Leitz Mechanical Stage no. 90 - Maintenance Notes

I'm not entirely sure that "mechanical stage no. 90" is the correct designation for the stage covered in these maintenance notes. First, I haven't been able to unambiguously cross-reference the no. 90 designation with any stage image in the Leitz documentation that can be found on the Internet. Second, one Leitz brochure that mentions the no. 90 stage informs that the stage surface is 165 by 135 mm, but the stage I have used in these notes measures 165 by 145 mm. Until better information appears I'll tentatively stay with the "no. 90" moniker.

Leitz mechanical stage no. 90 (Figure 1) can be found on, for example, Laborlux S and Biomed microscopes with 160 mm mechanical tube length. It is attached to the microscope's focus mechanism where the coarse and fine focus controls determine the stage's vertical movements. The stage area is 165 mm (width) and 145 mm (depth.) The stage has a coaxial control to move the stage in the x-axis ("side-to-side") and the y-axis ("back-and-forth") directions, with the adjustment ranges of 76 mm and 52 mm, respectively. Vernier scales make it possible to map out and then later again find a certain specimen area. The stage surface has two M3 screw holes 51 mm apart for attaching an object glass holder (Figure 2.)

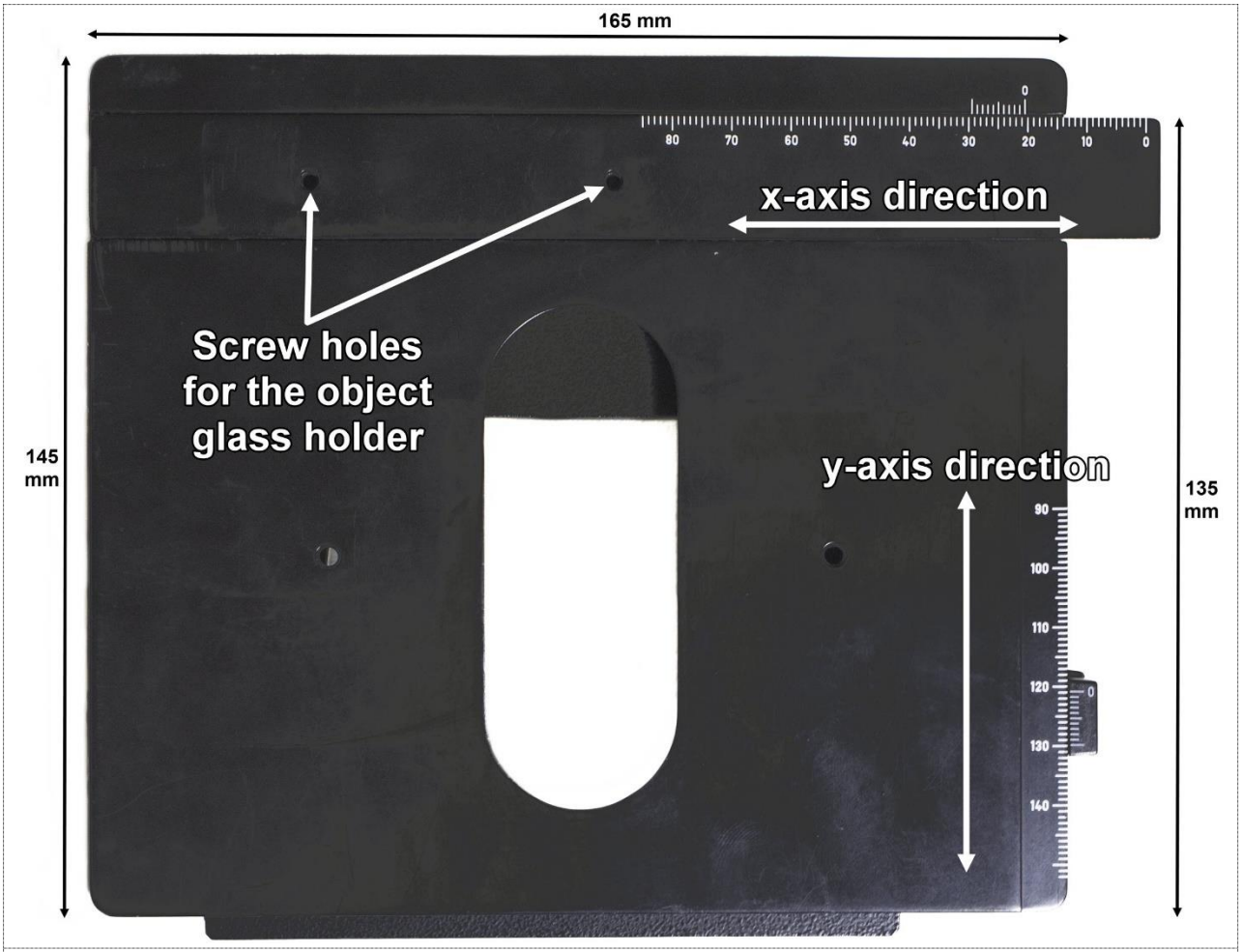

Figure 1: The stage viewed from above. The object glass clamp has been removed.

The stage movements must be both smooth, precise, and free from play, and to satisfy that, the stage utilizes linear ball bearings. The coaxial controls include provisions for adjusting the smoothness/sluggishness of the stage movements. The various stage mechanism parts generally appear quite robust, but due to aging grease and accumulated dust and dirt, the stage, or parts of it, may occasionally need to be taken apart, cleaned, regreased, and perhaps readjusted.

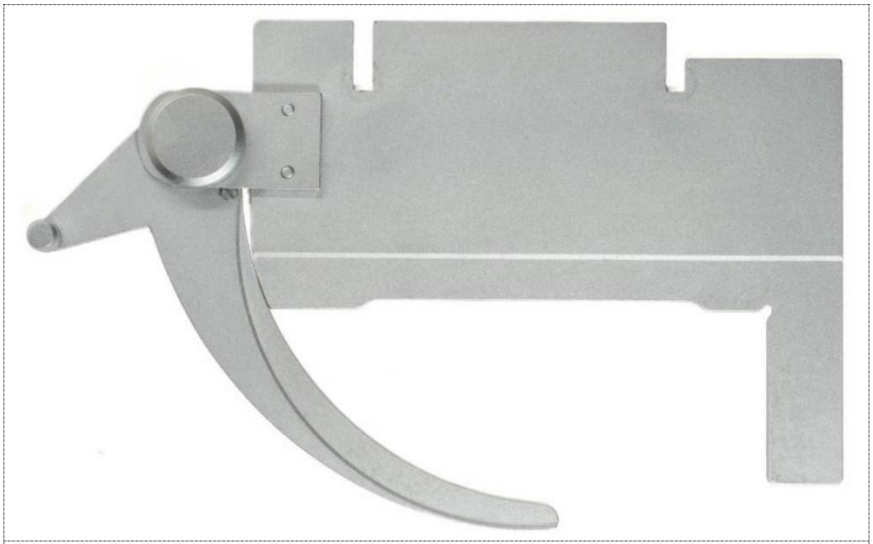

Figure 2: The object glass holder.

Scope

These maintenance notes describe the disassembly, cleaning, greasing and reassembly of the Leitz mechanical stage no. 90. Be aware that some technical details of your no. 90 stage may differ from what is described here.

Grease

There are different opinions whether a microscope stage's linear bearings should be greased or not. With grease or oil, the stage movements acquire a very smooth and pleasant feeling, but because grease and oil don't age well the bearings will need to be cleaned and regreased with regular intervals. Another disadvantage with grease or oil is that it catches and accumulates dust and dirt (for example, glass dust that forms when object glasses are clamped in the object glass holder) which also undermines the lubrication.

The choice of grease should not be critical, it's mostly a matter of choosing a suitable viscosity (thickness.) For the linear bearings in the x and y slides I have used Mobilgrease 28, but a high quality oil (for example, 3-in-one Multi Purpose PTFE Lubricant) should also work well. For the friction discs I have used the somewhat thicker Super Lube Multi-Purpose Synthetic Grease with Syncolon, NLGI grade 2.

Maintenance Notes

1. Remove the stage from the microscope.

Remove the object glass holder (Figure 2) – it is attached to the stage with two removable knob screws.

