Maintenance of the front-end illumination system of a newer (post-1963/64) Ortholux.

Introduction and Scope

These maintenance notes cover what could be called the "front-end" illumination system of the Leitz Ortholux microscope. It is situated in the front end of the microscope foot and consists of the following four components: The swing-out lens (a.k.a. the swing-in lens), the field diaphragm, the mirror, and the dust protection glass with its filter holder (Figure 1.) The designation "front-end" illumination system is meant as a contrast to the "back-end" illumination system which typically would be the Leitz 6V 30W lamp house "EYMZE" with its alignable incandescent bulb, focusable collector, and filter holder.

Sometime around 1963 or 1964 (estimated with the help of information from Wolfgang Lehmann's https://www.leitz-ortholux.de/) Leitz updated their Ortholux microscopes by including a field diaphragm in the microscope foot. Previously no built-in field diaphragm was needed because Ortholux microscopes were supplied with the versatile Berek condenser ("*Zweiblendenkondensor*" in German) which provided its own field diaphragm. However, to be able to properly use the newer 600 and 400 series condensers that didn't have any field diaphragm (but they of course had an aperture diaphragm), Leitz needed to build a field diaphragm into their Ortholux microscopes.

These maintenance notes apply only for post-1963/64 Ortholux microscopes, i.e., those that include a built-in field diaphragm. The easiest way to determine whether your Ortholux is pre- or post-1963/64 is to check if there is a field diaphragm in the foot (refer to Figure 1.) A look into the underside of the foot (Figure 2 and Figure 3) reveals more detail and differences.

The reason for bunching together the disparate front-end illumination components in these maintenance notes is that the parts are mechanically interconnected. If you need to fix one of them, then it makes sense and saves time to also check the rest of them. Here are some typical problems with the front-end illumination components:

Swing-out lens: After many years of use (or worse, many years of storage) the swing-out lens will typically be dirty or at least hazy. The swing-out mechanism is, however, rugged and should not need much attention.

Field diaphragm: Due to aging grease the field diaphragm can be expected to be anything from sluggish to completely stuck. The field diaphragm unit is supposed to be removable by picking it out from the microscope foot after its locking screw (Figure 1) has been loosened. Unfortunately, if the diaphragm got stuck in its fully open or fully closed position, then you will find that the diaphragm's thumbwheel is frozen in a way that makes it impossible to remove the diaphragm unit from the microscope foot.

Mirror: An oval mirror angled 45° in the microscope foot directs the illumination beam from the lamp up to the microscope condenser. Similarly as the swing-out lens, the mirror will most probably be hazy or dusty. As a first-surface mirror it is very sensitive for scratches from careless cleaning or handling.

Filter holder with dust protecting glass: It is common to get the dust protecting glass dusty or dirty as its upper surface is unprotected and exposed to the environment.

