Condenser Holders for Leitz Microscopes with 170 mm Tube Length

Scope and Introduction

These maintenance notes describe the disassembly, cleaning, greasing and reassembly of the condenser holders with a 46 mm dovetail fork changer that were manufactured for Leitz microscopes with 170 mm mechanical tube length (Figure 1 and Figure 2.) This "family" of condenser holders was designed to support Leitz' impressive range of condenser models and versions (one condenser model is shown in Figure 3) from the later "black" era of microscopes (typically microscope stands with a T-shaped or triangular foot) and for the entire "gray" era (microscope stands with a rectangular foot.)

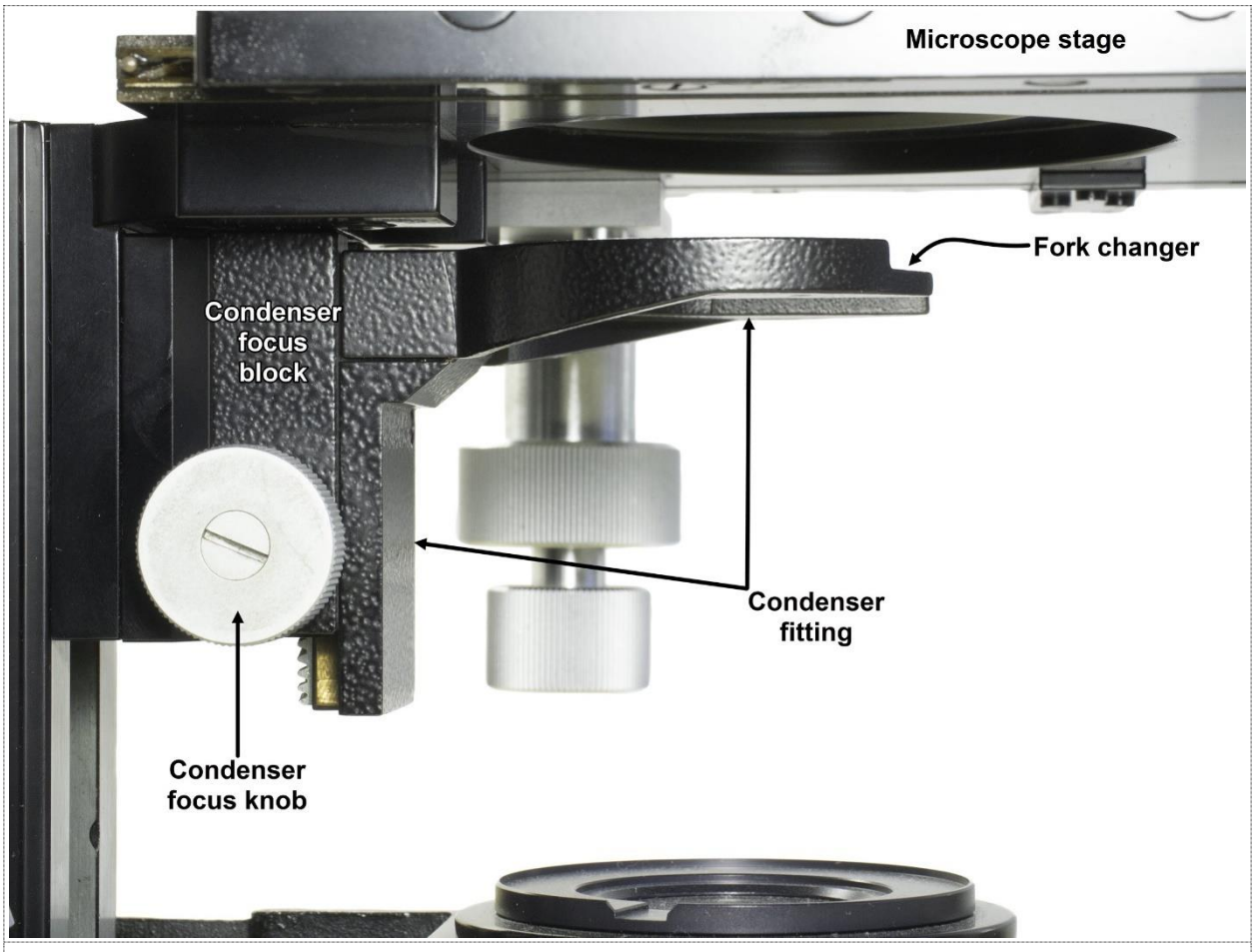

Figure 1: A condenser holder on an Ortholux microscope.

The purpose of the condenser holder is simple, but important; it is to reliably hold the condenser aligned in the microscope's illumination path and to allow the user to adjust the condenser's vertical position to set the optimal illumination conditions.

Figure 2: The condenser holder's characteristic U-shaped fork changer viewed from above.

Figure 3: The dovetail slide of the common series 600 condenser. The width of the slide is 46 mm (measured as the distance between the dovetail edges.)

The **condenser holder** (Figure 1, Figure 4 and Figure 5) consists of 1) a **condenser fitting** (the part on the left side of Figure 6) with a fork changer (Figure 2) for carrying the condenser and to allow for quick and easy condenser changes, and 2) a **condenser focus block** (the part on the right side of Figure 6) that attaches the condenser holder to the microscope and contains the rack-and-pinion mechanism that moves the condenser up or down to focus it to acquire the optimal specimen illumination. The condenser holder does not have any condenser centering mechanism; Leitz instead built separate centering mechanisms into all of the compatible condenser models that they manufactured.

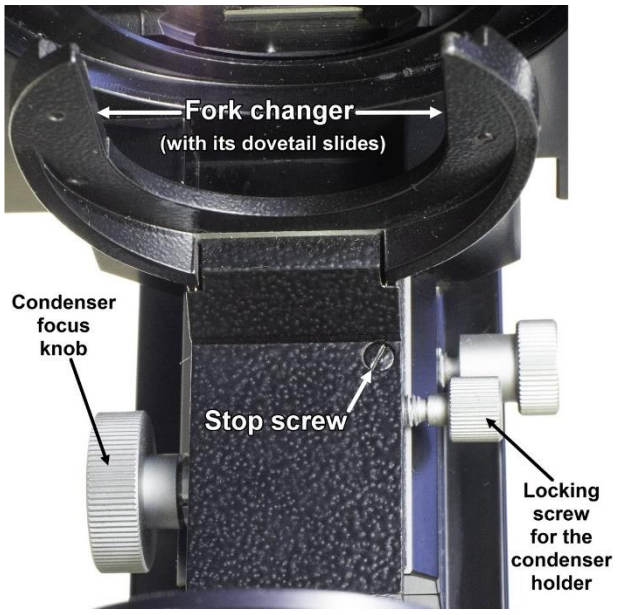

Figure 4: A removable Ortholux condenser holder – view from the front of the microscope obliquely from below.

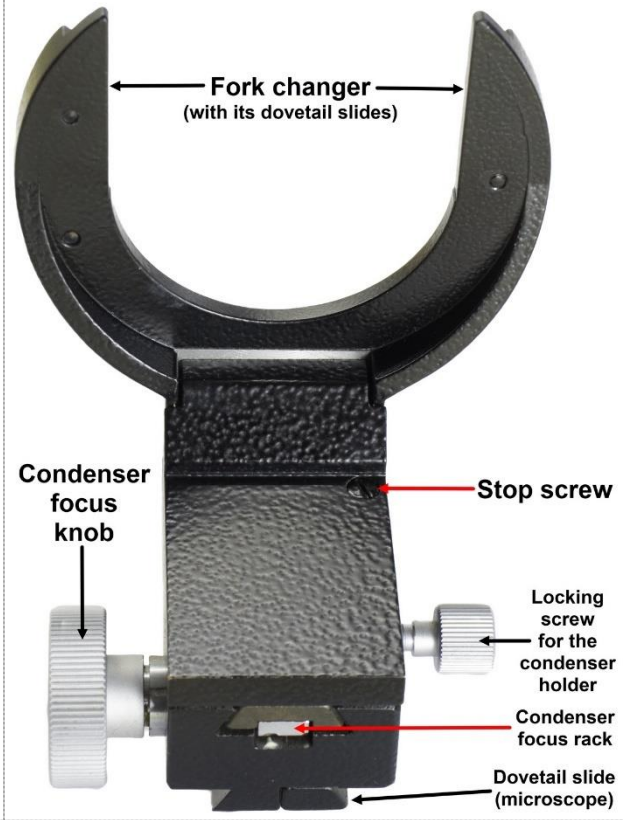

Figure 5: The removable Ortholux condenser holder after being removed from the microscope – oblique view.

Mechanically the condenser holders appear quite robust. Sluggishness of the condenser focus control is probably the most common problem, and typically it is caused by aged and hardened grease.

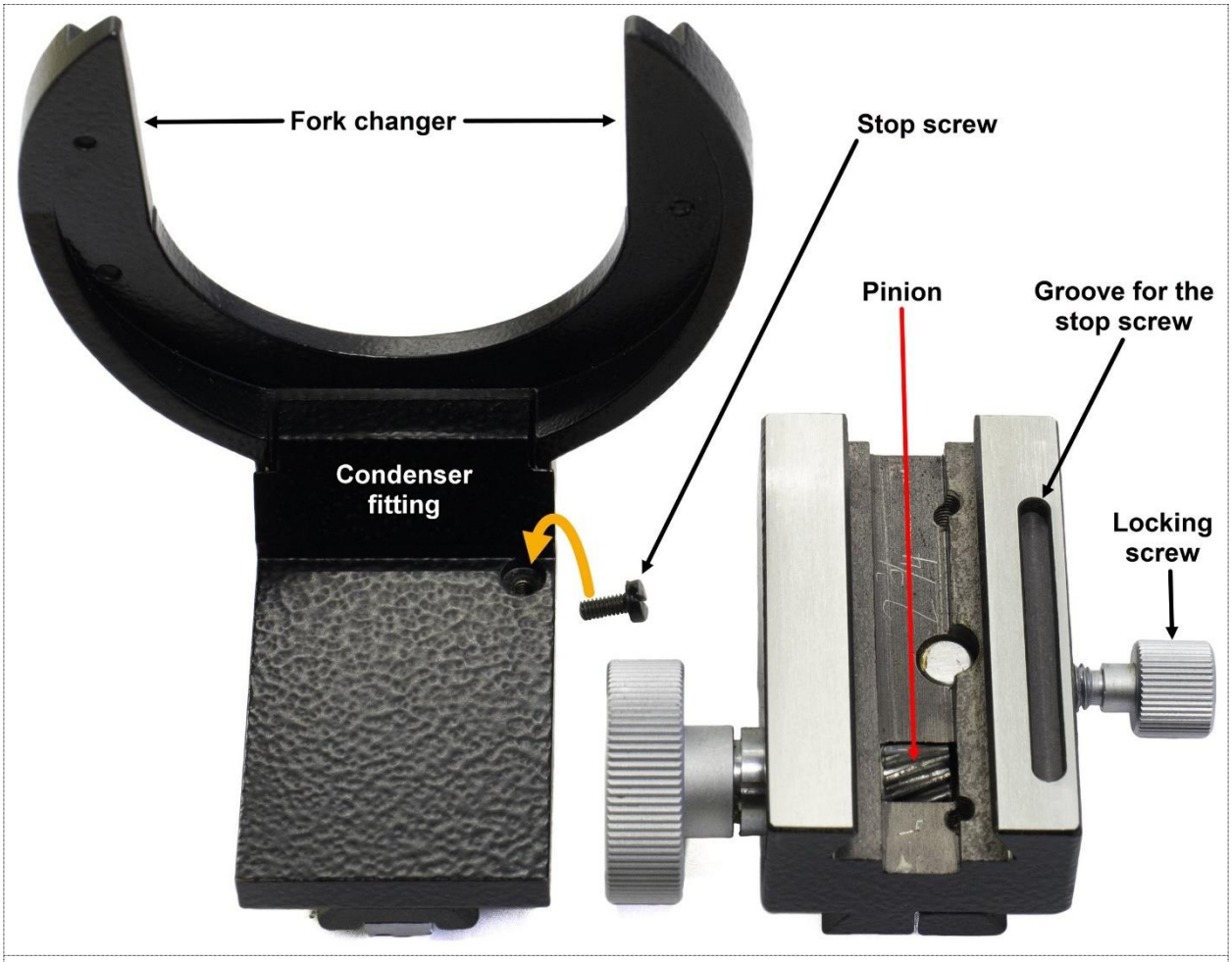

*Figure 6: A **condenser holder** disassembled into the **condenser fitting** (left) and the **condenser focus block** (right.)*

The earlier condenser holder models for circular 39.5 mm sleeve mount condensers are not covered in these maintenance notes, although many of their design features are very similar the dovetail condenser holders, if not even identical. It may be worth mentioning that Leitz offered a simple adapter (Figure 7) that made it possible to attach the older 39.5 mm sleeve condensers in the 46 mm dovetail condenser holders.

