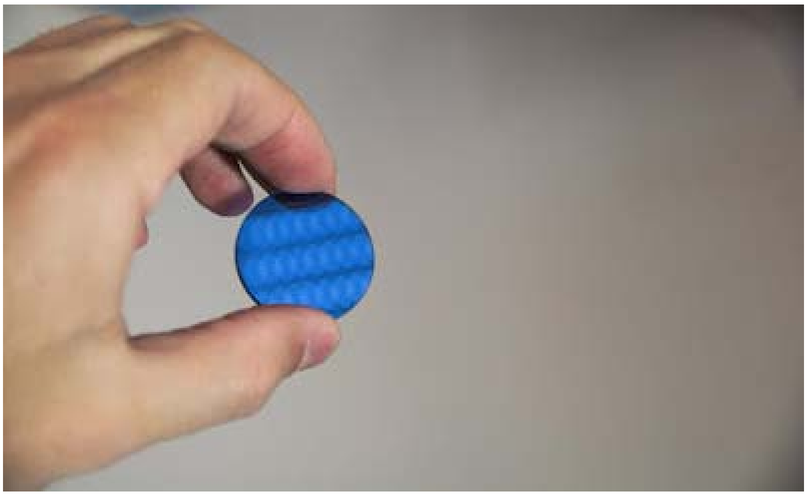
- a light dimmer circuit apparently made up of just a Triac, some capacitors and the potentiometer to control at which threshold the waveform is chopped (therefore causing the light to dim proportionally to how much of the wave is chopped):

- and interestingly, a Hitachi-branded mains plug:

However, for current use, this system would be impractical several fold:

- the specific type of tungsten bulb it requires is very difficult to obtain today, and those available (mostly new old stock) are not cheap;
- as listed in the specs of these light bulbs, the lifespan is stupidly small, in the range of 50 to 60 hours.

- incandescent illumination is not ideal because of reddish spectrum of light in lower power levels. A blue filter is normally required to adjust to a more even spectrum:



- given the low efficiency of tungsten bulbs, heat dissipation and IR radiation are high, affecting some types of specimen;
- in my location the mains voltage is 220 Volts instead of the 110 Volts required. This would imply adding a transformer to convert the voltage;

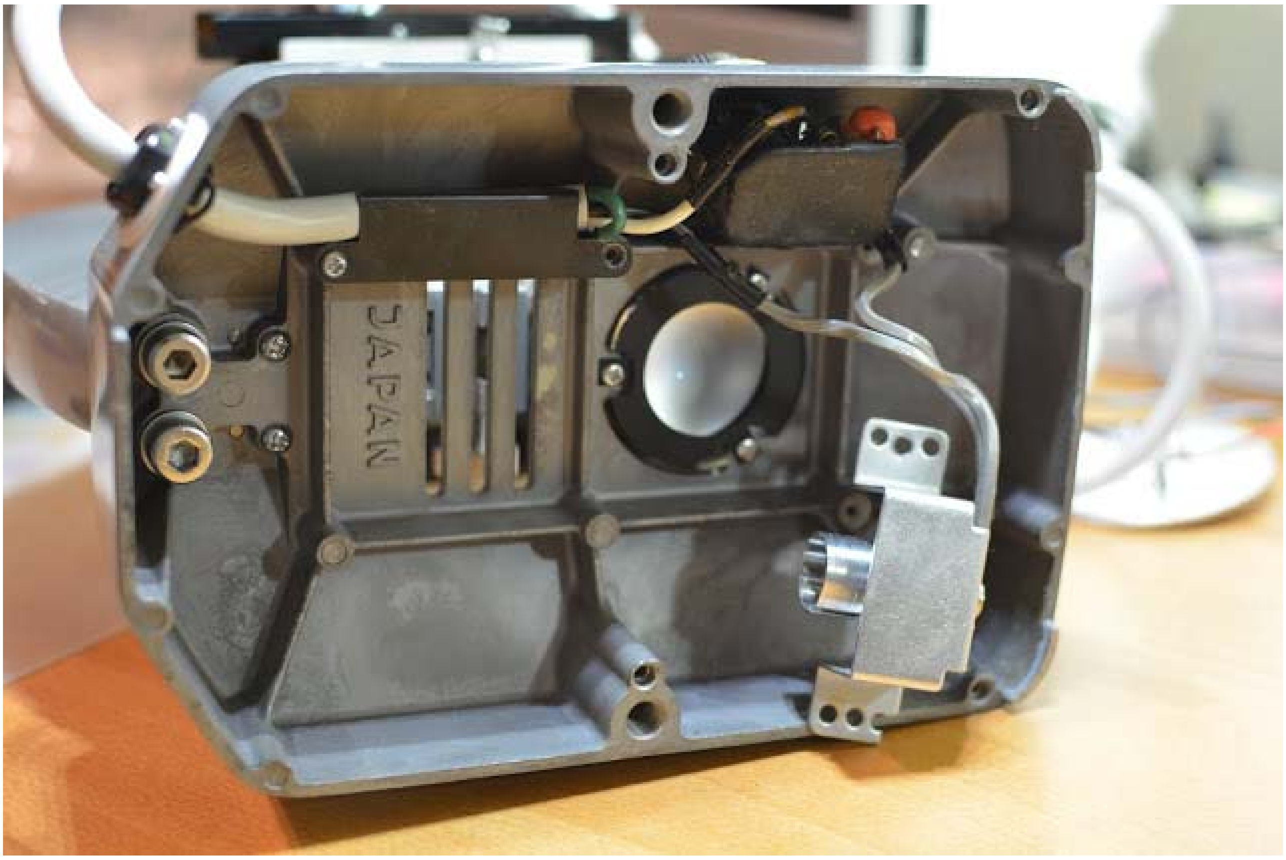
As such I studied the conversion to an LED light source, which I knew would have multiple advantages:

- LEDs are widely available and cheap;
- lifespan is high, in the order of tens of thousands of hours;
- light spectrum is consistent across all levels of intensity. Also (depending on the selected LED), a nearly pure white source is possible without having to add any filter;

Nevertheless, I had to take into consideration a few aspects:

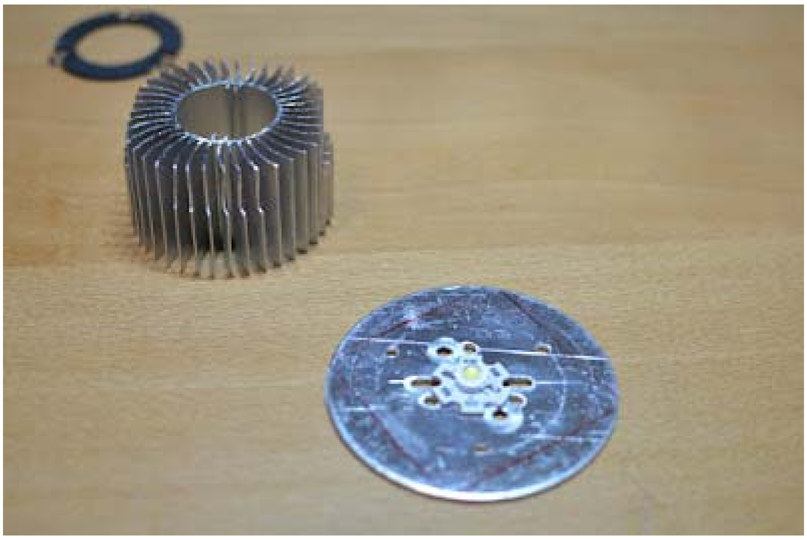
- make sure a good thermal dissipation would be allowed. LEDs don't like too much heat;
- ensure the maximum current delivered to the LED is actively limited, ideally by some regulator circuit;
- Like in the original system, provide a means for the LED intensity to be varied through a potentiometer installed in the same location of the original one.

As such I put my hands to work. Started by removing the original illumination gear:

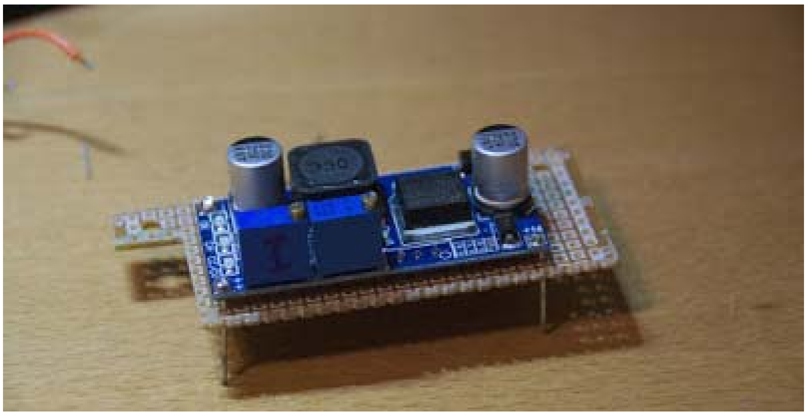


Ordered from banggood:

- a bunch of 3 Watt white LEDs (rated at about 210 lumens each);
- a power LED tailored heatsink:

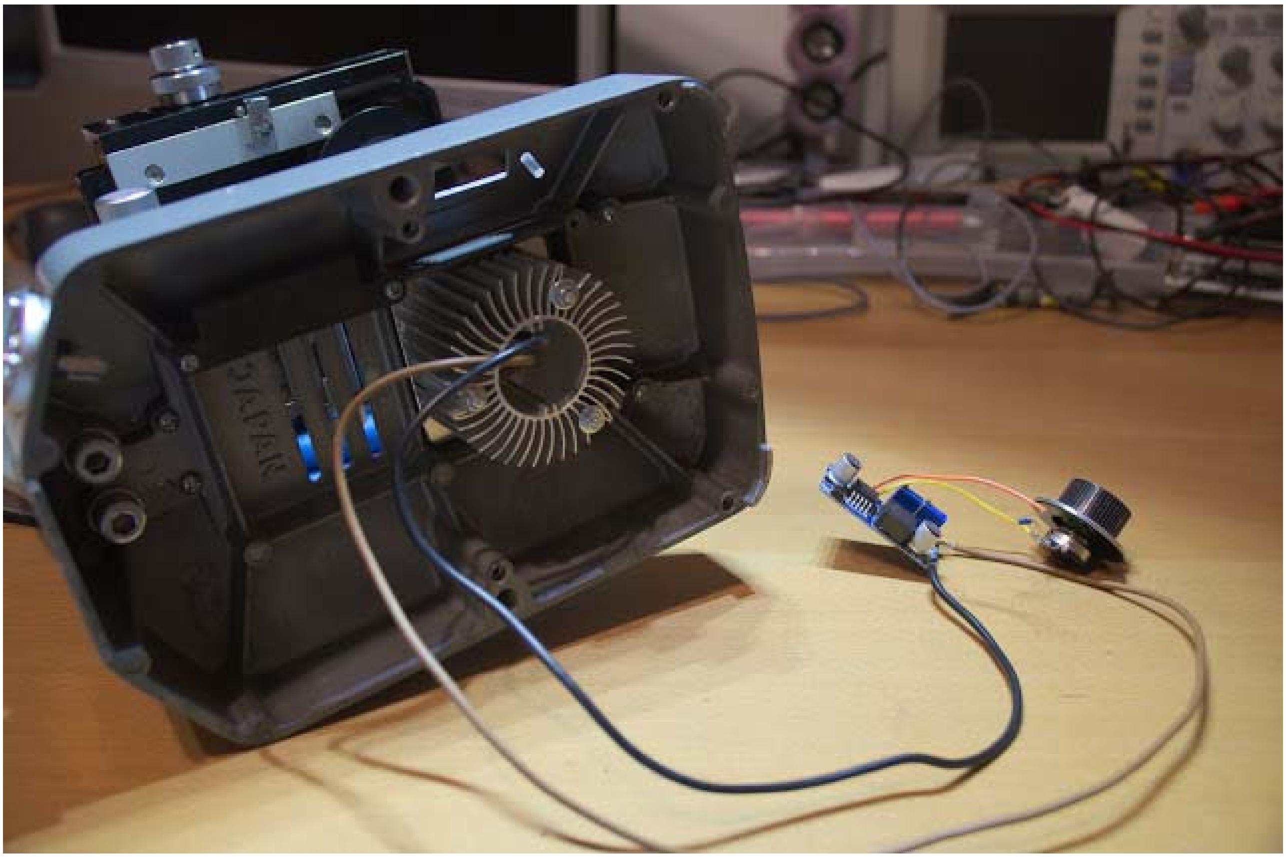


- a step-down (buck) converter rated at a maximum of 3 Amps, with controls for constant voltage and constant current applications:



The work started with the preparation of the heatsink to fit the area originally occupied by the bulb. Some cutting had to be done in order to make it a good fit. Tested the LED mounted on the heatsink for proper operation:

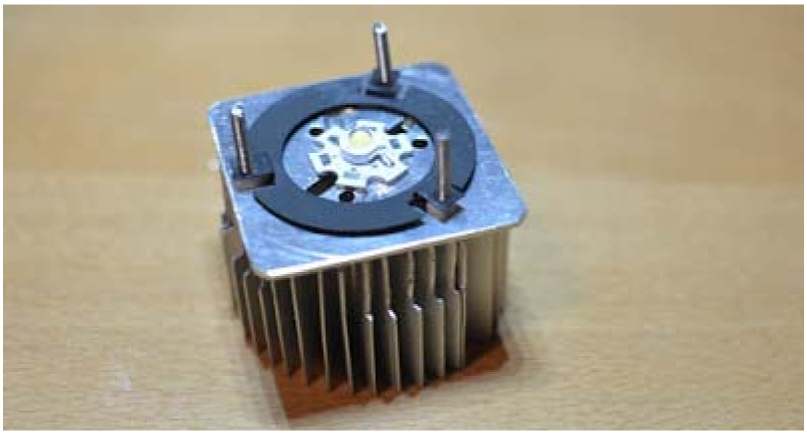
Made some tests with the step-down converter, limiting the current to 500 mA (below the rated 700 mA but more than enough for the lighting requirements), and replacing the on-board multiturn pot by a 500 Ohm panel potentiometer and a 220 Ohm resistor in series (and as such obtaining only the safe voltage range to be used for controlling the light):



- machined an aluminium disc to provide the necessary width for fitting a DC connector in the hole where originally the thick mains cable would pass through:

Well these specs won't remain true though (in particular the 20 Watts of consumption) ☺ :

While possibly not making much difference, preserved the original black mask:



Put it all together, inside the microscope base (mounted the LED + heatsink, the step-down converter PCB, the DC connector, and the potentiometer, in the place where the original one would go).

Fired it up and Bob's your uncle:

This document was originally published in 2016 as 3 parts of a blog by Luis Teixeira:

- http://creationfactory.blogspot.com/2016/08/reconditioning-50-year-old-microscope.html
- http://creationfactory.blogspot.com/2016/09/reconditioning-50-year-old-microscope.html
- http://creationfactory.blogspot.com/2016/09/reconditioning-50-year-old-microscope_10.html