Put the microscope on its back on the table. From the underside of the stage remove the four M4x10 screws (red circles in Figure 3) that hold the stage attached to the stage holder (Figure 4.) There may be one or a few thin metal shims (Figure 5) between the stage and the stage holder to ensure that the

stage is perpendicular to the microscope's optical axis. If there are any such shims, make sure to retrieve it/them and make a note of their location. The shims may fall out before you have had any chance to notice their location; in such cases it may still be possible to infer where they were sitting thanks to the faint imprints they leave on the metal surfaces.

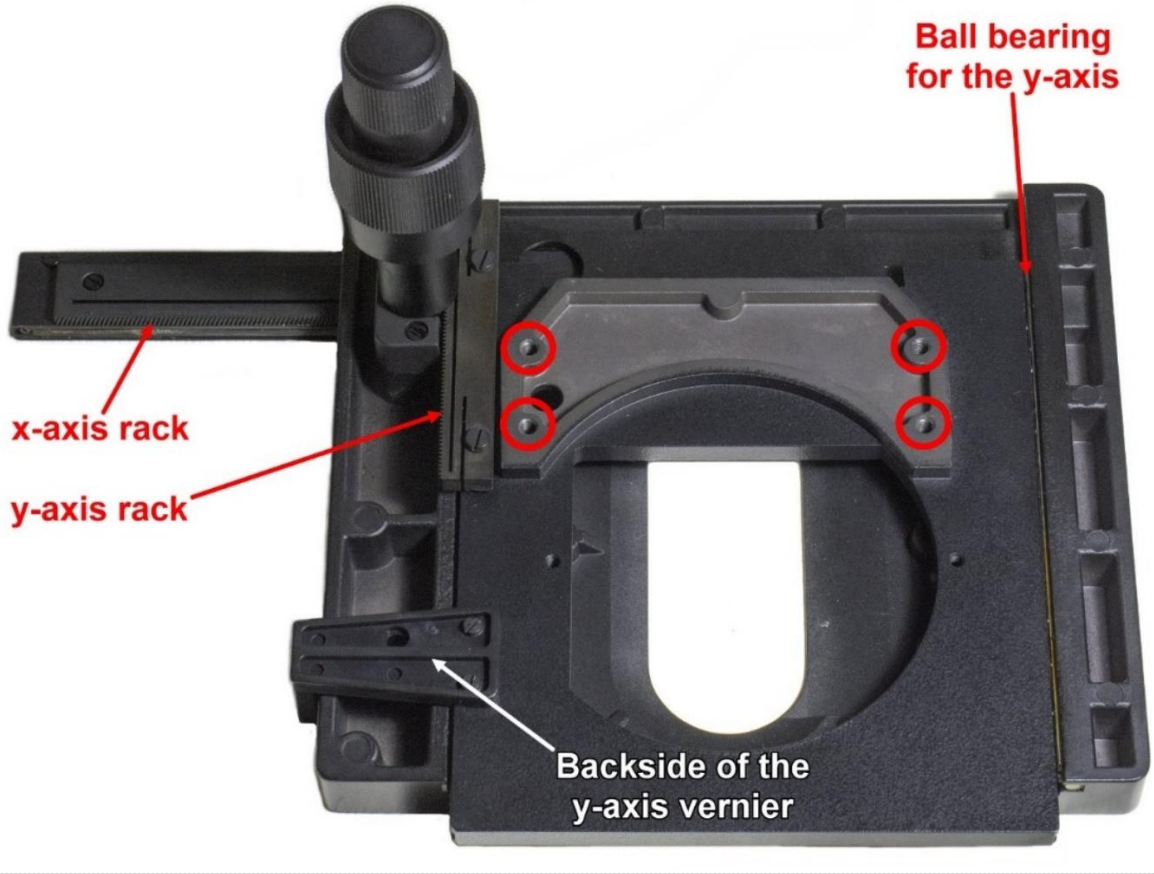

Figure 3: The stage viewed from the underside.
Red circles: Screw holes for the four screws attaching the stage to the focus slide.

Remove the y-axis vernier (Figure 3.) It is attached to the backside of the stage with two black M2x8 screws.

Figure 4: The stage holder.

Figure 5: A 0.07 thick shim next to the M4 screw around which it was attached.

2. Remove the coaxial stage control from the stage.

Remove the plastic cover (white arrow in Figure 6) that protects the base of the coaxial stage control.

Use a 1.5 mm Allen (hex) key to release the locking screw in the side of the y-axis knob (i.e., the larger of the two coaxial knobs) and slide the knob out of the way towards the base of the control (Figure 7.)

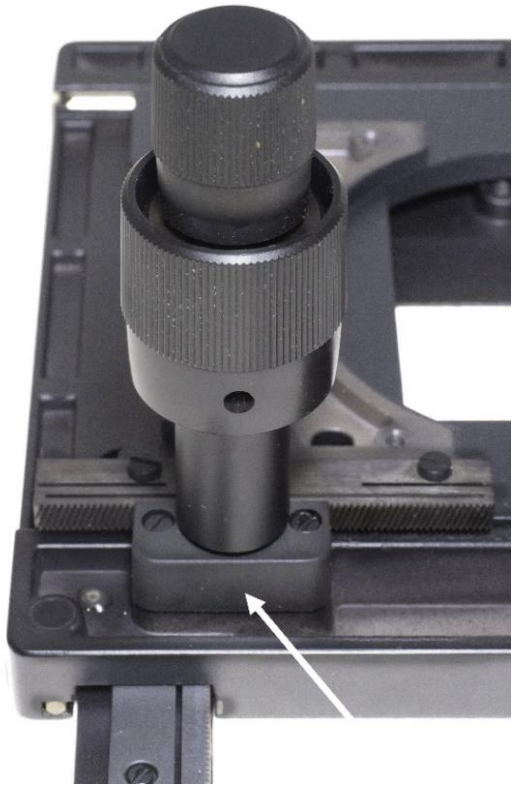

Figure 6: The coaxial stage control.
The white arrow points to the plastic cover over the base of the control.

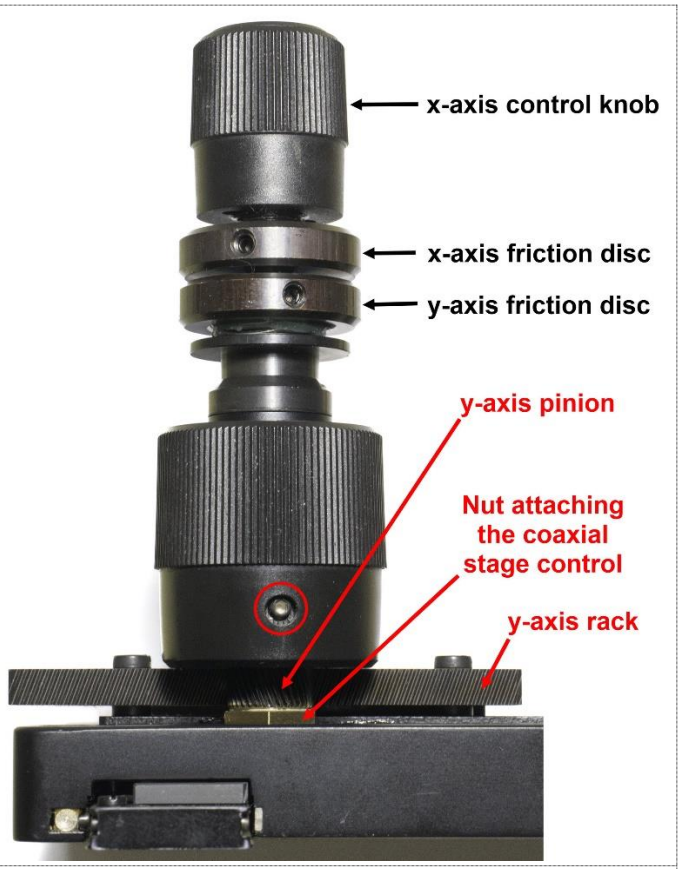

Figure 7: The coaxial stage control after the y-axis knob has been released. The friction discs are now available for adjustment.
Red circle: Hex screw that holds the y-axis knob attached to the control.