Figure 7: Adapter for 39.5 mm sleeve mount condensers.

Design differences

Throughout the years when Leitz manufactured the 46 mm dovetail condenser holders several design modifications or updates were introduced. Most of the modifications are minor; but there are a few more significant differences that deserve to be mentioned before getting to the maintenance work.

The condenser holders for the more advanced microscope models Ortholux (although only for the newer Ortholux models), Ortholux 2, and Orthoplan are of a modular design (Figure 8), i.e., the holder can easily be removed from the microscope by releasing a locking screw and sliding the holder down from the dovetail that attaches it to the microscope (actually, to the microscope's stage holder.) On the other microscope models the condenser holder is typically more permanently bolted to the microscope's stage holder by two screws (Figure 9.)

Late in the 170 mm tube length era (the "gray" era, late 1970s) some condenser holders were modernized to allow for factory adjustment of the tightness between the focus control's rack and pinion. The purpose was to eliminate any play in the condenser focus control before the microscopes were released for sale. The design differences will be explained later, but are easy to recognize even without removing the condenser holder from the microscope by checking the appearance of the bushing between the condenser focus block and the focus control knob (compare Figure 8 vs. Figure 9, and Figure 10 vs. Figure 11.)

With all design variances in mind, be prepared that parts of the condenser holder on your particular microscope may differ from the maintenance notes and the images provided here. This means that you may need to modify your maintenance procedures accordingly.

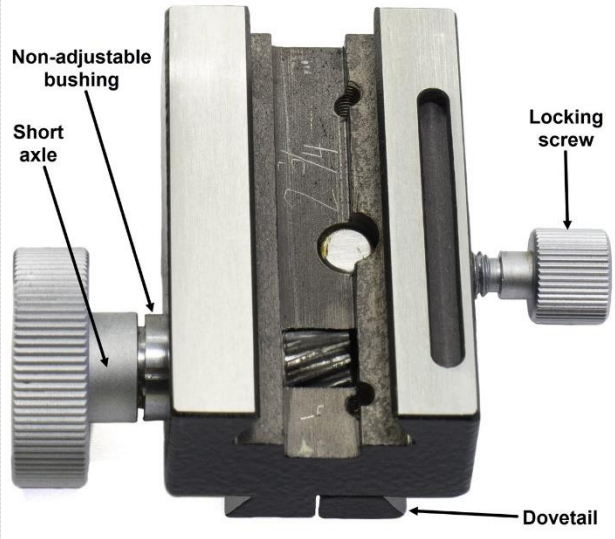

Figure 8: A condenser focus block of the removable modular type that is attached to the microscope with a dovetail mount.

The image illustrates the following design variants:

- *Dovetail mount for attachment to the microscope stand (including the locking screw)*
- *Short focus control axle*
- *Non-adjustable bushing holding the focus control axle*

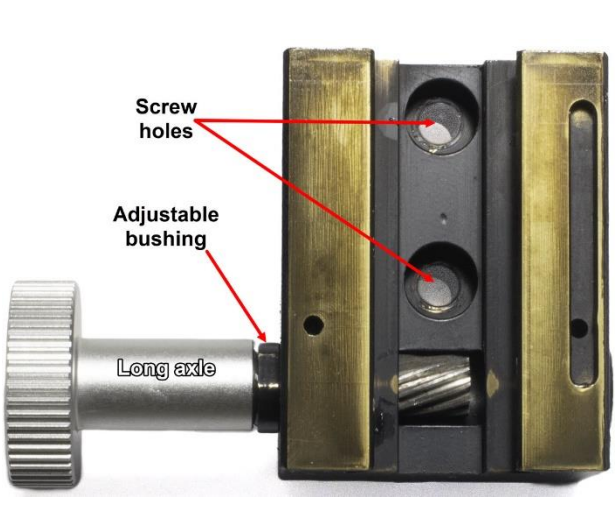

Figure 9: A condenser focus block of the permanent type that is attached to the microscope with two sturdy M4 screws.

The image illustrates the following design variants:

- *Two M4 screws for attachment to the microscope stand (no locking screw)*
- *Long focus control axle*
- *Adjustable bushing holding the focus control axle*

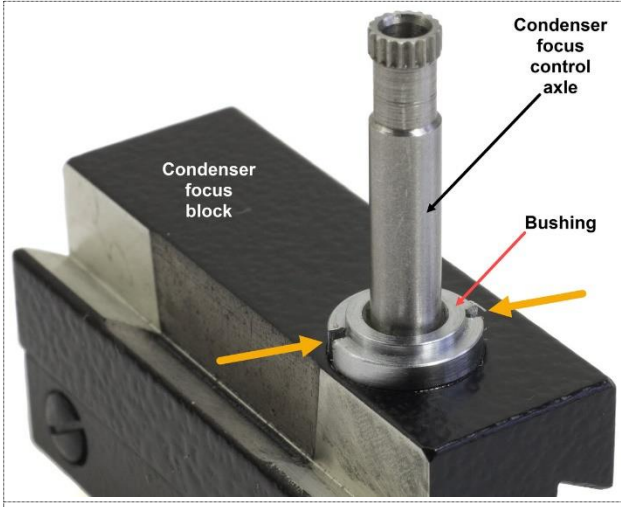

Figure 10: A condenser focus block with a non-adjustable bushing.

The control knob has been removed from the long focus control axle to show the bushing. Removing the bushing requires a special spanner that fits into the bushing slots indicated with orange arrows.

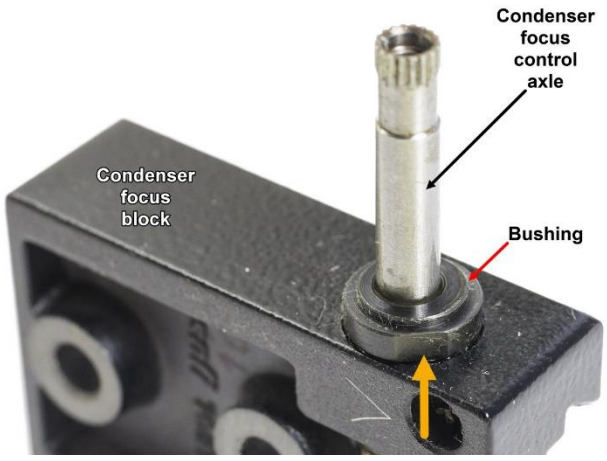

Figure 11:A condenser focus block with an adjustable bushing.

The control knob has been removed from the long focus control axle to show the bushing. Adjusting the tension between the condenser focus control's rack and pinion requires a thin wrench that is able to grip over the two flattened sides of the bushing (one of which is indicated with an orange arrow.)

A few things to consider prior to the work

During the maintenance work particularly two tasks may prove difficult; these are 1) releasing the condenser focus knob from the condenser focus axle, and 2) releasing the non-adjustable bushing (Figure 10) from the condenser focus block. The issues will be discussed in more detail later, including precautions and suggestions for problem remediation.

Another issue that is critical (but fortunately not difficult) is to know how to safely remove the fork changer from the condenser focus block (Figure 6.) The safe procedure is explained at the end of subsection 1.1 below and in Figure 15.

Before starting any maintenance work it is a good idea to think through what your condenser holder's maintenance needs are. Typically, you should not need to disassemble every part of the condenser holder. Limiting the work to what is necessary will not only save time, but also, let's face it, minimize the opportunity for accidental damage.

Grease

The condenser focus control is the part of the condenser holder that most depend on proper greasing. The grease determines how easy or hard it will be to turn the control. If the control is too loose, the condenser focus may sag due to gravity, and it may also feel somewhat unreliable, or flimsy, to the user. On the other hand, too much sluggishness makes the control unpleasant to use and increases the wear. In the maintenance notes I provide my suggestion for a balanced approach, but feel free to modify the greasing protocol according to your own preferences.

The condenser focus control has three locations (Figure 12) that can be greased; 1) the sliding surfaces between the condenser focus control axle and the bushing, 2) the sliding surfaces of the condenser focus control's dovetail, and 3) the rack-and-pinion.

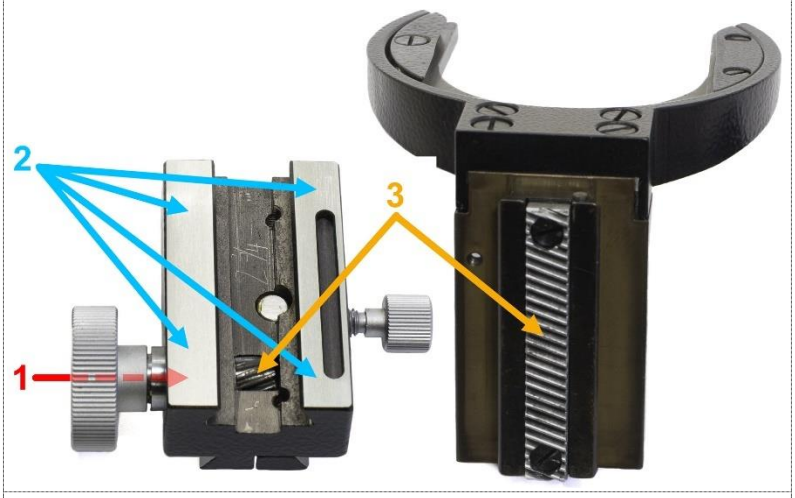

Figure 12: The condenser focus control's three greasing locations.

The smoothness/sluggishness of the condenser focus control can be adjusted by varying the grease viscosity ("thickness".) If you are interested to fine tune the feeling of the control, you could consider obtaining a few damping greases that cover a decent range of viscosities. Newgate Simms sell a "trial pack" of six Tribosyn 320 damping greases that I have found useful for testing out various microscope lubrication tasks. Also check out what other manufacturers have to offer, for example, many micro-scopists on internet appear to be fond supporters of various Nyogel greases.