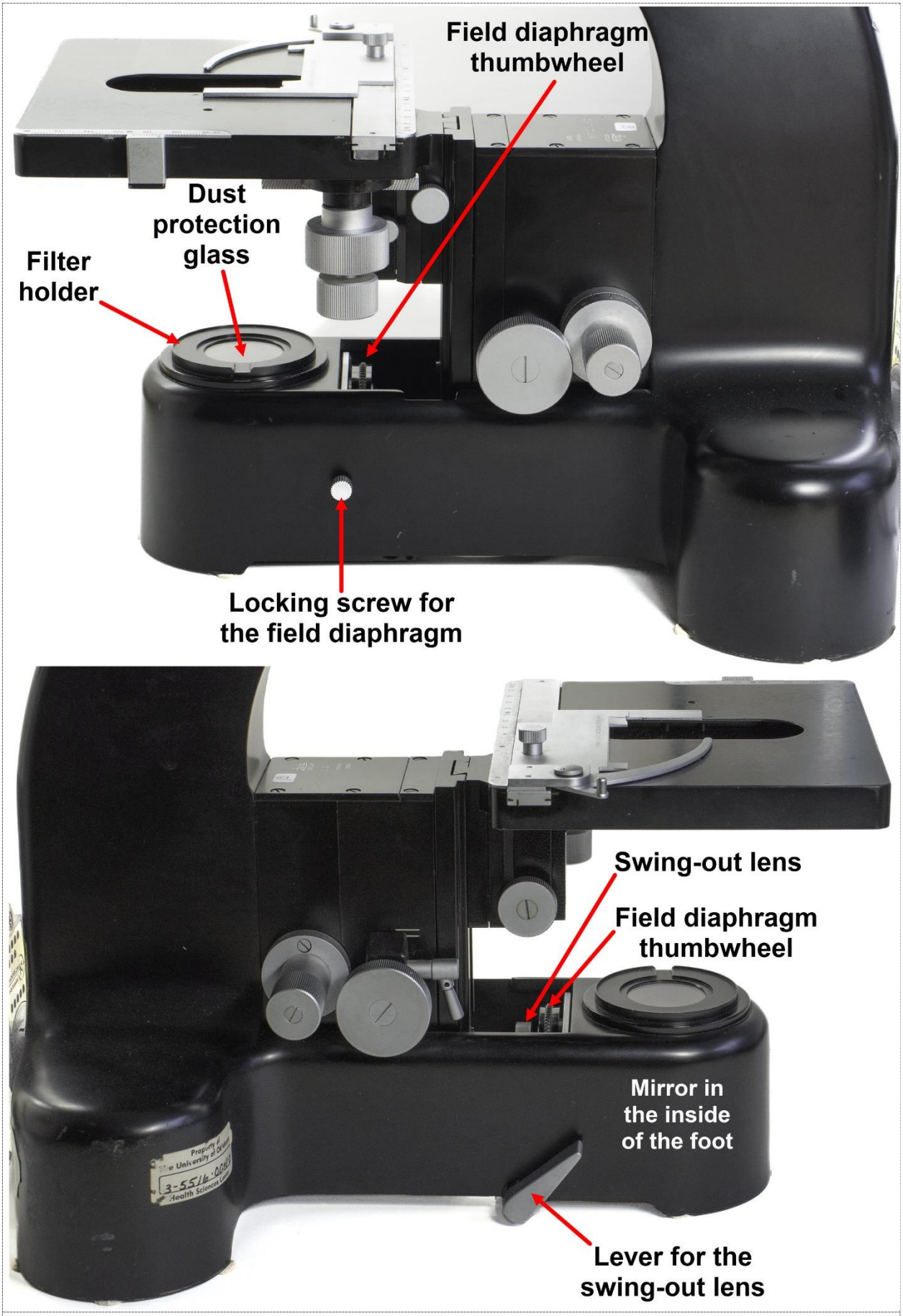

Figure 1: The foot of the Ortholux microscope stand (post-1963/64 model.)

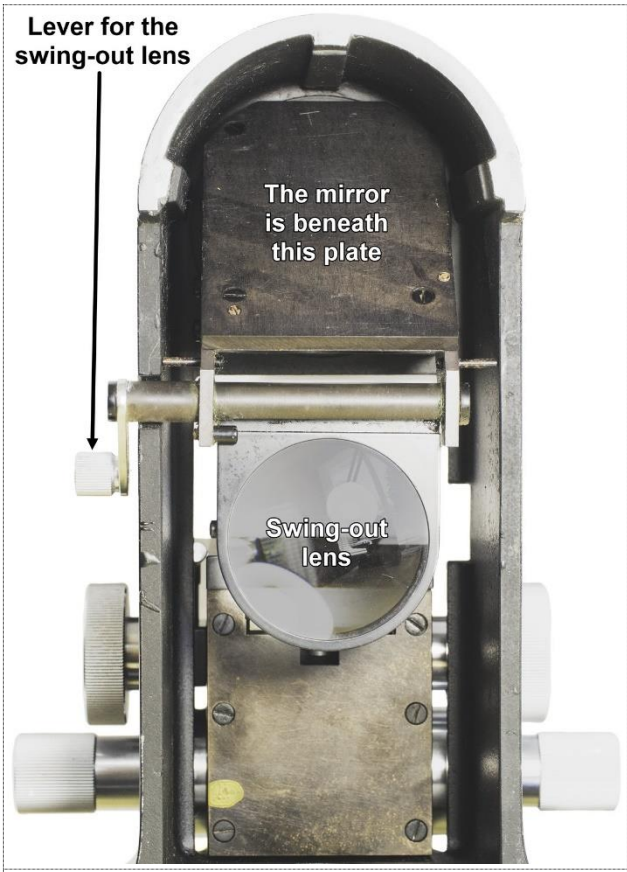

Figure 2: View into the underside of the foot of a pre-1963/64 microscope.