The coaxial stage control (Figure 6) has separate rack-and-pinion mechanisms for the movements in the x- and y-axis directions (Figure 3.) The racks do not have any grease applied. The smoothness of the control knobs can be adjusted with friction discs (Figure 7) under the y-axis knob (the larger of the knobs). The discs are greased and can be turned to be moved up and down on the shaft threads. By screwing the discs up or down, the pressure, and thereby also the friction, against the adjacent sliding surfaces on the control knobs can be varied to adjust how light or heavy the stage movements will be (Figure 7.) Before adjustment each disc must be unlocked by loosening a small hex screw in its periphery (using a 1.5 mm Allen key.)

Remove the y-axis rack (Figure 3) behind the stage control - it is attached with two M3x12 screws. Don't lose the 1.45 mm washers that sit between the rack and the stage.

Remove the coaxial stage control using a thin 12 mm open ended wrench to unscrew the brass nut at the base of the control (Figure 7.) The space around the nut is too narrow for a regular wrench, so a

special wrench with a maximal thickness of 2 mm is required. The nut is actually not only a simple nut, but also the visible part of a hollow brass shaft that supports both the x- and y-axis stage controls. Figure 8 shows the control after being removed from the stage.

Figure 8: The coaxial stage control after removal from the stage. The previously loosened y-axis knob is to the left and the cap from the x-axis knob is to the right. Below is the y-axis rack including its screws and washers.

3. Disassemble the coaxial stage control.

Remove the cap from the top of the x-axis control knob (Figure 8.) At a first glance it appears that the knob is solid because there is no visible slit revealing any cap. But there is a slit, although it is almost invisible. Use a scalpel or a sharp knife to find the slit and carefully pry off the cap. On the inside of the hollow knob is a nut covered with red threadlocker (Figure 9.) Due to the threadlocker and the constrained space the nut is somewhat challenging to remove. Start with cotton swabs wetted with acetone to dissolve and wipe off all the red threadlocker from the surface of the nut. The difficult part is however to soften the threadlocker that has penetrated into the threads of the nut. Typically, one would use heat to soften the threadlocker, but this could damage the knob which is made of plastics. A gentler (albeit

Figure 9: The x-axis knob with the cap removed. The nut is covered with a red threadlocker.

slower and more tedious) way is to treat the nut with acetone to soften the threadlocker. With the stage control in a vertical position and the knob facing upwards, arrange a small piece of cotton to sit on top of the nut and use it as a wick to keep the top of the nut wet with acetone. The acetone evaporates quickly, so it is important to dropwise (use a pipette) add acetone quite often to keep the swab well moistened with acetone all the time. The plastic knob appears to be tolerant to acetone, but it is probably a good idea to prevent the acetone from overflowing anyway. Note that acetone is very flammable.

After an hour of acetone treatment make a first effort to release the nut. Fasten the steel pinion that sticks out from the bottom of the stage control in a vise. If possible, avoid regular flat vise jaws, instead use a vise with semi-circular jaws of the type that often is used for pipes. But above all, it is very important to protect the pinion teeth from damage by the vise jaws. Therefore, thoroughly line the jaws with layer(s) of some durable material (e.g., a piece of a PVC hose, or slices from an old bicycle tire) and be careful not to tighten the vise so hard that the pinion teeth break through the protection and get damaged by direct contact with the jaws.

Use a 5.5 mm socket wrench to release the nut in the knob. If it doesn't work (the main worry is that the pinion in the vise could be damaged), repeat the acetone treatment of the nut, this time for a longer time, and then make another try to remove it.

Once the nut has been successfully removed and the knob unscrewed, the rest of the stage control can easily be completely disassembled. Figure 10 and Figure 11 illustrate and describe the disassembled parts. Be aware that due to manufacturing changes some details of your stage may differ from this description. Therefore, make your own notes/photos to be sure that you will be able to reassemble the parts again.

Use solvent (e.g., white spirit) to thoroughly clean all parts from old grease. Allow the parts dry in the air.

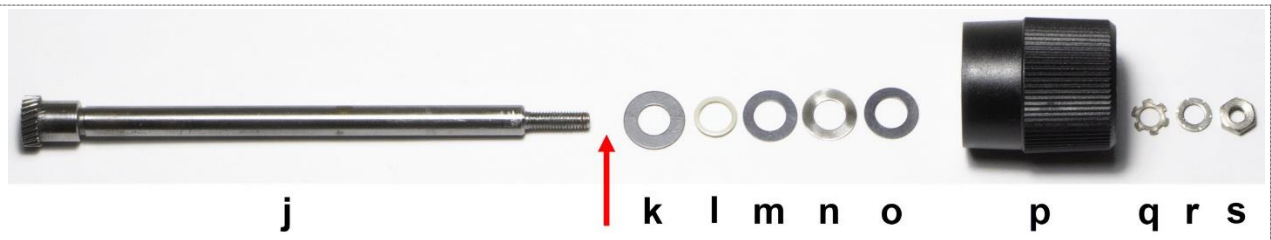

Figure 10: The x-axis control parts after disassembly. From the left to the right:

- *The x-axis control axle (steel) with the pinion at the lower end and a M3 thread on the upper end.*
- *(The red arrow indicates where the parts from Figure 11 will go at reassembly.)*
- *Black metal washer, 0.5 mm thick, i.d. 5.1 mm, o.d. 10.0 mm*
- *White plastic washer, 0.8 mm thick, i.d. 5.1 mm, o.d. 7.0 mm*
- *Black metal washer, 0.2 mm thick, i.d. 5.1 mm, o.d. 8.9 mm*
- *Shiny wave washer, 0.2 mm thick, i.d. 5.1 mm, o.d. 8.9 mm*
- *Black metal washer, 0.2 mm thick, i.d. 5.1 mm, o.d. 8.9 mm*
- *Black plastic x-axis knob with inside M3 thread (the cap is not included in the figure)*
- *Star washer with six teeth, 0.85 mm thick, i.d. 3.2 mm, o.d. 6 mm*
- *Shiny metal washer, 0.5 mm thick, i.d. 3.3 mm, o.d. 5.7 mm*
- *M3 nut, fits a 5.5 mm socket wrench*

Figure 11: The y-axis control parts after disassembly. From the left to the right:

- *White plastic washer, 0.8 mm thick, i.d. 5.1 mm, o.d. 8.9 mm. This washer sits on the inside of the threaded end of the hollow brass shaft.*
- *Hollow brass shaft that supports the x- and y-axis controls. It is attached to the stage by a thread below the nut*
- *White plastic washer, 0.5 mm thick, i.d. 7.6 mm, o.d. 11.0 mm*
- *The y-axis control barrel (black metal) with the y-axis pinion at the lower end. The y-axis control knob is attached to its upper end*
- *White plastic washer, 0.6 mm thick, i.d. 7.6 mm, o.d. 13.7 mm*
- *Wave washer, 0.2 mm thick, i.d. 8.1 mm, o.d. 13.8 mm*
- *White plastic washer, 0.6 mm thick, i.d. 7.6 mm, o.d. 13.7 mm*
- *y-axis friction disc*
- *x-axis friction disc*

4. Grease and reassemble the coaxial -stage control.

The consistency of the grease used in the coaxial control determines how light vs. heavily the stage will move, although some adjustment also can be done with the two friction discs (Figure 7.) I prefer a fairly easily moving stage, so I choose to use Super Lube (refer to section Grease above) which can be characterized as a medium thick grease. Apply the grease generously and wipe off any excess of grease after assembly.

Grease the white plastic washer (“a” in Figure 11) thoroughly and push it down over the hollow brass shaft (“b” in Figure 11) all the way down to the nut. Grease the outside of the hollow brass shaft but avoid getting grease on the threads. Push the shaft all the way into the y-axis control barrel (“c” in Figure 11) while slowly rotating it to spread the grease evenly. Wipe off any excess grease that has been displaced.

Thoroughly grease both sides of the three washers (“d”, “e” and “f” in Figure 11) below the y-axis friction disc (“g” in Figure 11) and push them in the correct order over the upper end of the hollow brass shaft so they rest on the flat end (flange) of the y-axis control barrel (“c” in Figure 11.) Grease the underside of the y-axis friction disc and screw it all the way down on the thread of the hollow brass shaft until it reaches the washers. Then also screw the x-axis friction disc (“h” in Figure 11) all the way down until it almost reaches the y-axis friction disc. Apply grease on the upper surface of the x-axis friction disc.