For any other sliding parts, like the moving parts on the condenser fitting's dovetail slide (Figure 17), I have used the ubiquitous grease Super Lube Multi-Purpose Synthetic Grease with Syncolon (NLGI grade 2.)

Maintenance Notes

1. Remove the condenser holder from the microscope and disassemble it.

As mentioned above, the condenser holders come in two basic designs; one modular and easy to remove (Figure 8), the other more permanently attached (Figure 9) with screws to the microscope. If your condenser holder is of the modular design, then follow the procedures in subsection 1.1 below; if your condenser is attached by screws, then instead jump to the procedures in subsection 1.2 below.

1.1. Remove and disassemble the condenser holder: Modular condenser holder.

The modular condenser holder is recognized by a locking screw on the right side and by the vertical dovetail on its backside that attaches it to the microscope stand (Figure 8.) Modular holders are typically found on Ortholux (although only on the newer Ortholux models), Ortholux 2, Orthoplan, and occasionally on certain Diavert microscopes.

If not already done, remove the condenser from the condenser holder.

Turn the microscope's coarse focus control to move the microscope stage up into its highest position.

Turn the knob of the condenser focus control (a.k.a. the "condenser height adjustment") to move the condenser fitting up into its highest position.

If your microscope is an Ortholux, then push the swing-out lens's lever (on the left side of the microscope foot) backward to fold down the swing-out lens.

If your microscope is an Ortholux, also remove the field diaphragm from the microscope foot. It can be pulled out from the microscope foot 1) after releasing its locking screw on the right side of the microscope foot (Figure 13), and 2) after turning its thumbwheel so its knurled edge faces straight up (this means that the field diaphragm will be half open.) Note that older Ortholux models lack the field diaphragm.

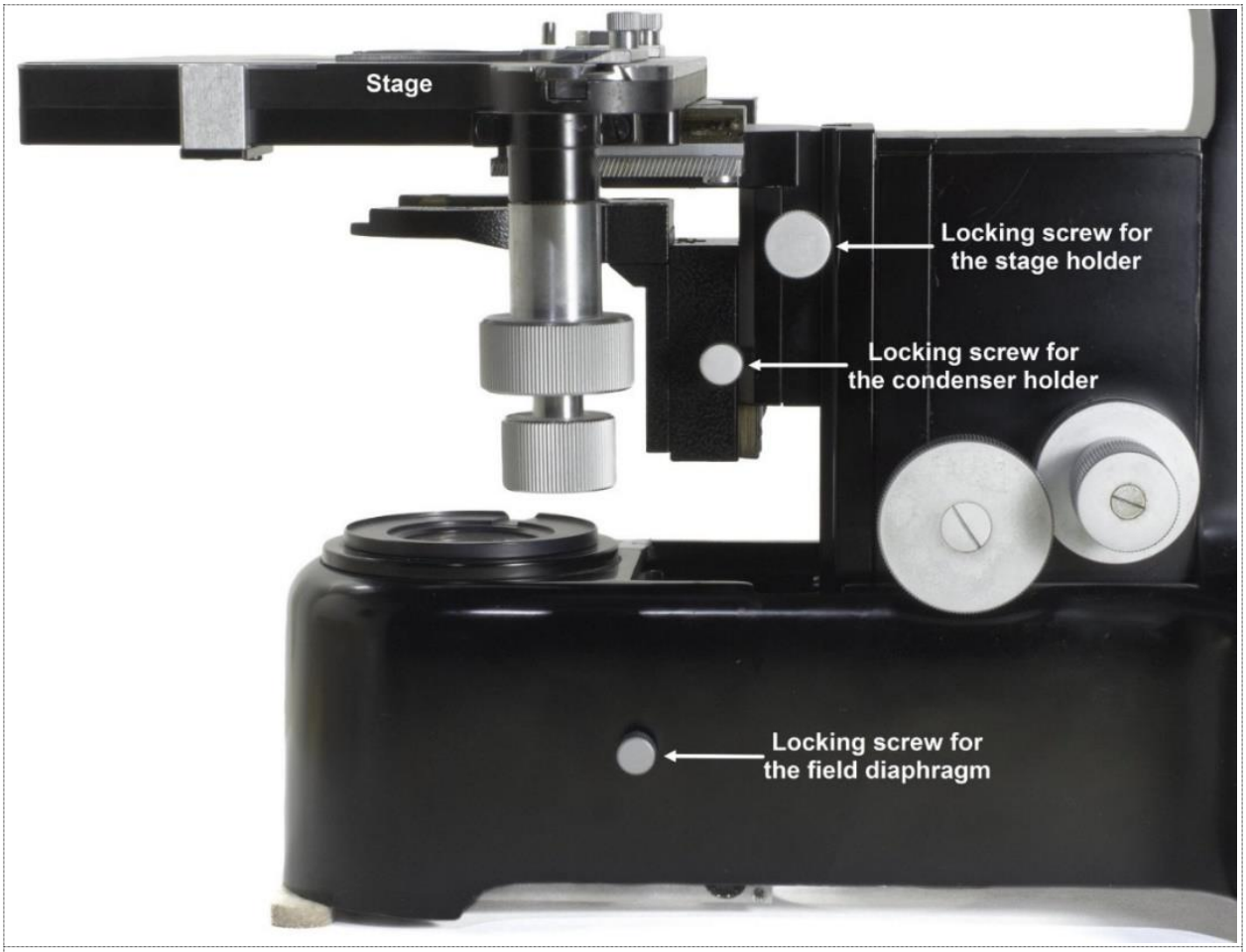

Figure 13: Some of the Ortholux microscope's locking screws.

Loosen the condenser holder's locking screw (Figure 4, Figure 5 and Figure 13.)

Remove the entire condenser holder (Figure 5) from the microscope by carefully pulling it downward. It will slide down and release from the microscope's dovetail.

If this doesn't work due to lack of space between the stage and microscope foot (which can happen on some Ortholux configurations) then you will need first to remove the objectives and the revolving nosepiece, and then to remove the entire stage (with the condenser holder attached) from the microscope. The stage is easy to remove, if you need instructions, they can be found online in Leitz' Ortholux user manuals. Once the stage has been removed from the microscope you will have plenty of space to remove the condenser holder from it.

Next, the condenser fitting is separated from the condenser focus block (Figure 6.) Start by removing the M2x5 stop screw from the condenser fitting (Figure 4, Figure 5 and Figure 6.) The tip of the stop screw reaches into a groove (black, on the right side of Figure 6) in the condenser focus block which determines the range of the condenser focus setting. With the stop screw out of the way, turn the condenser focus knob to move the condenser fitting all the way down and then manually pull it further down until it comes off from the focus control's dovetail (Figure 6 and Figure 14.)

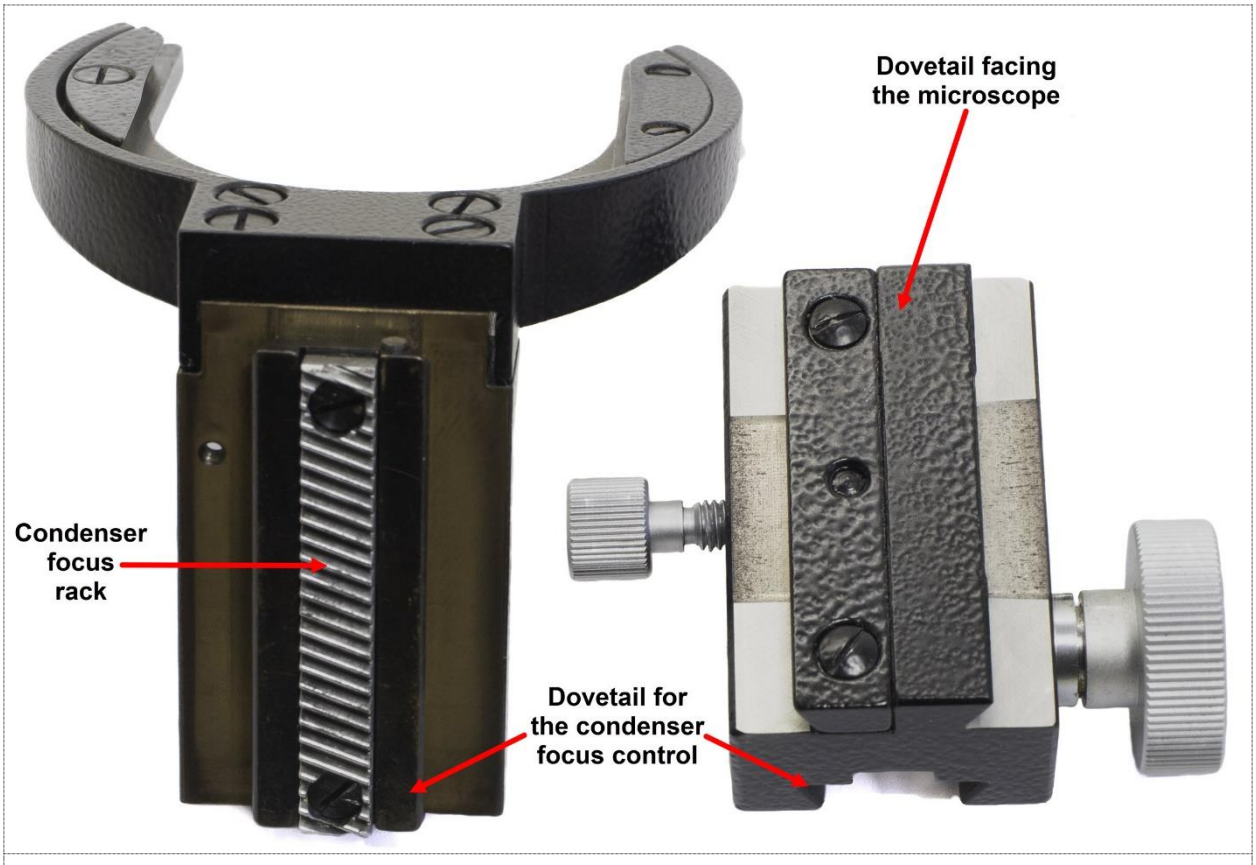

Figure 14: The same parts as in Figure 6 but viewed from their backsides.

Use solvent (white spirit) to clean the rack and all sliding surfaces between the condenser fitting and the condenser focus block (facing the viewer in Figure 14.)

Warning: Some (but not all) condenser focus racks are attached to the condenser fitting in a way that doesn't allow for removing the condenser fitting by pulling it upwards (Figure 15) from the condenser focus block. In these cases, the reason is that the lower of the two M2 screws (Figure 16) that attach the rack to the backside of the condenser fitting is insufficiently recessed, i.e., the top of its cylindrical head sticks up higher than the valleys between the rack's teeth. This of course will block the pinion and prevent further raising of the condenser fitting. The danger is that if you try to force it through, then the pinion teeth may become destroyed. Again, this doesn't apply for all condenser fittings, but to play it safe it may still be a reasonable precaution to never remove a condenser fitting by pulling it upwards from the condenser focus block.

Proceed to subsection 2 below.

Figure 15: Potentially unsafe vs. safe way to remove the condenser fitting from the condenser focus block.