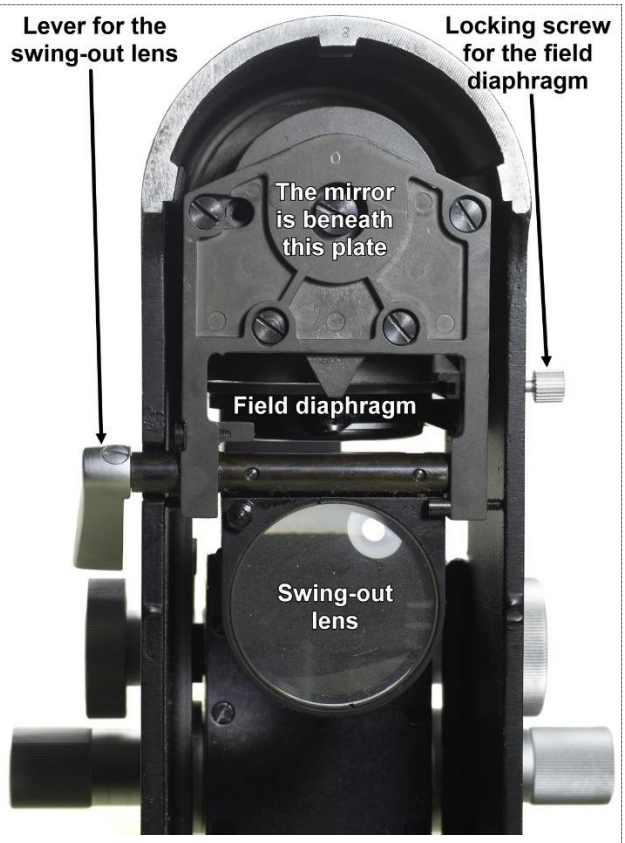

Figure 3: View into the underside of the foot of a post-1963/64 microscope.

Lastly, a warning if you find out that you will need to remove the mirror and swing-out lens holder (as described in subsection 2) to complete your maintenance work. The alignment of the mirror and swing-out lens holder (where the mirror is the critical component) has some significance for the microscope's collimation, or to be more precise, for the requirement that the optical axis of the microscope's illumination system coincides with the optical axis of the microscope's image forming system (i.e., condenser, objective, head and eyepieces.) It is unavoidable that some miscollimation may be introduced if the mirror and swing-out lens holder is removed, serviced, and then put back again. Due to the robust construction of the Ortholux microscope I would not expect that there is room for any *serious* miscollimation, but nevertheless, if collimation is important to you, you should conclude your work by performing the collimation as described in Appendix 1: Collimate the mirror and swing-out lens holder below.

Maintenance Notes

1. Remove the field diaphragm

Let's start with the field diaphragm because it typically is the first part of the front-end illumination components that catches one's attention when a used Ortholux microscope is acquired.

To access the removable field diaphragm for any repair or maintenance it must be removed from the microscope stand. Start by removing the condenser, then raise the microscope stage and the condenser holder as far as possible, loosen the field diaphragm locking screw (Figure 1 and Figure 3), turn the field

diaphragm's knurled thumbwheel into its middle position (as in Figure 5), and simply pick up the field diaphragm unit from its slot in the microscope foot. If the field diaphragm is sluggish you may need to use some force to turn the thumbwheel into the middle position, but be careful, it's made of plastic, and too much force may break it. If your field diaphragm is stuck, either fully open (as in Figure 4) or fully closed, then the thumbwheel will stick out to the side (as the red arrow in Figure 4 indicates) which prevents the field diaphragm unit from being removed from the microscope. You will then instead need to remove the field diaphragm unit from the underside of the microscope foot. And to do this, you will first need to remove the entire mirror and swing-out lens holder (Figure 6 and Figure 7.)