Grease both sides of the plastic washer (“i” in Figure 11) and attach it onto the ledge on the inside of the bottom of the hollow brass shaft. Thoroughly grease the x-axis control axle (“j” in Figure 10) except the pinion and the thread. Push it all the way into the hollow brass shaft while slowly rotating it to spread the grease evenly. Wipe off any superfluous grease above the pinion.

Thoroughly grease both sides of the five washers (“k”, “l”, “m”, “n” and “o” in Figure 10) that should sit below the x-axis knob (“p” in Figure 10) and put them in the correct order over the end of the x-axis control axle until they rest on the x-axis friction disc. Wipe off any grease that may have become

attached to the threads on the upper end of the x-axis control axle and clean the thread with cotton swabs wetted with solvent. It is important to remove any grease on these threads as it would inhibit the curing of the threadlocker applied later.

Attach the x-axis knob onto the end of the x-axis control axle. Screw it down as far as it goes and tighten it with your fingers only. Attach (without greasing them) the star washer ("q" in Figure 10) and the shiny washer ("r" in Figure 10) to the tip of the x-axis control axle on the inside of the knob. Clean again the thread above the washers with cotton swabs wetted with solvent. Apply fresh threadlocker (for example, Blue Loctite or Green Loctite) to the thread above the washers and then attach the nut ("s" in Figure 10.) Protect your fingers with a piece of cloth, hold the pinion at the bottom of the stage control with your fingers, and use a 5.5 mm socket wrench to tighten the nut. The purpose of this finger tightening is to have the nut firmly attached without overdoing it.

Leave the threadlocker to cure for at least 24 hours. If, after completed curing, there is any excess threadlocker on the surface of the locking nut, then wipe it off with a cotton swab. Note that the threadlocker only cures under oxygen deficiency, i.e., only where it has penetrated the thread, so it is normal to find uncured threadlocker on external surfaces.

Attach the cap to the top of the x-axis control.

5. Disassemble and clean the stage's x-axis slide.

The stage's x-axis slide (Figure 1) moves on linear ball bearings, with one bearing on each side of the slide. The tension over the bearings and the slide can be varied by six adjustment screws on the back side of the stage (Figure 12.) The tips of the screws press against the side of a guide rail (Figure 14 and Figure 16), which in turn distributes the tension over the bearings and the slide.

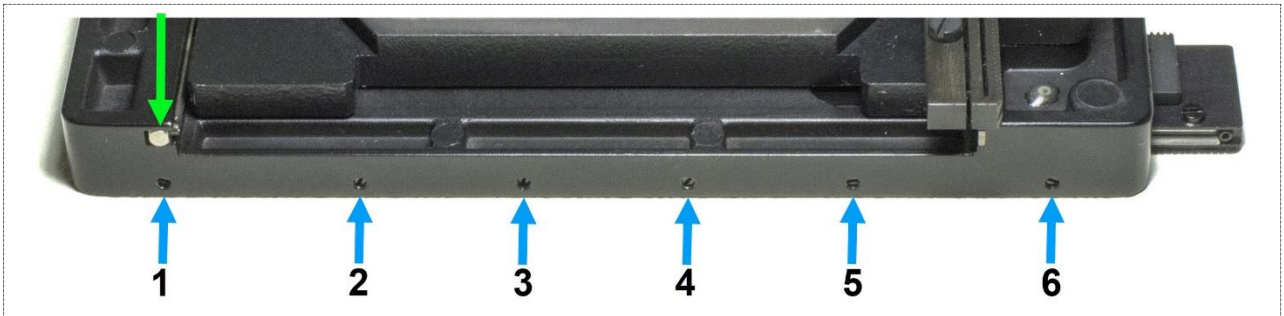

Figure 12: Bearing adjustment screws for the x-axis slide.

Blue arrows: Adjustment screws for the tension applied over the x-axis ball bearings.
Green arrow: The tip of the guide rail of the y-axis slide.

To disassemble the x-axis slide put the stage on the table with its underside facing up. Pull out the x-axis slide until the four screws on its underside are accessible as shown in Figure 13.

Remove the two screws (M2x3) that limit the x-axis slide range ("A "in Figure 13.) The x-axis rack doesn't need to be removed from the slide, so just leave the "B" screws as they are.

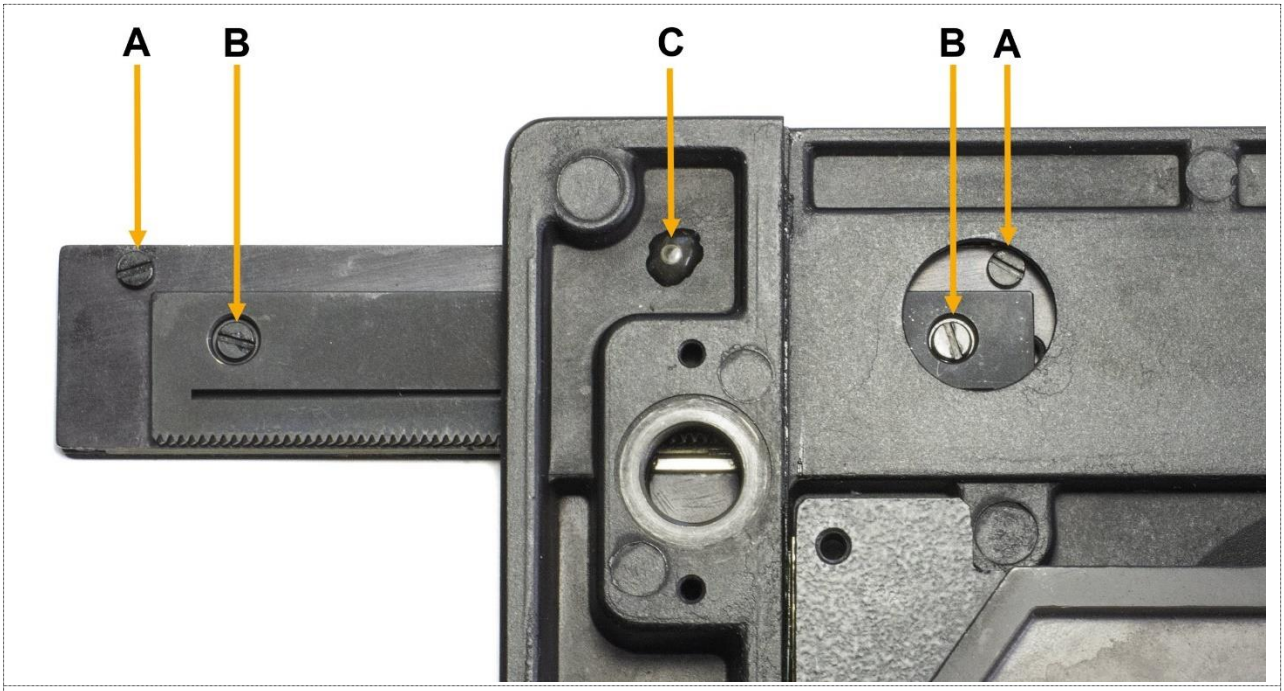

Figure 13: The x-axis slide pulled out to reveal four screws on its underside. The purpose of the circular hole in the stage base is to provide access to two of these screws.

A = Stop screws (M2x3) limiting the range of the x-axis slide. The screws can't move past a pin that sticks down at position C.
B = Screws (M2x4) to adjust the tightness between the x-axis control pinion and the x-axis rack. (Just below the rack are washers (0.2 mm thick, i.d. 2.6 mm, o.d. 5.4 mm) that raise the rack by 0.2 mm from the backside of the x-axis slide.

Now we need to remove the six bearing adjustment screws indicated with blue arrows in Figure 12. These screws are of the headless slotted type and sit a few mm down in the screw holes. They are also secured with a light threadlocker (probably shellac). The threadlocker can be softened by applying a small drop of alcohol (iso-propanol) into each screw hole, then after a couple of minutes the screws can be loosened and removed with a good 1.8-2.0 mm screwdriver. (Don't clean off any remaining threadlocker – when the screws later are reattached the remaining threadlocker will still be able to keep the screws enough well secured.)