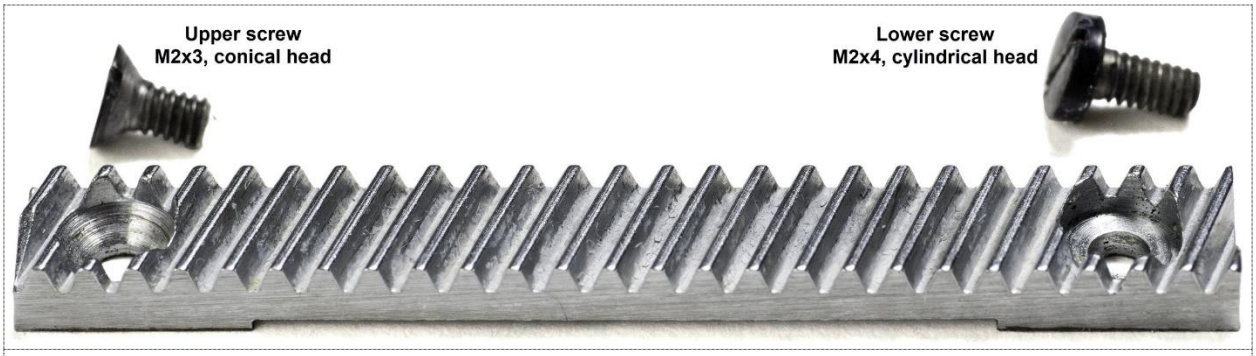

Figure 16: A condenser focus rack with its screws.

1.2. Remove and disassemble the condenser holder: Condenser holder attached by screws.

The condenser holders that are permanently attached to the microscope by screws do not have any locking screw on the side (Figure 9.)

If not already done, remove the condenser from the condenser holder.

Turn the microscope's coarse focus control to move the microscope stage up into its highest position.

The condenser fitting must be removed from the condenser focus block (looks like Figure 6 disregarding the locking screw) to get access the screws that attach the condenser holder to the microscope. Start by removing the M2x4 stop screw from the front of the condenser fitting (Figure 6.) The tip of the stop screw reaches into a groove (black, on the right side of Figure 6) in the condenser focus block which

determines the range of the condenser focus setting. With the stop screw out of the way, turn the condenser focus knob to move the condenser fitting all the way down and then manually pull it further down until it comes off from the focus control's dovetail (Figure 6.)

Although less relevant for this type of condenser holder, review the warning and Figure 15 and Figure 16 in subsection 1.1 above.

Remove the two black M4 screws that now are accessible in the condenser focus block (Figure 9) and remove the block from the microscope stand. The screws may be tight and difficult to release so be sure to use a well-fitting screwdriver. There may be one or a few thin metal shims between the condenser focus block and the microscope stand to support the condenser's alignment in the microscope's illumination path. If there are any such shims, make sure to retrieve it/them and save a note of their location.

Use solvent (white spirit) to clean the rack and all sliding surfaces between the condenser fitting and the condenser focus block (facing the viewer in Figure 14.)

2. Sluggish condenser focus control: Identify where the issue is.

If you have found out that your condenser focus control is sluggish and decided that it needs to be fixed, then now is a good time to investigate the issue. Unless there are any mechanical problems or breakage, the cause will most probably be aged grease in any of the following three locations (Figure 12):

- Between the bushing and the condenser focus control axle
- The sliding surfaces of the condenser focus control's dovetail (this is the most probable cause)
- The rack-and-pinion (this is the least probable cause)

With the condenser focus block now liberated from the condenser fitting turn the condenser focus knob back and forth to check if it still is sluggish. If it is, then the condenser focus control's sluggishness can mainly be attributed to bad grease between the bushing and the condenser focus control axle. To access and fix it, you will need to further disassemble the condenser focus control (more about that later.) On the other hand, if the focus knob moves freely, then it is good news; it means that you will not need to further disassemble the focus control. The sluggishness should most probably be easy to fix simply by cleaning and regreasing the dovetail slide between the condenser fitting and the condenser focus block.

3. Check the condenser fitting and the fork changer for faults.

The backside of the condenser fitting has a rack made of steel (Figure 14) or, in newer condenser holders, of plastics. I don't know whether Leitz intended the rack to be greased or to run dry, but whatever it is, I don't think it matters much because the rack-and-pinion is not subject to a lot of load or wear. Grease provides a smooth feeling, protects from wear and may to some extent prevent a minor play in the condenser focus control, but grease also deteriorates with age and catches dust, so it is a trade-off. If the rack is dirty or feels sticky from old grease it makes sense to clean it (and the corresponding pinion.)

The fork changer (a.k.a. condenser fork, condenser mount, or condenser slide) has horizontal dovetail rails (Figure 17) that carry the condenser and hold it steady. One of the rails is stationary while the other is spring-loaded.

The spring-loaded right dovetail rail (Figure 18) is lightly greased, and it seems that it usually works well even with the original, aged grease. In case you still wish to clean and regrease it, simply release the special screw (the thread appears to be somewhere between M2 and M2.5) in the middle of the rail (Figure 18) to disassemble it. Don't lose the small washer (o.d. 5.0 mm, i.d. 3.0 mm, 0.05 mm thick) below the screw and don't lose the two small coil springs. Clean the parts with white spirit, thinly grease the sliding surfaces and the springs, put the springs back into their holes in the rail, and reassemble the rail on the slide. The edge of the rail is rather sharp, so use gloves to save your fingers when you push the rail against the springs. Tighten the screw and check that the rail moves when it is pushed against the springs and that the slide accepts a condenser.

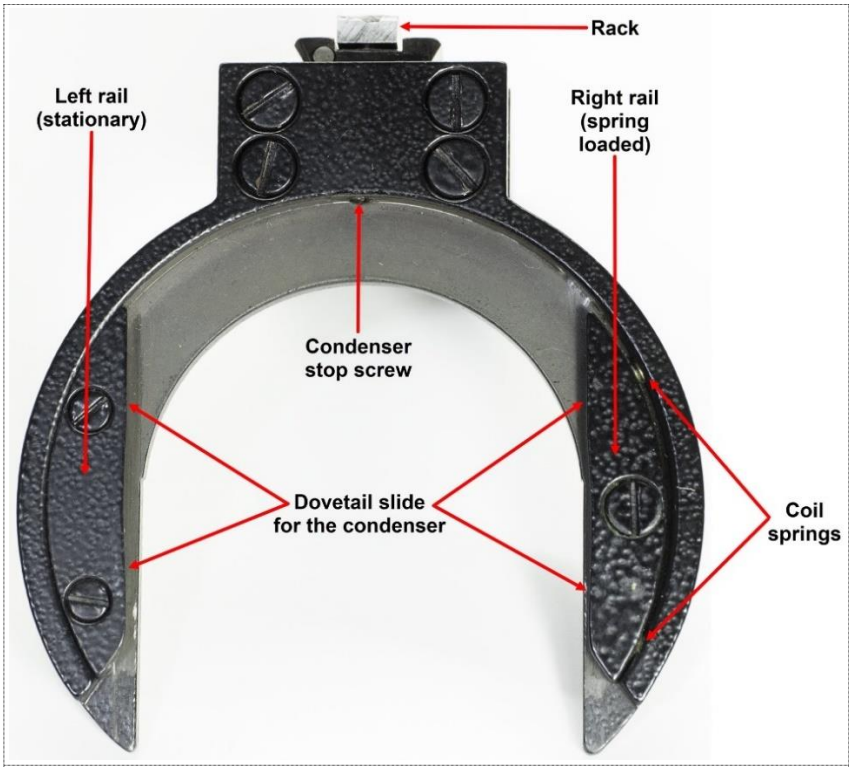

Figure 17: The fork changer – view from above.

Figure 18: Closeup of the disassembled right dovetail rail.

The small condenser stop screw (Figure 17) is factory adjusted to align the condenser with the microscope's optical path. It is best to leave the stop screw as it is, unless you are sure you have a good reason to adjust it.

4. Disassemble, clean, grease and reassemble the condenser focus control.

The condenser focus block (the part on the right side of Figure 6 and Figure 14) contains the condenser focus control that moves the condenser fitting up and down along a vertical, greased dovetail slide (Figure 14.) The condenser focus control is a rack-and-pinion mechanism controlled by the condenser focus knob. The plastic or metal rack on the backside of the condenser fitting engages with the condenser focus control's steel pinion that is attached on a steel axle with a focus knob (Figure 29.) The axle sits in a greased bushing, or plain bearing, that ensures that the condenser focus control axle turns smoothly and without play.

As mentioned in section Design differences some newer condenser focus controls may have an adjustable bushing that is set to eliminate any play between the rack and the pinion. Identify which of the bushings it is that you have on your microscope by comparing it with Figure 8, Figure 9, Figure 10 and Figure 11, and then proceed with the procedures under subsection 4.1 or subsection 4.2 below that apply to your case.

4.1. Condenser focus control with a non-adjustable bushing (Figure 10 and Figure 19.)

Remove the chrome plated M2.5 screw from the center of the condenser focus knob. The screw is attached to the hollow tip of the condenser focus axle. To avoid ugly-looking damage to the screw head use a well-fitting screwdriver and hold the knob very steady. If the screw appears difficult to remove, clamp the knob in a vise after protecting it by wrapping a cut-up piece of a PVC hose around its knurled periphery.

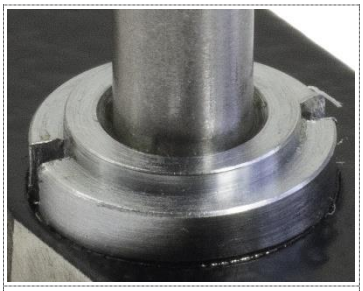

Figure 19: Non-adjustable bushing.

4.1.1. Condenser focus control with a non-adjustable bushing: Remove the control knob.

The knob is now ready for removal from the condenser focus axle. The knob will however most probably be stuck on the axle why we will need to use the "hammer and rod" method to release it. This requires a steel rod of carefully selected dimensions: It should be at least 30 mm long, but preferably not much longer. It should be as thick as possible, but not thicker than it can freely fit into an M2.5 nut. This means maximally 2.1 mm diameter. The reason is that the rod must be sufficiently strong, while still able to pass through the 2.5 mm inside threads in the axle tip to reach down to the bottom of the axle hole without hurting the inside threads. Sacrificing a 2.0 mm or $^{5}/_{64}$" drill bit makes a perfect and inexpensive steel rod for this purpose.