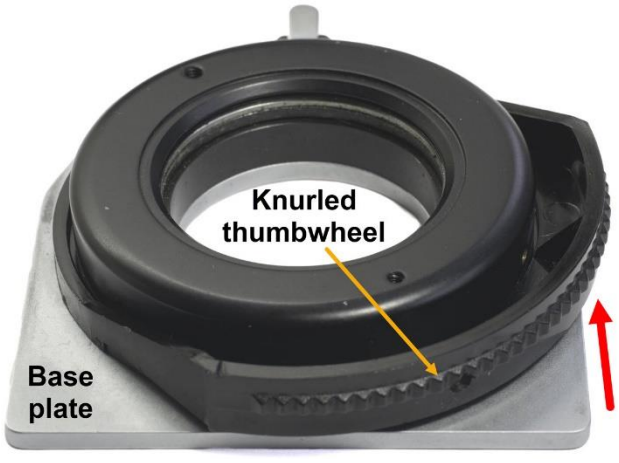

Figure 4: The removed field diaphragm unit. This diaphragm is stuck in its maximally open position – the knurled thumbwheel reaches outside of the width of the base plate (red arrow) which hinders the unit's normal removal from the microscope.

Figure 5: The removed field diaphragm unit. This diaphragm is in its middle position – the knurled thumbwheel doesn't reach outside of the width of the base plate.

2. Remove the mirror and swing-out lens holder

The mirror and swing-out lens holder (Figure 6 and Figure 7) must be removed if either the mirror, the swing-out lens, or both need cleaning. Furthermore, as explained in subsection 1 above, the mirror and swing-out lens holder must also be removed from the microscope foot if the field diaphragm is stuck in a way that prevents it from being pulled up from its slot.

As indicated by the somewhat awkward name I have given it, the mirror and swing-out lens holder's purpose is to hold the illuminating mirror and the swing-out lens fixed in the microscope's illumination path. Its design also allows for collimation of the illumination path with the microscope's image forming path, or in other words, to make adjustments to ensure that both of these optical paths are mutually aligned.

The mirror and swing-out lens holder is attached to the microscope stand with four M4x10 screws (indicated with green circles in Figure 6.) The screw holes in the holder allow for some lateral (sideways) play which is helpful for the collimation. Two M3x9 lateral alignment screws (Figure 6) can be used to further support the collimation. By tightening the alignment screws against the inner walls of the microscope foot the entire holder becomes firmly anchored.

The red circle in Figure 6 indicates the screw that attaches the mirror to the holder. Loosening would allow for a more extensive collimation/adjustment of the mirror. I believe that it is best to avoid loosening this screw because it appears to be nearly impossible to access and re-collimate the mirror

after the mirror and swing-out lens holder has been reattached into the microscope foot. My guess is that Leitz performed an initial mirror alignment in some special alignment jig before they attached the mirror and swing-out lens holder into the microscope. Once put into the microscope, any required fine-tuning could be done by alignment of the entire mirror and swing-out lens holder.