Push/pull out the ball bearing guide rail (from the side as the blue arrow indicates in Figure 14) and then also pull out the x-axis slide as shown in Figure 15. This will provide a small gap between the guide rail and the slide (green arrow in Figure 15). Through this gap pull out and remove the ball bearing retainer with the bearing balls (faintly visible between the slide and the guide rail in Figure 15). After that it's easy to pick apart the entire x-axis slide (Figure 16.) Be very careful not to get any bends on the thin race rails.

Figure 14: The side of the x-axis slide. The arrow points to the end of the ball bearing guide rail. Also refer to Figure 17.

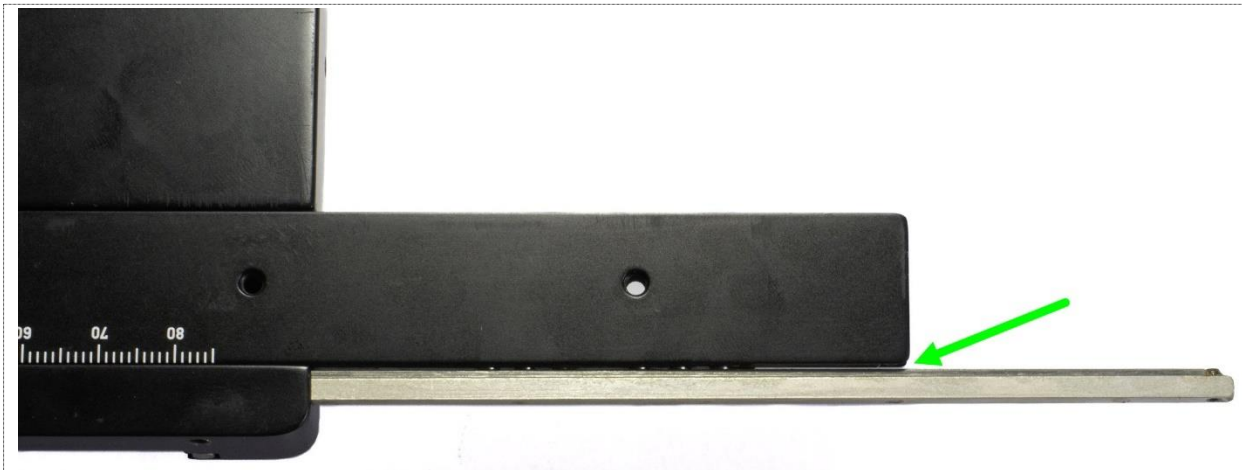

Figure 15: The x-axis slide and the bearing guide rail partly pulled out to provide a gap (green arrow) for pulling out the bearing retainer and the bearing balls.

Figure 16: The x-axis slide entirely disassembled. The image shows the following, from the top and down:

- *The back side of the stage base (the x-slide is removed.)*
- *Two ball bearing race rails (steel, 157.5 mm).*
- *Ball bearing retainer (brass) with 12 bearing balls (steel), each 2.5 mm diameter.*
- *Two ball bearing race rails (steel, 172.5 mm).*
- *The x-axis slide.*
- *Two ball bearing race rails (steel, 172.5 mm).*
- *Ball bearing retainer (brass) with 12 bearing balls (steel), each 2.5 mm diameter.*
- *Two ball bearing race rails (steel, 157.5 mm).*
- *The removable ball bearing guide rail (steel) with stop pins at both ends.*

The ball bearing race rails have triangular profiles with their hypotenuse sides facing the bearing balls. The rails sit loosely attached in grooves in the slide and the stage base (Figure 17.) Only the bearing on the outer side of the stage has a movable guide rail with tension adjustment screws.

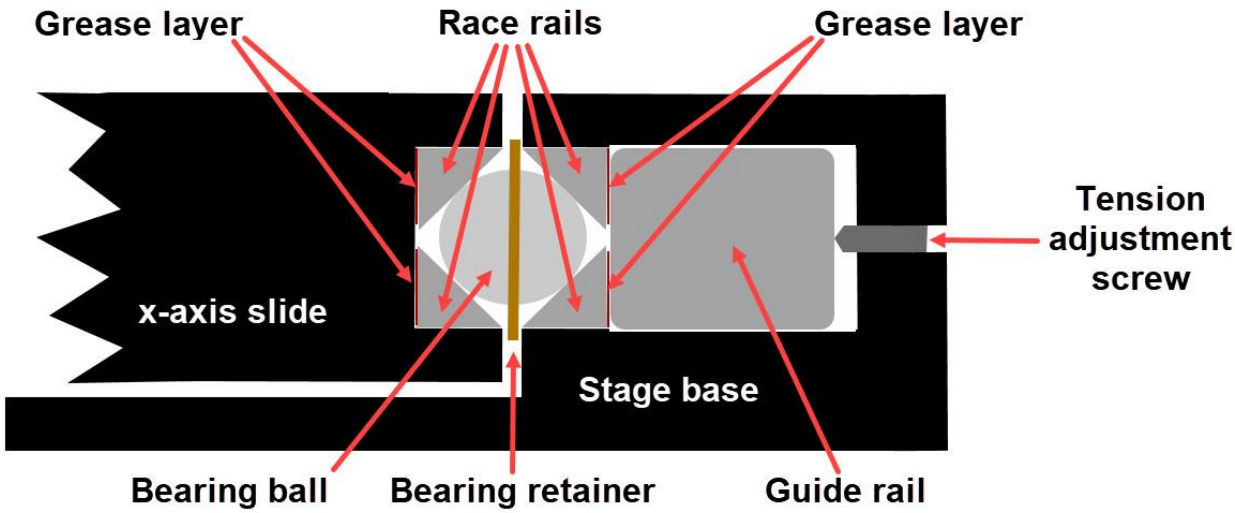

Figure 17: Drawing of the outer ball bearing viewed from the side. The x-axis slide movement is perpendicular to the image plane.

Use solvent to thoroughly clean all x-axis slide and bearing parts from old grease, dust and debris.

Check that the ball bearing retainers are straight and not bent. If necessary, straighten the retainers – they are made of brass and not difficult to straighten.

6. Reassemble the stage's x-axis slide.

Before assembling the x-axis slide you need to decide whether you want to have oil or grease applied to its linear ball bearings or let them run "dry", refer to section Grease above.

Put the x-axis guide rail into its groove on the outer side of the stage base (Figure 14 and Figure 15.) The small black stop pins at the ends of the guide rail should point towards the x-axis slide.

Now we need to attach all 8 race rails into the four ball bearing grooves. To keep the race rails in their place and prevent them from falling out while we are assembling the ball bearings, we will use medium thick grease as a temporary adhesive. Note that this grease is NOT for lubrication. Here is how to do that:

Apply some medium thick grease* to both ends of all four bearing grooves (two on the sides of the x-axis slide and two on the stage base), the red ovals in Figure 18 indicate the location and size of the greased areas. Note that the grease should not be applied along the entire length of the groove, it should only be applied as 5-8 mm rather thin blobs at the ends. Put the race rails into the grooves. Position them and push them down so they sit firmly in the corners of the grooves and with the hypothenuse side of the rails facing the bearing balls, see Figure 17. Use several cotton swabs to thoroughly wipe off any superfluous grease from the surfaces at the ends of the race rails, but be careful not to disturb the rails. Only wipe, don't use solvent. The idea is to remove all grease from the external

surfaces, leaving only the thin layers that act as a “glue” between the ends of the race rails and the grooves (Figure 17.)

* The type of medium thick grease is not critical. It should just be thick enough to keep the race rails secured in the grooves while we are assembling the x-axis ball bearings and slide. I used the very thick grease NyoGel 767A – it worked very well as a “glue”, but it was so thick that it was somewhat difficult to wipe off. A medium thick grease, for example Molykote 111, would be easier to wipe off.