Loosely hang the condenser focus control knob in a vise that has the jaws lined with some suitable protection, e.g., plastic jaw pads. The knob should be facing upward, loosely resting on the vise jaws, and the condenser focus block should be allowed to loosely hang down below (Figure 20), i.e., the block mustn't be clamped between the vise jaws. Put something soft, like a towel, under the vise to catch the condenser focus block when it releases from the knob (so the block doesn't fall on the floor.) Put the steel rod into the knob's screw-opening and all the way down into the hollow axle

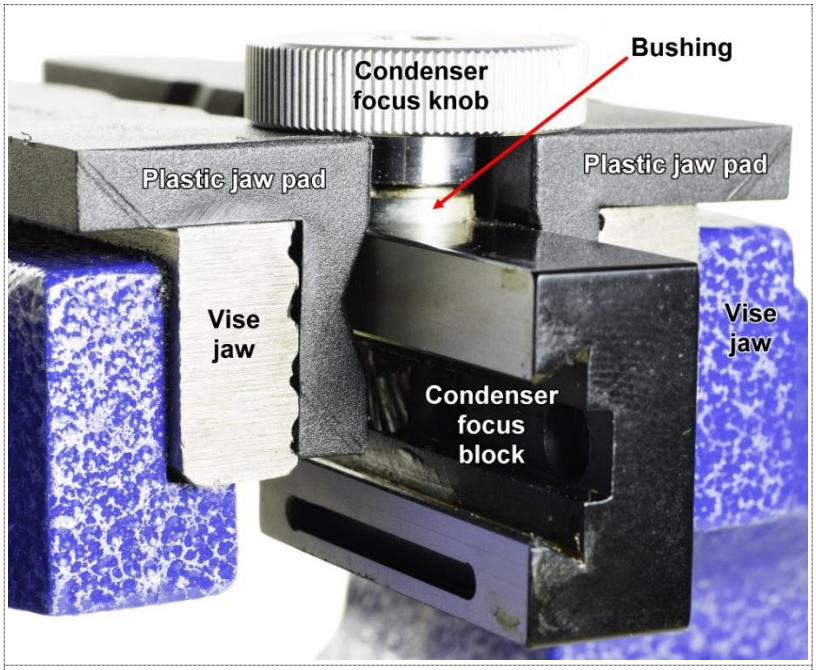

Figure 20: The condenser focus knob resting on the vise jaws (with plastic pad jaw protection) and with the condenser focus block freely hanging below.

tip. Tap the rod carefully with a small hammer. Begin with gentle taps, tap many times, and then tap harder and harder, as necessary, but use your judgement to avoid excessive force. It may require many taps, but eventually the axle (with the condenser focus block) should release from the knob.

If the knob remains stuck and doesn't release, put a few drops of penetrating oil (e.g., WD-40 or CRC 5-56) into the empty screw hole in the center of the knob and let it sit for one or a few days. Heat the knob with an electric heat gun until it is just too warm to touch (approx. 50-60°C, or 120-140°F), but be careful not to overheat it - heat guns are quite powerful and there is a possibly heat sensitive plastic washer below the knob. Then, while the knob still is warm, try again to release the knob with the "hammer and rod" method.

As an alternative, you could try to release a stuck knob by leaving the block in a freezer over the night and then use the "hammer and rod" method.

Once the knob has released retrieve the transparent plastic washer just below the knob (Figure 21.)

Figure 21: The condenser focus control with the removed knob.

Figure 22: Condenser focus axle where the tip has a "crown".

Figure 23: Condenser focus axle where the tip is flattened.

With the condenser focus knob removed you will be able to see the tip of the axle. As mentioned earlier, the axle could be short or long (Figure 8 vs. Figure 9.) Furthermore, there are two different tip designs, both meant to prevent the knob from sliding on the condenser focus axle. One of the designs has a "crown" with fins (Figure 22 and Figure 25) that dig into the inside of the knob, the other has a flattened tip (Figure 23) that fits into a constriction in the upper end of the knob's hole.

Don't despair if the knob resists all removal attempts; there is a hack that still may save the situation and leave you with a less sluggish condenser focus control: Apply a drop of penetrating oil (WD-40, CRC 5-56, or similar) into the crevice between the inner end of the knob and the top of the bushing (Figure 24.) Turn the knob for a couple of minutes to allow the penetrating oil to creep into the sliding surfaces between the bushing and the axle. Add a new drop and repeat the turning. Do the same a third time. The secret is to be patient and turn the control many times so the penetrating oil really is allowed to get through. After the treatment you should find that the axle with the knob turns much easier.

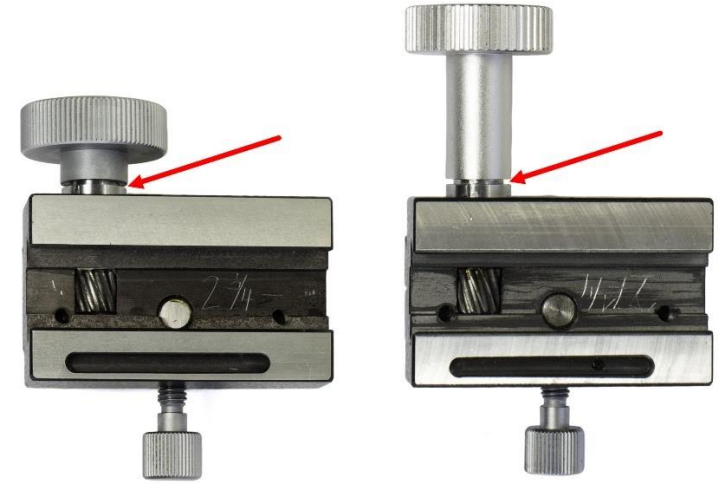

Figure 24: The red arrows show where to apply penetrating oil in the case that the knob couldn't be removed from the axle.

Penetrating oil has two main components: Oil and a white spirit type of solvent. The solvent dissolves and mixes with the old grease making it less sticky, and it also carries fresh oil to the sliding surfaces. It's a "hack" because as the solvent slowly evaporates the remaining old grease will again become more noticeable and eventually increase the control's sluggishness. It will however still turn easier due to the added fresh grease; with some luck it may be good for several more years. And by then it will be easy to repeat the hack – it can even be done without removing the condenser holder from the microscope.

4.1.2. Condenser focus control with a non-adjustable bushing: Remove the bushing and the axle.

Figure 25: Closeup of the "crown" on the axle tip.

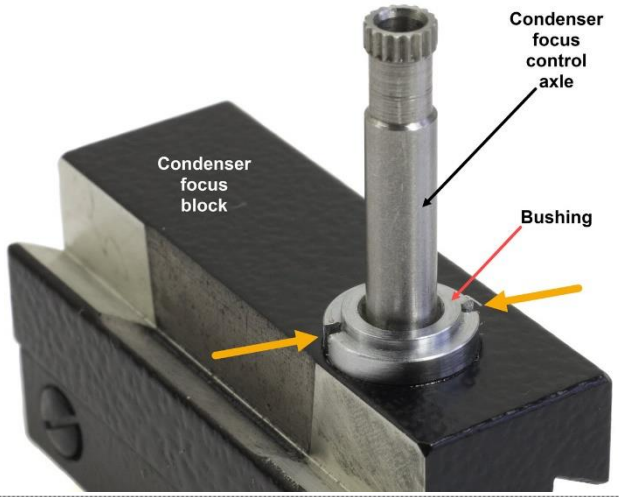

Figure 26: The condenser focus control axle sticking out from the condenser focus block. The yellow arrows indicate the slots for the spanner that is required for bushing removal.

Now we will attempt to separate the condenser focus control axle from the condenser focus block. This is done by unscrewing the axle's bushing (Figure 26), a.k.a. plain bearing, from the condenser focus block. Two obstacles may make the task somewhat challenging: 1) During manufacturing the bushing's thread was sealed with a threadlocker, and 2) unscrewing the bushing requires a special spanner that snugly fits into slots in the bushings rim.

First the threadlocker should be softened. Put the condenser focus block with its axle in a small container with a lid and cover the block with isopropanol (a.k.a. isopropyl alcohol, or 2-propanol.) The solvent is very flammable, so take any necessary precautions. Don't use acetone - it may destroy the plastic washer(s) below the bushing. Soak the block in the isopropanol at least over the night (but preferably longer) to soften the threadlocker.

Obtaining a real, professional spanner that properly fits into the bushing's slots (yellow arrows in Figure 26) is not realistic for most of us microscope amateurs. Adjustable camera lens spanners (Figure 27) are tempting and affordable replacements, particularly if they come with a set of interchangeable tips. The main problem with them is that even when thoroughly adjusted and tightened they are too wobbly; they tend to warp and deform as soon as a little force is applied, which results in slipping and damage of the bushing's slots.

The camera lens spanner approach can however be improved (although it will never be as good as a proper bespoke spanner.) First, obtain a lens spanner with removable tips. The tips must be of the flat screwdriver design (i.e., not the more common pointed tips), like in Figure 27, and the tips must also fit well into the bushing slots. Remove the tips from the lens spanner and clamp them in a heavy vise, like in Figure 28. Adjust the distance between the tips so they perfectly fit into your condenser focus block's bushing slots (yellow arrows in Figure 26.) Thoroughly tighten the vise jaws to make sure that the spanner tips are clamped rock solid. There still will be a weakness with this arrangement; when you resolutely attempt to release the bushing, the spanner tips are forced outwards and may slip out of the bushing slots thereby damaging them (red arrows in Figure 30.) To minimize the risk of such accidents, you could consider providing some additional stability, for example, by holding the tips fixed with large pliers, or even better, by locking them in with a suitable C-clamp.

Figure 27: A camera lens spanner with interchangeable tips.

Figure 28: Flat tips removed from an inexpensive camera lens spanner and secured in a heavy vise.

Remove the condenser focus block from the isopropanol bath and wipe its surface dry. Without further delay, fit the condenser focus block over the spanner tips in the vise ensuring that the tips are completely and firmly inserted in the bushing slots. With a steady hand and without wobbling press the condenser focus block down on the tips and turn the block counterclockwise to release the bushing thread. Avoid too much force, if you use all your strength, you will inevitably wobble and slip and damage the bushing slots (Figure 30.) If the bushing remains stuck, you may need to repeat the solvent soaking for several more days before again trying to release the bushing. Another approach if the bushing is stuck is to soak the condenser focus block in the more powerful solvent acetone rather than in isopropanol. The disadvantage is that it may destroy the plastic washer that sits above the pinion. Then you will need to obtain a replacement plastic washer (on Amazon or eBay.)

Once the bushing has released from the thread, unscrew and remove it together with the axle and the washers. The parts are typically as shown in Figure 29 but be prepared that your parts may appear differently, there could for example be an extra steel washer between the pinion and the plastic washer.

Use solvent (white spirit) to clean off any old grease from the parts and let them dry.

Figure 29: Exploded view of the condenser focus block's focus control parts. From the left side:

- *The condenser focus block with the focus control's dovetail slide facing up,*
- *the condenser focus axle with the pinion in one end and a flattened tip with an inside M2.5 thread in the other end; axle diameter 4.1 mm,*
- *transparent plastic washer; o.d. 7 mm, i.d. 4.1 mm, 1.0 mm thick,*
- *steel bushing (plain bearing), with a fine outer thread and a spiral grease groove on the inside; in the image the outer thread is still covered with a brownish red threadlocker. (See Figure 19 and Figure 30 for closer views of the bushing.)*
- *transparent plastic washer; o.d. 7 mm, i.d. 4.1 mm, 1.0 mm thick,*
- *condenser focus control knob, aluminum, and*
- *M2.5x8 screw.*

4.1.3. Condenser focus control with a non-adjustable bushing: Grease and reassemble the condenser focus axle with the bushing.

The condenser focus control should now be clean and ready for regreasing and reassembly.

Review section Grease and consider how you would like to grease your condenser focus control. I suggest the following approach as a workable greasing protocol; see it as a starting point for your own modifications:

The sliding surface between the condenser focus control axle and the bushing (red arrow labeled "1" in Figure 31.) This location should preferably be lubricated with a grease that is as viscous ("thick" or

"heavy") as possible, but of course not so viscous that the control feels excessively sluggish. I have with good results used the very thick damping grease Tribosyn 320 "blue" (which is the thickest in the Tribosyn 320 series) with a base viscosity of approximately 120.000 mPa·s (at 25°C.)