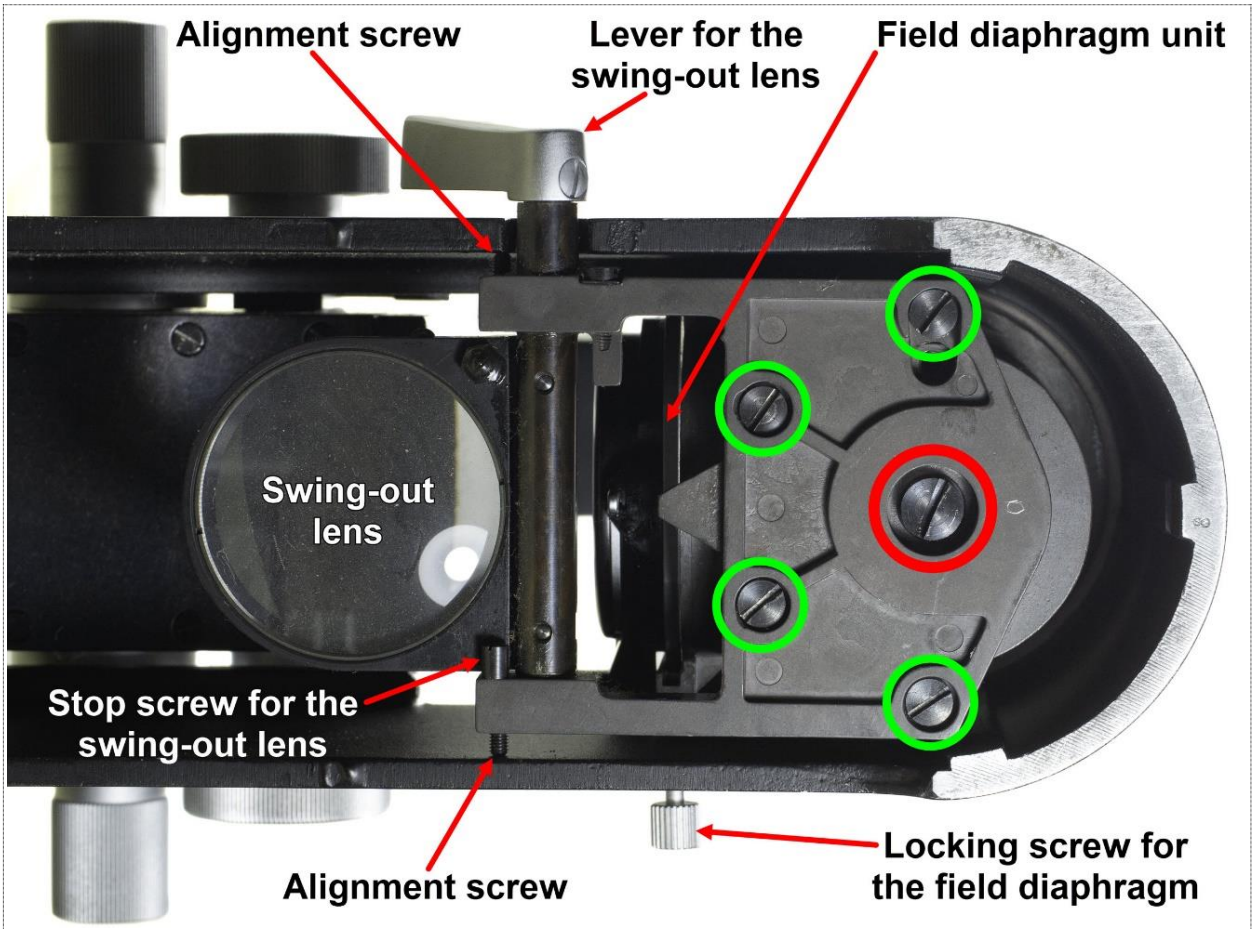

Figure 6: The mirror and swing-out lens holder viewed from the underside of the microscope foot.

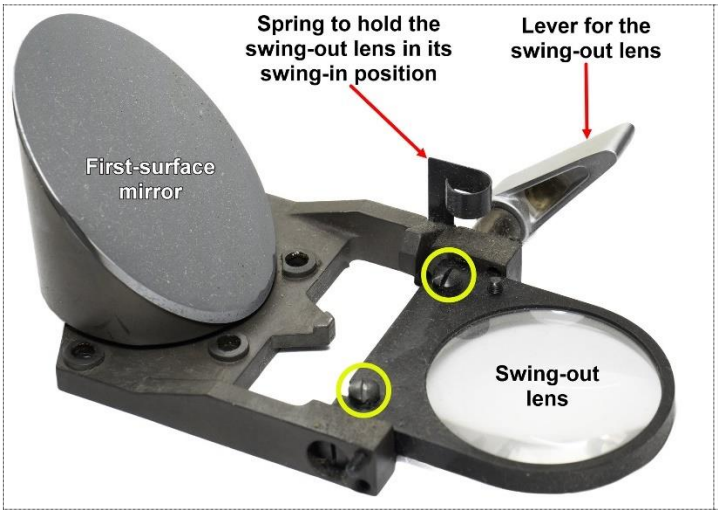

Figure 7: The removed mirror and swing-out lens holder. The lens is in its swing-out position. The yellow circles indicate the screws that attach the swing-out lens to its axle.

Figure 8: The removed mirror and swing-out lens holder. Here the lens is in its swing-in position.

Figure 6 also shows a stop screw for the swing-out lens – this screw simply protects the swing-out lens by preventing it from being folded down beyond its horizontal orientation. There is no need to change it.

To remove the mirror and swing-out lens holder start by unscrewing the four M4x10 screws (indicated with green circles in Figure 6.) Retrieve any washers/shims that you may find sitting around the screws between the mirror and swing-out lens holder and the microscope foot. If present, these washers/shims are critical for the collimation of the holder. You should therefore make a note of where any of these washers/shims were attached and also include the thickness of each of them (measured with a caliper; they will probably be between 0.05 and 0.5 mm thick.) The record is important, so you later are able to put back the holder into the microscope foot with the collimation as close as possible to what it originally was before you removed it.