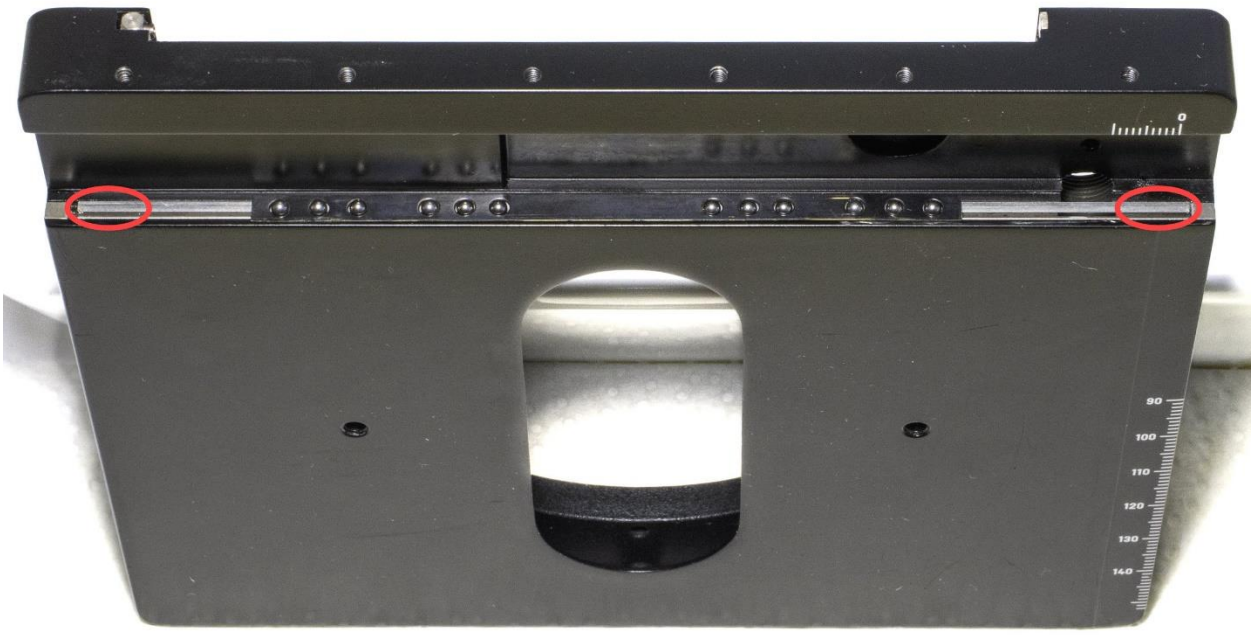

Figure 18: The stage base after race rails, retainer and bearing balls have been put in place.
*The red ovals indicate the areas where the medium thick grease was applied **(below the rails!)** as a “glue” for the rails.*

With all 8 race rails safely and properly positioned and “glued” in the four grooves we are ready to assemble the ball bearings.

Starting with the inner ball bearing (i.e., the ball bearing that does not have the adjustable guide rail), put the stage base in a vertical position, as indicated in Figure 18 (it’s OK to lean it slightly slanted against some books, for example.) Put one of the retainers over the race rails and use forceps to put 12 of the bearing balls in the retainer holes. Tap lightly on the balls to position them properly in the race. If you decided to lubricate the bearings, apply a tiny blob or drop of a suitable grease or oil (refer to section Grease) on each of the balls. Assemble the bearing by holding the x-axis slide somewhat slanted and put it over the just assembled bearing balls. Then push the x-axis slide towards the stage base until it rests on the bearing on the base. The spaces for the bearings between the stage base and the x-axis slide are so constrained that the inner bearing is secured and will not fall apart (at least as long as we don’t pull out the slide or turn the stage upside down, of course.)

Push the x-axis slide to center it in the stage base, i.e., to sit end-to-end with the stage base (Figure 19), and make sure that it remains in this position during the following procedure. Use a stick or a nail to push and pull out the guide rail until approximately half of it sticks out from the side of the stage as in Figure 19. The thick “glue” grease below the race rails should keep the rails properly positioned on top of the guide rail, but be careful, they are still vulnerable to come loose if nudged. Without disturbing the

race rails put the other bearing guide on top of the rails (Figure 19) and carefully push it in so its end is just within the opening between the stage base and the x-axis slide, as in Figure 19. Use tweezers to put one bearing ball in the first hole, i.e., the hole closest to the slide. (If you decided to lubricate the bearings, also apply a tiny blob of grease or oil to the ball.) Carefully push the retainer only (not the guide rail) further in until the ball just disappears between the slide and the stage base. Then put the next ball in the next hole (and add a grease or oil blob to it, if applicable), and again push the retainer further in until this 2nd ball also disappears. Proceed in the same way for each of the remaining 10 balls. After half of the balls, or so, have been added, the retainer will eventually no longer stick out more than the guide rail – it will sit between the guide rail's stop pins. From this point you should push in the guide rail together with the retainer after each added ball. Finish by pushing in the guide rail so it is centered in its groove in the stage base with none of it ends sticking out.

Figure 19: The guide rail pulled halfway out of the x-axis slide. Then the retainer can be inserted on top of it, and the bearing balls can be added.

Attach the two stop screws (M2x3) that limit the range of the x-axis slide (denoted by "A" in Figure 13.)

Attach the six bearing adjustment screws to the side of the stage base (Figure 12) but don't tighten them yet. These screws will now be used to "tune" the x-axis slide so it moves without any play but at the same time completely freely. Hold the stage with the x-axis slide in a vertical position. Move the slide up and let go of it, so it falls/slides down by its own weight (carefully, of course, we don't want to break the stop screws). At this stage the slide will move freely through its entire range (as determined by the stop screws), but there will also be a lot of play. Now tighten the six bearing adjustment screws until they just begin to feel tight, and then release them ½ turn. The slide should still move freely and fall down through the entire range by gravity only. Start by tightening screw no. 1 (in Figure 12) in small increments until the slide stops moving freely in some part of the movement range. Release the screw a (very) small amount and test the movement. The goal is to tighten the screw as much as possible, but not so much that the slide's movement by gravity is inhibited in any part of its range. It may be a good idea to try it back and forth several times to acquire a feeling for how it works. It is quite surprising how sensitive the slide is for even the smallest turning of the screws. When screw no. 1 is satisfactorily adjusted, proceed in the same way with screws 6, 2, 5, 3 and 4 (in this order.) Do a final check that the slide still moves freely (i.e., by its own weight) through the entire movement range.

The threadlocker left in the threads when the adjustment screws were removed is probably still good enough to keep the screws secured. But if desired, the screws can be additionally secured by applying a small drop of a suitable fresh threadlocker to their heads; for example, shellac dissolved in isopropanol (approx. proportion 1:10, note that the solution has limited shelf life.)

7. Disassemble, clean and reassemble the stage's y-axis slide.

Apart from a few obvious details, the procedure for the y-axis slide is the same as for the assembly of the x-axis slide. Therefore, please refer to the work notes above for the x-axis slide.

One difference is that the tension over y-axis slide is applied with only four adjustment screws, refer to Figure 20. When reassembling and adjusting the slide tighten these screws in the following order: No. 1, and then 4, 2 and 3.

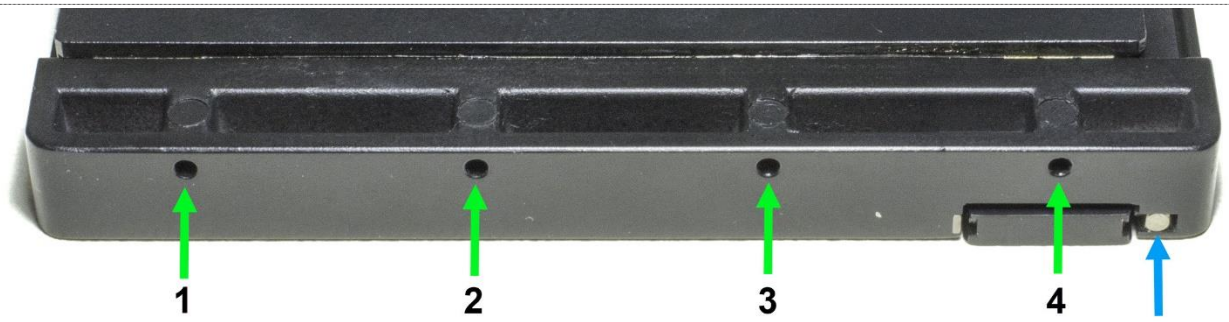

Figure 20: Bearing adjustment screws for the y-axis slide.