Figure 30: Closeup view of the bushing.

The red arrows illustrate damage inflicted to the bushing slots due to the following naive approach: Using maximal force to release the bushing from the condenser focus block → starting to wobble → slipping → damaged slots.

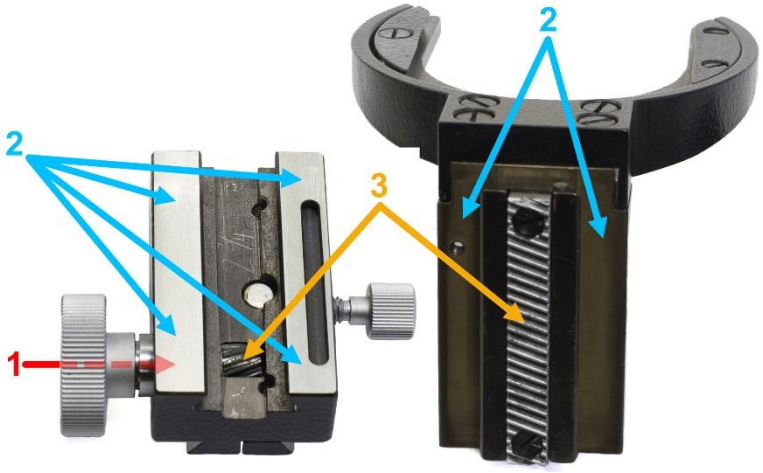

Figure 31: The condenser focus control's three greasing locations.

The sliding surfaces of the condenser focus control's dovetail slide (blue arrows labeled "2" in Figure 31.) Due to the large sliding surface area, the grease used here is the main determining factor for the focus control's turning resistance. My suggestion is to start with a medium viscosity damping grease, like Tribosyn 320 "yellow" with a base viscosity of around 16.000 mPa·s (at 25°C), and then perhaps try out other grease viscosities. If desired later, after a period of routine use, it is easy to remove the condenser fitting from the condenser focus block to clean and regrease the dovetail slide with a different grease. (Changing the grease between the bushing and the axle would be much more onerous.)

The rack-and-pinion of the condenser focus control (orange arrows labeled "3" in Figure 31.) I would suggest that applying grease on the rack-and-pinion is optional. The viscosity of the grease here will only negligibly affect the control's turning resistance. One reason to grease could be if you need to reduce any remaining play in the condenser focus control, but more about this later in subsection 4.1.5.

If you don't wish to fuss with different grease viscosities, you could certainly choose to use one and the same damping grease for all of the three greasing points mentioned above. In this case an approximately 50.000 mPa·s (at 25°C) damping grease should work (for example, Nyogel 767A or Tribosyn 320 "green") although it will render the control somewhat sluggish. A less heavy damping grease (for example, Tribosyn 320 "yellow" at 16.000 mPa·s) will provide a lighter condenser focus control.

Once the greasing protocol has been decided, the axle and the bushing are ready for greasing and reassembly.

Using the same grease as you have chosen for the bushing/axle, grease one of the plastic washers and push it down over the axle all the way to the pinion. Lightly grease the axle and the inside of the

bushing. Slide the bushing down over the axle and all the way against the washer and pinion; do it with a turning movement to distribute the grease over the sliding surface, and make sure that you don't contaminate the bushing threads with any of the grease. Thoroughly wipe off any excess grease.

4.1.4. Condenser focus control with a <u>non-adjustable</u> bushing: Reassemble the condenser focus block.

Screw down the bushing (including the axle) into its hole in the side of the condenser focus block. Tighten the bushing (solidly, but still not too hard, use your judgement) using the spanner tips in the vise (Figure 28.) Lightly grease the other plastic washer (with the same grease as you used for the bushing/ axle) and push it over the axle all the way down to the bushing. To facilitate attaching the knob to the axle, you may in some cases need to insert the tip of a small screwdriver into the slot below the pinion (Figure 32) – this is to temporarily prevent the pinion and the axle from collapsing deeper down into the condenser focus block when the knob is attached to the axle. With your fingers push down the aluminum knob over the axle as far as it goes without forcing it. This is straightforward to do if the axle tip is of the "crown" design (Figure 22), but if the tip is of the flattened design (Figure 23) it is important to keep the flattened tip aligned with the constriction in the knob's hole.

Figure 32: The yellow arrow shows where to put the screwdriver tip just prior to attaching the knob.

Remove the screwdriver tip from the slot below the pinion. Attach the M2.5 screw to the knob and tighten it with a well-fitting screwdriver. Hold on to the knob's knurled edge (you could alternatively clamp the knob in a vise but remember to protect it from being dented by the vise jaws) while carefully and incrementally tightening the screw. The goal is to force the knob down onto the axle until the knob is just enough tight against the bushing (and the washer(s) between) that there is no more axial play in the axle (i.e., no play in the direction along the axle, refer to Figure 33), but at the same time not so tight that the knob becomes sluggish. Check that the knob turns freely.

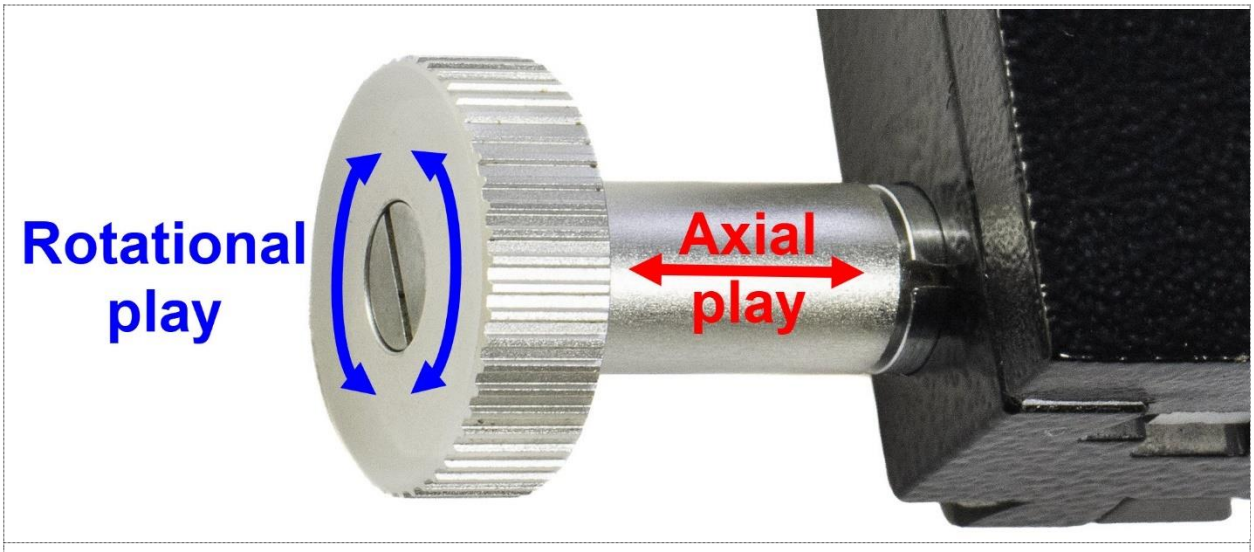

Figure 33: Illustration of play in the condenser focus control.

4.1.5. Condenser focus control with a non-adjustable bushing: Reassemble the condenser fitting to the condenser focus block.

Use the grease you have chosen for the condenser focus slide (blue arrows labeled "2" in Figure 31) to lightly grease all sliding surfaces of the condenser's focusing slide, i.e., both on the condenser focus block and the condenser fitting. Refer to Figure 34 that indicates the slides that should be greased. Cover the entire surfaces of the indicated slides with a thin layer of the grease.

Hold the condenser focus block and the condenser fitting oriented as in Figure 6 and carefully push the fitting into the underside (refer to the warning at the end of subsection 1.1 and Figure 18) of the block's slide. Without using force let the pinion catch the rack and then turn the knob to move the fitting up until it is level with the block. Attach the stop screw to the fitting and tighten it lightly. Turn the knob to move the condenser focus control several times back-and-forth through the entire range to distribute the grease evenly.

Wipe of any excess grease that has been squeezed out from the sides of the slides.

Check that the condenser focus control moves as desired. If you are satisfied, proceed to sub-section 4.1.7 below. Otherwise, the issues may be 1) that the control feels jerky when turned, 2) that the control shows some rotational play (refer to Figure 33), or 3) that you are not satisfied with the turning resistance of the control.

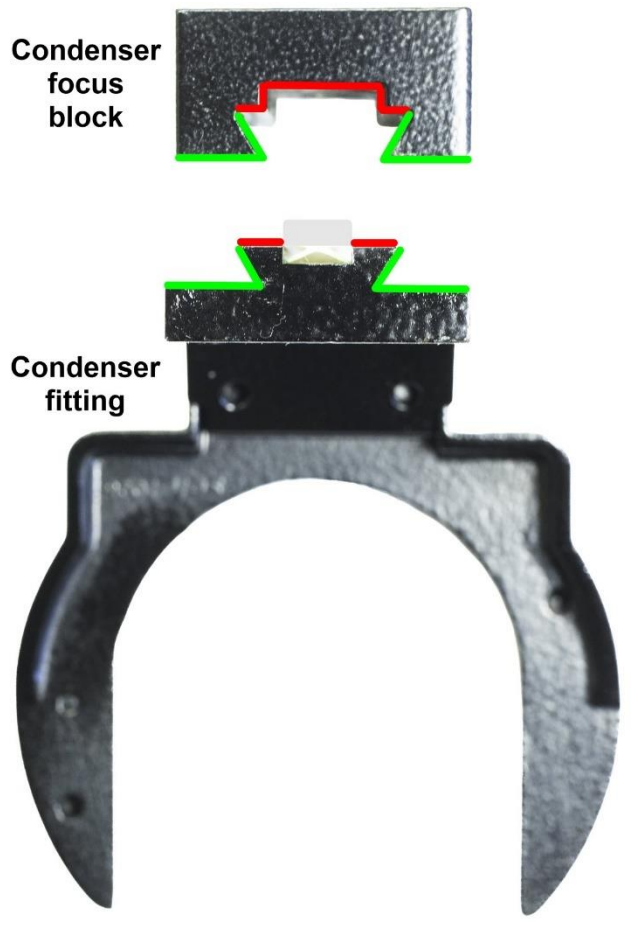

Figure 34: The greased surfaces of the condenser focus slide. The green markings indicate the slides that should be greased; the red markings indicate surfaces that don't need any grease.

1) A jerky control means that the rack and the pinion are too tight, that is, pressed too hard against each other. When this unexpectedly happened to me I found out that it could be remedied by leaving the bushing slightly loose (untightened) in the condenser focus block. Proceed to subsection 4.1.6 if your condenser focus control feels jerky.

2) A control with rotational play has the opposite cause; it happens if the rack and the pinion are slightly too far apart. A simple relief could be to apply a thick damping grease to the rack and the pinion. It may not completely eliminate the play, but it will lessen the play and improve the controls haptic feeling.

   For a more permanent fix of the play the rack needs to be raised ever so slightly to get into closer contact with the pinion. Remove the rack (Figure 16) from the backside of the condenser fitting and insert thin M2 washers (i.e., approx. 2.2 mm inner diameter) between the fitting and the rack before reattaching the rack. Getting it right will probably require some trials with different washer

thicknesses. Brass washers down to 0.05 mm thickness are available online, and thinner washers (spacers) can with some effort be cut out from plastic or aluminium foils of varying thicknesses.

3) If you are not satisfied with the condenser focus control's turning resistance you will need to go back and experiment with modifying your greasing protocol (refer to subsection 4.1.3.)

4.1.6. Condenser focus control with a non-adjustable bushing: Remedial action if the rack and the pinion are too tight.

This subsection applies only if you in subsection 4.1.5 above experienced that the condenser focus control knob feels jerky when turned. As mentioned there, the reason is that the rack and the pinion are too tight. I don't know exactly why this may occasionally happen, but it seems that it can be remedied by not tightening the bushing when it is attached in the condenser block. To prevent the bushing from turning when the condenser focus is changed, the bushing must however be secured (or "glued") with a suitable threadlocker.

First a few thoughts about threadlocker use. As mentioned in subsection 4.1.2 (and as can be seen in the bushing thread in Figure 29) at manufacturing Leitz applied some threadlocker (of unknown origin to me) to ensure that the bushing remained reliably attached in the condenser focus block. I generally try to avoid threadlockers, but there may indeed be situations when they are required. Then choosing a suitable threadlocker becomes important. I think that the modern methacrylate based anaerobic threadlockers (originally as Loctite, but also available today by other manufacturers) generally should be avoided. After curing they are very difficult to break, why releasing the joined parts may be impossible or at least require a lot of force and/or serious heating. This is hardly desirable for delicate microscope components. Apart from securing the thread, the ideal threadlocker should be easy to release, preferably after softening it with a solvent like isopropanol. I have only managed to find three types of threadlockers that might fit the requirements: Shellac, rosin (a.k.a. colophony) and acrylic paint. Shellac and rosin are traditional, "old fashioned" threadlockers that are prepared and used as alcohol solutions. Acrylic paints of various types and colors are available in hobby shops. All of these threadlockers can be softened with isopropanol. I have however only tried out the shellac threadlocker, so I will limit my discussion to that one. Shellac is a natural resinous product that is available in several qualities, shapes and colors; fortunately, any kind of shellac will work for our purposes. There are two inconveniences with shellac: 1) It dissolves very slowly in the solvent (whether ethanol or isopropanol), and 2) information on internet indicates that the shellac solution has a limited shelf life, like 1 year only. The shelf life applies however to its use as a sophisticated fine furniture varnish – I believe that it should be usable as a threadlocker for much longer than that.

Recipe for a shellac threadlocking solution:

Shellac	6 g (approx. 2½ teaspoons)
Isopropanol (or ethanol), at least 99% purity	30 mL (2 tablespoons)

Add the shellac to the isopropanol in a bottle with a tight stopper or cap and shake immediately – if you wait with the shaking, the undissolved shellac will clump together and take longer time to dissolve. In any case, you will find that it requires frequent shaking over several days to get everything to dissolve.

Before you apply the threadlocker make sure that you have greased and assembled the bushing with the first plastic washer and the condenser focus axle as described in subsection 4.1.3. Also make sure that the thread hasn't been contaminated with grease. Hold the bushing with the axle horizontal and use a

wooden stick to richly apply the shellac threadlocking solution over the bushing's entire thread. Avoid getting any threadlocker outside of the bushing's thread. Still holding the bushing horizontally, screw it all the way down into the condenser focus block's thread, and then release it slightly (i.e., by less than ¼ turn.) With the bushing still horizontal put the assembled block down on your table. Leave it sitting undisturbed for at least three days to allow the solvent do dry. Complete the remaining assembly procedures as described in subsections 4.1.4 and 4.1.5.

4.1.7. Condenser focus control with a non-adjustable bushing: Attach the condenser holder to the microscope.

When you are satisfied with how the condenser focus control moves, the condenser holder can be reattached to the microscope. If your condenser holder is of the type that is attached with screws (Figure 9), you will first need to remove the condenser fitting from the condenser block, then attach the block to the microscope with the M4 screws, and finally reattach the fitting to the block.

With the complete condenser holder attached on the microscope do a final check that the condenser focus control works as expected.

This concludes the maintenance work of the condenser holder with the non-adjustable bushing.

4.2. Condenser focus control with an adjustable bushing (Figure 11 and Figure 35.)

Remove the chrome plated M3 screw from the center of the condenser focus knob. The screw is attached to the hollow tip of the condenser focus axle. To avoid ugly-looking damage to the screw head use a well-fitting screwdriver and hold the knob very steady. If the screw appears difficult to remove, clamp the knob in a vise after protecting it by wrapping a cut-up piece of a PVC hose around its knurled periphery.

Figure 35: Adjustable bushing.

4.2.1. Condenser focus control with an adjustable bushing: Optional checking of the condenser fitting's plastic rack.

Disregard this subsection of your condenser fitting has a steel rack.

While a steel rack typically is attached to the condenser fitting with two M2 screws (Figure 16), a plastic (most probably polyamide, or "Nylon") rack (Figure 36) is not attached by any screws, it just sits in a groove on the backside of the condenser fitting where it is held in place by a cylindrical locating pin (Figure 36 and Figure 37.)

Figure 36: The plastic rack removed from the condenser fitting's backside.

The plastic rack may need to be removed for cleaning or if it is broken and needs to be replaced. To remove the rack, insert the tip of a small screwdriver into the small slot in the middle of the rack's side (Figure 38) and gently pry it out from the condenser fitting's groove.

Clean the rack with solvent (isopropanol or white spirit), either by brushing, or in an ultrasonic bath.

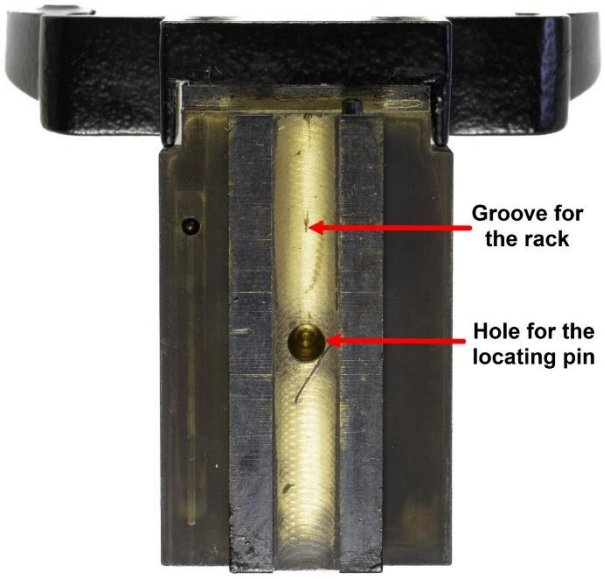

Figure 37: The backside of the condenser fitting after the plastic rack has been removed.

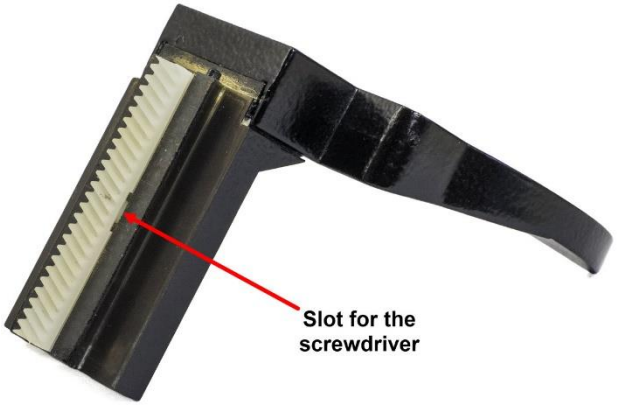

Figure 38: Condenser fitting with a plastic rack.

4.2.2. Condenser focus control with an adjustable bushing: Remove the bushing with the condenser focus axle and the control knob.

Remove the condenser focus axle from the condenser focus block after releasing the bushing's fixing screw (Figure 39) accessible from the block's backside. Note that the adjustable bushing doesn't have any thread, it is held in the block only by the fixing screw. Pull out the knob with the bushing and the axle. The bushing may be somewhat stuck in the block, but it usually releases after some pulling and wiggling. If it remains stuck, check that the fixing screw really is loosened, and then use a 9 mm open-end wrench to loosen the bushing.

Figure 39: The green circle shows the fixing screw that holds and locks the bushing in the condenser holder block.

4.2.3. Condenser focus control with an adjustable bushing: Remove the knob from the axle.

The knob is now ready for removal from the condenser focus axle. The knob will however most probably be stuck on the axle why we will need to use the "hammer and rod" method to release it. This requires a steel rod of carefully selected dimensions: It should be at least 30 mm long, but preferably not much longer. It should be as thick as possible, but not thicker than it can freely fit into an M3 nut. This means maximally 2.4 mm or $^{3}/_{32}$" diameter. The reason is that the rod must be sufficiently strong, while still able to pass through the 3 mm inside threads in the axle tip to reach down to the bottom of the axle hole without hurting the inside threads. Sacrificing a $^{3}/_{32}$" drill bit makes a perfect and inexpensive steel rod for this purpose.

Loosely hang the condenser focus control knob (with its bushing and axle) in a vise that has the jaws lined with some suitable protection, e.g., plastic jaw pads. The knob should be facing upward, loosely resting on the vise jaws, and the axle with the bushing and pinion should be allowed to loosely hang down below (Figure 40), i.e., the axle mustn't be clamped between the vise jaws. Put something soft, like a towel, under the vise to catch the axle when it releases from the knob (so it doesn't fall on the floor.) Put the steel rod into the knob's screw-opening and all the way down into the hollow axle tip. Tap the rod carefully with a small hammer. Begin with gentle taps, tap many times, and then tap harder and harder, as necessary, but use your judgement to avoid excessive force. It may take many taps, but eventually the axle should release from the knob.

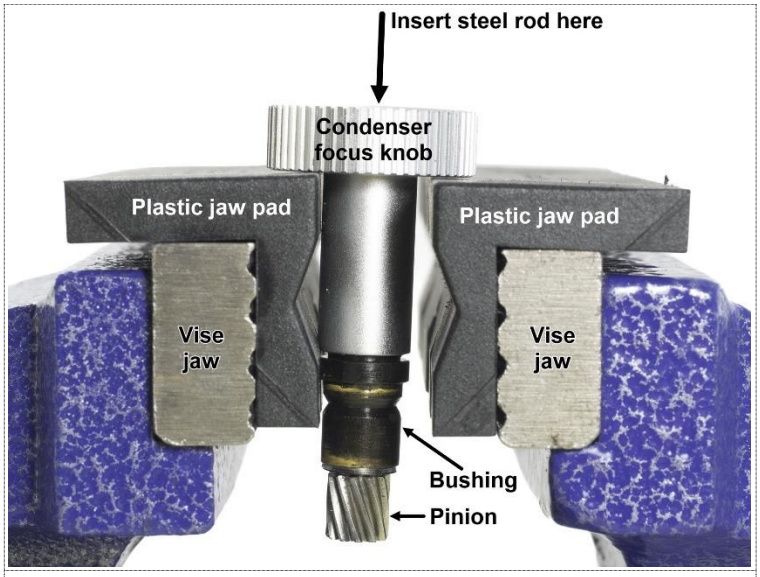

Figure 40: The knob with the bushing and axle hanging in a vise.