Green arrows: Adjustment screws for the tension applied over the y-axis ball bearings.
Blue arrow: The tip of the guide rail of the x-axis slide.

8. Attach the coaxial stage control to the stage.

Check that the friction discs ("g" and "h" in Figure 11) are only loosely touching against the collar of the y-axis control axle ("c" in Figure 11) and the underside of the x-axis knob ("p" in Figure 10), respectively. We need the knobs to turn with minimal friction when we adjust the racks.

Push the y-axis control knob over the coaxial stage control (Figure 8) from the underside. Tighten the knob's locking screw (but not too hard, we will soon need to loosen it again when we adjust the friction discs.)

Attach the coaxial stage control to the stage (Figure 7.) Use a thin (max. 2 mm) 12 mm open ended wrench to tighten the brass nut to the stage.

9. Adjust the y-axis rack.

Attach the y-axis rack (Figure 3, Figure 6, Figure 7 and Figure 8) including the washers to the stage, but leave the screws only loosely tightened. We now need to adjust the tension between the y-axis rack and the y-axis pinion until the movement of the y-axis slide through its entire range is completely free from play while still running very smoothly. This is accomplished by repeated trials of pressing the rack with the fingers against the pinion, successively tightening the rack screws, and turning the y-axis knob to test the movement through the entire range.

Begin by turning the y-axis control knob until one of the screws attaching the rack is adjacent to the pinion. Use your fingers to press the rack against the pinion and tighten the rack screw just enough to retain the rack's tightness vs. the pinion. Test the slide movement by turning the knob slightly back and forth. Even the faintest play means that the rack needs to be set tighter against the pinion. On the other

hand, too much tightness is indicated by a movement that feels somewhat rough and “hard”. Typically, a few trials back and forth will be needed before it feels satisfactory.

Then turn the knob to move the slide so the other rack screw is adjacent to the pinion and repeat the above adjustment procedure.

Check that the slide movement is satisfactory through the entire range. Readjust, if necessary, and then give the rack screws a final tightening.

10. Adjust the x-axis rack.

Use the same procedure as above to adjust the tension between the x-axis rack (Figure 3 and Figure 13) and pinion, this time with screws “B” in Figure 13.

Attach the plastic cover (white arrow in Figure 6) over the base of the coaxial stage control.

11. Adjust the friction applied on the coaxial stage control knobs.

There are different opinions about how light or heavy the stage movement should be for the best performance and ergonomics. It is very much a matter of personal preference, so on your microscope, you will decide.

Generally, you should strive to get roughly the same feeling for both the x-axis and the y-axis knobs. Also, you should be aware that opting for very light knob movements may lead to an irritating tendency for the stage to move inadvertently in the Y-direction just by grabbing the coaxial control.

Loosen the locking screw in the side of the y-axis knob and push the knob down towards the stage base to provide access to the friction discs (Figure 7.)

If not already loose, loosen (but don’t remove) the small locking screw in the periphery of the x-axis friction disc. Turn the x-axis knob back and forth while screwing the x-axis friction disc tighter and tighter against the underside of the knob. Switch between tightening the disc and loosening it, to find an optimal tightness. Once you like the feeling of the x-axis knob, secure the position of the friction disc by tightening its locking screw.

If not already loose, loosen (but don’t remove) the small locking screw in the periphery of the y-axis friction disc. Turn the black y-axis control barrel (“c” in Figure 11, recall that the knob is not attached for now) back and forth while screwing the y-axis friction disc tighter or looser against the collar of the barrel. Same as above, once you like the feeling, secure the position of the friction disc by tightening its locking screw.

Push back the y-axis knob towards the x-axis knob and secure it by tightening its locking screw.

Do a final check that you are satisfied with the feeling of the knobs.

12. Attach the stage to the microscope.

Attach the y-axis vernier (Figure 3) to the stage. Before tightening the screws adjust it so its scale is close to the stage edge without scraping against it when the y-axis knob is turned.

Attach the stage to the microscope (Figure 3.) Don’t forget any of the shims (if applicable.)

Appendix 1: The Object Glass Holder

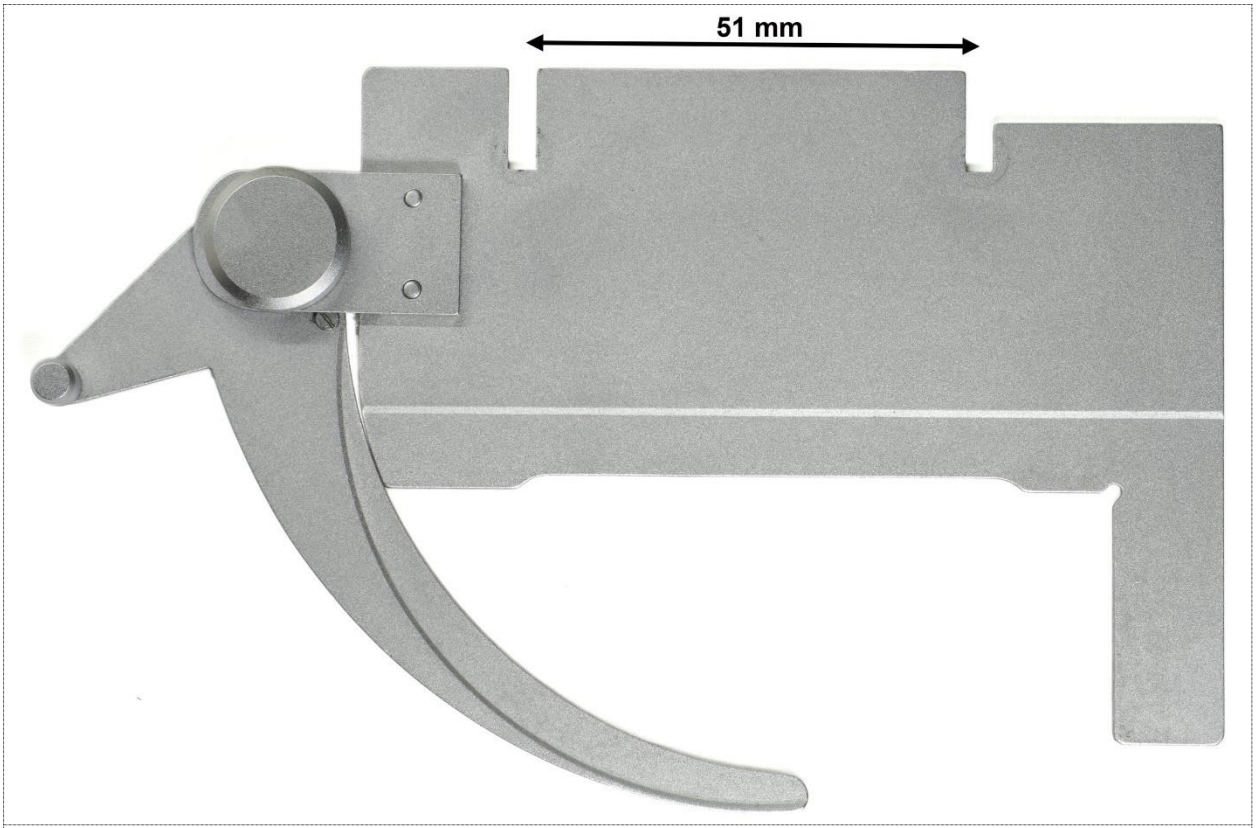

Figure 21: The object glass holder.