If the knob remains stuck and doesn't release, put a few drops of penetrating oil (e.g., WD-40 or CRC 5-56) into the empty screw hole in the center of the knob and let it work for one or a few days. Heat the knob with an electric heat gun until it is just too warm to touch (approx. 50-60°C, or 120-140°F), but be careful not to overheat it - heat guns are quite powerful and there are a couple of heat sensitive plastic washers below the knob. Then, while knob still is warm, try again to knock out the axle as described above.

As an alternative, you could try to release a stuck knob by leaving the block in a freezer over the night and then use the "hammer and rod" method.

Don't despair if the knob resists all removal attempts; there is a hack that still may save the situation and leave you with a less sluggish condenser focus control: Apply a drop of penetrating oil (WD-40, CRC 5-56, or similar) into the crevice between the inner end of the knob and the top of the bushing. Turn the knob with the axle within the bushing for a couple of minutes to allow the penetrating oil to creep into the sliding surfaces between the bushing and the axle. Add a new drop and repeat the turning. Do the same a third time. The secret is to be patient and turn the control many times so the penetrating oil

really is allowed to get through. After the treatment you should find that the axle with the knob turns much easier.

Penetrating oil has two main components: Oil, and a white spirit type of solvent. The solvent dissolves and mixes with the old grease making it less sticky, and it also carries fresh oil to the sliding surfaces. It's a "hack" because as the solvent slowly evaporates the remaining old grease will again become more noticeable and eventually increase the control's sluggishness. It will however still turn easier due to the added fresh grease; with some luck it may be good for several more years. And by then it will be easy to repeat the hack – it can even be done without removing the condenser holder from the microscope.

4.2.4. Condenser focus control with an adjustable bushing: Take apart the condenser focus axle and clean it.

Once the knob is removed it's easy to also remove the remaining parts from the axle. The parts are as follows (refer to Figure 41):

- Axle (o.d. 4.5 mm) with pinion
- Black conical steel washer, 0.2 mm thick, i.d. 5.1 mm, o.d. 8.0 mm, convex side facing the pinion
- Transparent plastic washer, 0.5 mm thick, i.d. 4.5 mm, o.d. 8.0 mm
- Bushing (plain brass bearing), with an excentric hole, with the collar facing the knob
- Transparent plastic washer, 0.5 mm thick, i.d. 4.5 mm, o.d. 8.0 mm
- Knob, aluminium
- Chrome plated M3 screw

Use solvent (white spirit) to clean the axle, bushing and washers from old grease and let the parts dry.

Figure 41: The condenser focus mechanism pulled out from the brass block.

4.2.5. Condenser focus control with an adjustable bushing: Grease and reassemble the condenser focus axle with the bushing and with the condenser focus block.

The condenser focus control should now be clean and ready for regreasing and reassembly.

Review section Grease and consider how you would like to grease your condenser focus control. I suggest the following approach as a workable greasing protocol; see it as a starting point for your own modifications:

The sliding surface between the condenser focus control axle and the bushing (red arrow labeled "1" in Figure 42.) This location should preferably be lubricated with a grease that is as viscous ("thick" or "heavy") as possible, but of course not so viscous that the control feels excessively sluggish. I have with

good results used the very thick damping grease Tribosyn 320 “blue” (which is the thickest in the Tribosyn 320 series) with a base viscosity at approximately 120.000 mPa·s (at 25°C.)

The sliding surfaces of the condenser focus control’s dovetail slide (blue arrows labeled “2” in Figure 42.) Due to the large sliding surface area, the grease used here is the main determining factor for the focus control’s turning resistance. My suggestion is to start with a medium viscosity damping grease, like Tribosyn 320 “yellow” with a base viscosity of around 16.000 mPa·s (at 25°C), and then perhaps try out other grease viscosities. If desired later, after a period of routine use, it is easy to remove the condenser fitting from the condenser focus block to clean and regrease the dovetail slide with a different grease. (Changing the grease between the bushing and the axle would be much more onerous.)

The rack-and-pinion of the condenser focus control (orange arrows labeled “3” in Figure 42.) I would suggest that applying grease on the rack-and-pinion is optional. The viscosity of the grease here will only negligibly affect the control’s turning resistance.

If you don’t wish to fuss with different grease viscosities, you could certainly choose to use one and the same damping grease for all of the three greasing points mentioned above. In this case an approximately 50.000 mPa·s (at 25°C) damping grease should work (for example, Nyogel 767A or Tribosyn 320 “green”) although it will render the control somewhat sluggish. A less heavy damping grease (for example, Tribosyn 320 “yellow” at 16.000 mPa·s) will provide a lighter condenser focus control.

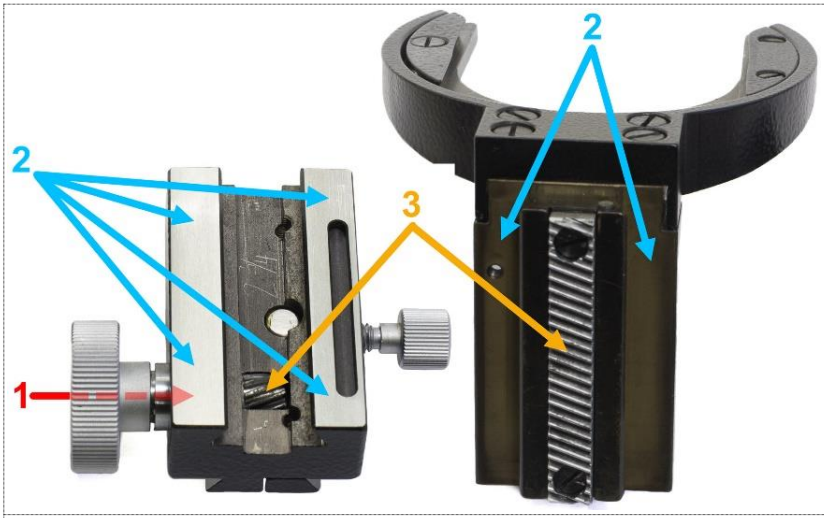

Figure 42: The condenser focus control’s three greasing locations..

Figure 43: Illustration of play in the condenser focus control.

Once the greasing protocol has been decided, the axle and the bushing are ready for greasing and reassembly.

Using the same grease as you have chosen for the bushing/axle grease the washer(s) that were sitting between the bushing and the pinion (Figure 41) and push it/them down over the axle all the way to the pinion. Lightly grease the axle and the inside of the bushing. Slide the bushing down over the axle and all the way against the washer and pinion; do it with a turning movement to distribute the grease over the sliding surface. Wipe off any excess grease.

Attach the knob over the axle end and use a vise to carefully press down the knob. The knob should be pressed down onto the axle just enough to prevent axial play (Figure 43, although a minimal axial play is

acceptable), but not as far as to make the axle to move sluggishly in the bushing. If overdone, you can always again use the “hammer and rod” procedure to knock the axle back ever so slightly. Finally attach the chromium plated M3 screw to the knob and tighten the screw lightly. Check that the axle still rotates freely in the bushing.

Push the axle with the bushing all the way down into its opening in the side of the condenser focus block - make sure that the bushing’s collar is touching the block. To hold the bushing fixed in the block attach the fixing screw from the backside of the block (Figure 39.) Screw it all the way down and then release it slightly (by less than ¼ turn.)

4.2.6. Condenser focus control with an adjustable bushing: Reassemble the condenser fitting to the condenser focus block and adjust the tightness between the rack and the pinion.

The idea with the adjustable bushing is that it can be used to adjust the tightness between the rack and the pinion. The tightness matters, because a too tight rack and pinion will make the condenser focusing jerky and strained, while a too loose rack and pinion will result in some rotational play in the condenser focus control (refer to Figure 43.) The adjustment can be done thanks to the excentric hole in the condenser focus axle bushing (Figure 44). By turning the bushing with a 9 mm open ended wrench, the condenser focus axle with the pinion can be moved closer or further away from the rack. The access to the two flat sides of the bearing collar (Figure 44) is in a narrow space (between the condenser focus block and the condenser focus knob in Figure 9) why a special thin wrench (max. 2.5 mm) is required. If not possible to source one, a suitable wrench can quite easily be manufactured from a piece of 1.5-2.5 mm aluminum sheet metal or hard plastic. No precision is required; it only needs to have two parallel sides approx. 9.1 mm apart to fit over the flat sides of the bearing collar. The bearing rotates quite easily in its hole, so the wrench doesn’t need to be particularly sturdy.

Figure 44: The condenser focus axle bearing. The image shows the excentricity of the axle hole and the parallel flat sides of the collar made to fit a thin wrench.

The rack-and-pinion tightness adjustment must be done before the condenser focus block is attached to the microscope. The reason is that after the bearing adjustment is completed, the bushing must be locked by tightening its fixing screw which is only accessible from the backside of the condenser focus block (Figure 39.)

To perform the rack-and-pinion adjustment the condenser fitting must first be attached to the condenser focus block. Use the grease you have chosen for the condenser focus slide (blue arrows labeled “2” in Figure 42) to lightly grease all sliding surfaces of the condenser’s focusing slide, i.e., both on the condenser focus block and the condenser fitting. Refer to Figure 34 that indicates the slides that should be greased. Cover the entire surfaces of the indicated slides with a thin layer of the grease.

Use the thin 9 mm open ended wrench (mentioned above) to turn the bearing into a starting position where the pinion is retracted as deeply down as possible into the condenser focus block (i.e., leaving maximal space between the rack and the pinion.) Remove the stop screw (refer to Figure 6) from the condenser fitting. Hold the condenser focus block and the condenser fitting oriented as in Figure 6 and carefully push the fitting into the underside (refer to the warning at the end of subsection 1.1 and Figure 18) of the block's slide. Without using force (particularly important if the rack is made of plastics) let the pinion catch the rack and then turn the knob to move the fitting up until it is level with the block. Reattach the stop screw to the fitting and tighten it lightly. Turn the condenser focus knob to move the condenser focus control several times back-and-forth through the entire range to distribute the grease evenly. In the starting position the rack and the pinion will be maximally separated which will be apparent by some rotational play (Figure 43) when the knob is turned back and forth. Use the thin 9 mm wrench to turn the bearing in very small steps until the knob's play just disappears. The goal is that through the entire condenser focus range the knob should turn evenly and freely while at the same time there should not be any rotational play. When the adjustment feels satisfactory, fix the bearing by tightening the fixing screw on the backside of the condenser focus block (Figure 39.)

Wipe of any excess grease that has been squeezed out from the sides of the condenser focus slides.

Check that the condenser focus control turning resistance appears adequate to you. If not, you will need to go back and modify your greasing protocol (refer to subsection 4.2.5.)

4.2.7. Condenser focus control with an adjustable bushing: Attach the condenser holder to the microscope.

Loosen the stop screw (Figure 6) and detach the condenser fitting from the condenser focus block. Attach the condenser focus block to the microscope stand with the two M4 screws (Figure 9), and if applicable, don't forget to put back any of the shim(s). Attach again the condenser fitting to the focus block and tighten the stop screw.

Perform a last check that the condenser focusing control works as desired.