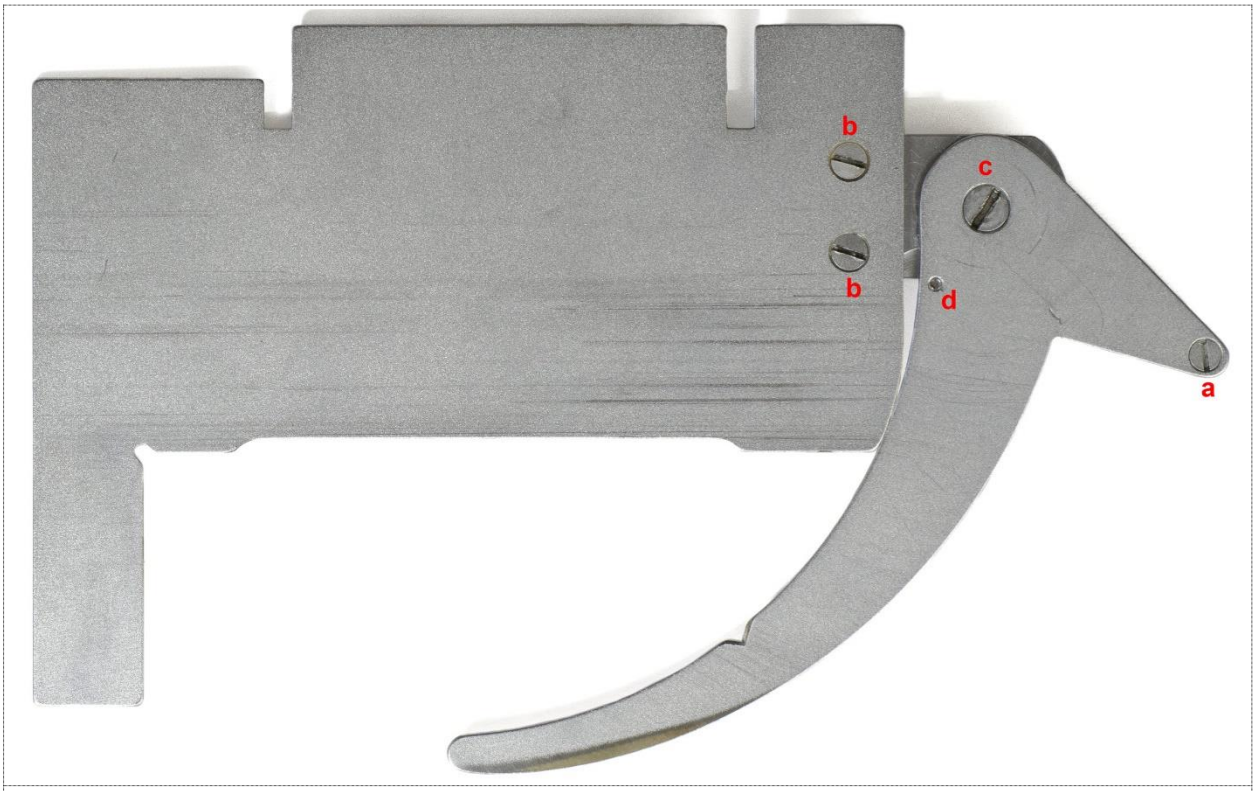

Figure 22: The underside of the object glass holder. The letters indicate the same screws as in Figure 25.

The object glass holder (Figure 21) is made of brass with a frosted chrome- or nickel-plated surface. It is attached to the stage with two M3 thumbscrews with knurled heads (Figure 23.) The only moving part is the spring-loaded object glass clamp that is used to hold the object glass in a consistent position which allows the user to (with the help of the stage's verniers) return to a previously viewed specimen area.

Figure 23: The thumbscrews that attach the object glass holder to the stage.

There is not much to maintain on the object glass holder. It may need cleaning due to dirt or corrosion from chemicals or moisture, and the spring that closes the clamp may need to be adjusted. Inspecting the clamp may by the way provide a clue to how intensely the microscope has been used. A well used clamp (for example, from a pathology lab) will show an abrasion indentation, sometimes up to a few millimeters deep (Figure 22 and Figure 24), at the point where the clamp touches the corner of the object glass.

Figure 24: Closeup of the underside of a well used object glass clamp.

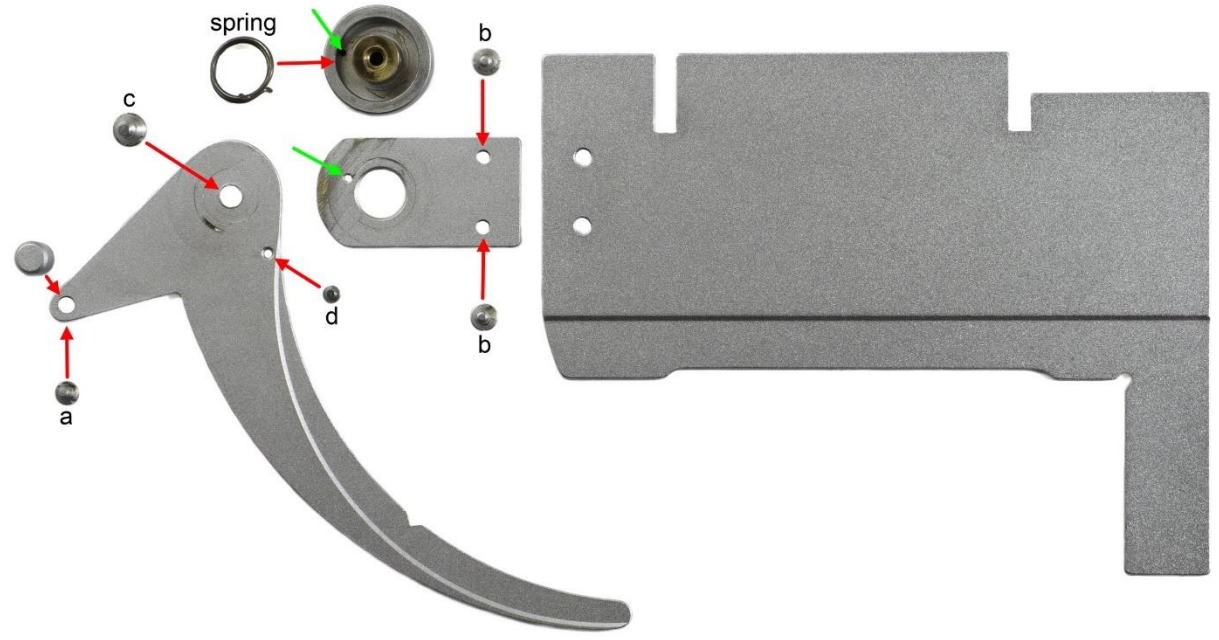

Figure 25: The object glass holder disassembled.
The red arrows indicates where the various parts are attached. The green arrows point to the holes for the spring's ends.

1. Clean the object glass holder

Most often cleaning can be done without disassembling the object glass holder, but if, for example, oil has penetrated the holder, then it may be necessary to take it more or less apart. Be aware that the small screws (Figure 22 and Figure 25) may be difficult to remove and that they have narrow drives (slots in the head), so it is important to use a well fitting screwdriver in a steady hand.

For cleaning, use pieces of cloth or cotton swabs wetted with various solvents (e.g., white spirit, isopropanol, acetone), but be careful with using water (and dishwashing detergent) as it may penetrate and stay between the various parts causing corrosion. Tarnish and milder surface corrosion can often be removed with a metal polish (e.g., Autosol) – it seems that the frosted surface plating tolerates such polishing without any signs of wear. Cleaning in an ultrasound bath with isopropanol or warm water with detergent is very efficient but works best with the object glass holder completely disassembled.

2. Adjust the tension of the object glass clamp spring

A coil spring below the small metal cap determines the tension by which the object glass clamp holds the object glass. The spring's ends stick up perpendicularly to the plane of the coil; one end fits into a small hole in the holder and the other end fits into a small hole on the inside of the cap (green arrows in Figure 25.) To adjust the spring's tension, just *barely* release screw "c" in Figure 22 and Figure 25, turn the cap clockwise (as viewed from above, typically less than ¼ of a turn will be sufficient) to apply the desired tension, and while holding the cap fixed in that position tighten screw "c" again to lock the cap. It is a little tricky, you may need to redo it a few times to get the right clamp tension.

3. Repair an indentation in the object glass clamp

Having an indentation in the clamp will only marginally hamper its function, it is mostly a cosmetic issue. It can be fixed, however, but it may be difficult to get it as nice as when it was new. One can try to fill the indentation with steel reinforced epoxy putty (for example, J-B Weld SteelStik) and file and sand it down to be as close as possible to its original shape. A more permanent repair could perhaps be attempted with something like silver brazing followed by grinding. If a narrower clamp can be accepted, the indentation could alternatively be evened out by grinding the clamp's inside in a way that retains its curvature. The clamp will in this case of course become thinner.