If the alignment screws (Figure 6) are so tightly screwed against the inner walls of the microscope foot that they prevent the holder from being removed, use a 1.4 mm watchmaker type screwdriver to unscrew each of them by exactly 1 turn. Note that:

1) The alignment screws are M3x9 grub screws that sit recessed in their screw holes in the mirror and swing-out lens holder. Because of the constrained space, the screwdriver can't be much larger than 1.4 mm and must be held slightly inclined, and
2) unscrewing both grub screws by exactly 1 turn (not more, not less) is important to ensure that the alignment (collimation) of the mirror and swing-out lens holder can be reproduced by tightening the screws by exactly 1 turn after the holder has been reattached in the microscope foot.

Carefully remove the mirror and swing-out lens holder from the microscope foot making sure not to touch or scratch the sensitive surface of the mirror (Figure 7 and Figure 8.)

With the mirror and swing-out lens holder removed, the field diaphragm unit is easily to pick out from the underside of the microscope foot.

3. Clean and regrease the field diaphragm

Remove the field diaphragm's metal base plate from the black diaphragm housing and the black plastic thumbwheel by unscrewing the four M2x5 screws from the backside of the base plate (Figure 9.) Separate the three components (Figure 10.)

Figure 9: The field diaphragm unit with its base plate facing up.

The base plate holds the field diaphragm properly positioned in the microscope. The locking screw in the side of the microscope foot holds the base plate tight in its slot in the microscope.

The black plastic thumbwheel sits between the base plate and the field diaphragm housing (Figure 10) and has a notch that fits over the field diaphragm lever. By turning the thumbwheel, the aperture of the field diaphragm can be changed.

The field diaphragm housing (right side of Figure 10) is attached by its mount to the base plate with the four M2x5 screws. The housing contains the diaphragm mechanism (actuator, blades, etc.) and is held together by three M2 grub screws in the periphery of the housing (two of the grub screws are annotated with green arrows in Figure 10.) Don't remove these grub screws unless you have good reasons to do so – releasing them may allow the delicate mechanism parts to come apart and leave you with the onerous and painstaking task to reassemble the diaphragm.

Figure 10: The disassembled field diaphragm unit.

If your field diaphragm was stuck or sluggish, you can now find out whether the cause is aged grease on the plastic thumbwheel only, or aged grease inside of the diaphragm housing. If the field diaphragm lever on the housing moves freely and the diaphragm opens and closes as expected, then you know that the diaphragm mechanism is OK, and all you need to do is to clean off the old grease from the thumbwheel and the adjacent surfaces (and optionally reapply fresh grease as described below.)

If however the field diaphragm in the housing (the part on the right side of Figure 10) is stuck or sluggish, then you could try to release it by soaking the housing in a vial with solvent for several hours. I was pleasantly surprised how a completely frozen field diaphragm quite easily could be released by soaking the housing in pure (99%) isopropanol (after unexpectedly finding out that soaking in my favorite grease cleaning solvent white spirit didn't work at all.) Putting the entire solvent vial in the water bath of an ultrasonic cleaner speeds up the releasing considerably. When the diaphragm releases, open and close it (while submerged in the isopropanol solvent) several times to allow the solvent to reach all surfaces and to dissolve and flush out all of the old grease. Repeat the soaking and flushing with fresh isopropanol at least two more times. Leave the field diaphragm housing to dry in the air - it may take a few days to dry unless you are able keep it at a slightly elevated temperature.

After it has dried, check that the diaphragm opens and closes freely. Do not lubricate the diaphragm blades or the mechanism inside of the field diaphragm housing.

Before reassembling the field diaphragm unit, you need to decide whether you wish to use grease to smoothen and dampen the turning movement of the thumbwheel. Although I usually am inclined to keep my microscope parts grease free, in this case I think that without grease the thumbwheel feels too easy to turn and becomes vulnerable to inadvertent changes.

If you choose to grease the thumbwheel, apply a rather thin layer of a suitable grease. I have used the ubiquitous Super Lube Multi-Purpose Synthetic Grease with Syncolon, NLGI grade 2 to lightly grease both sliding surfaces of the thumbwheel (Figure 11.)

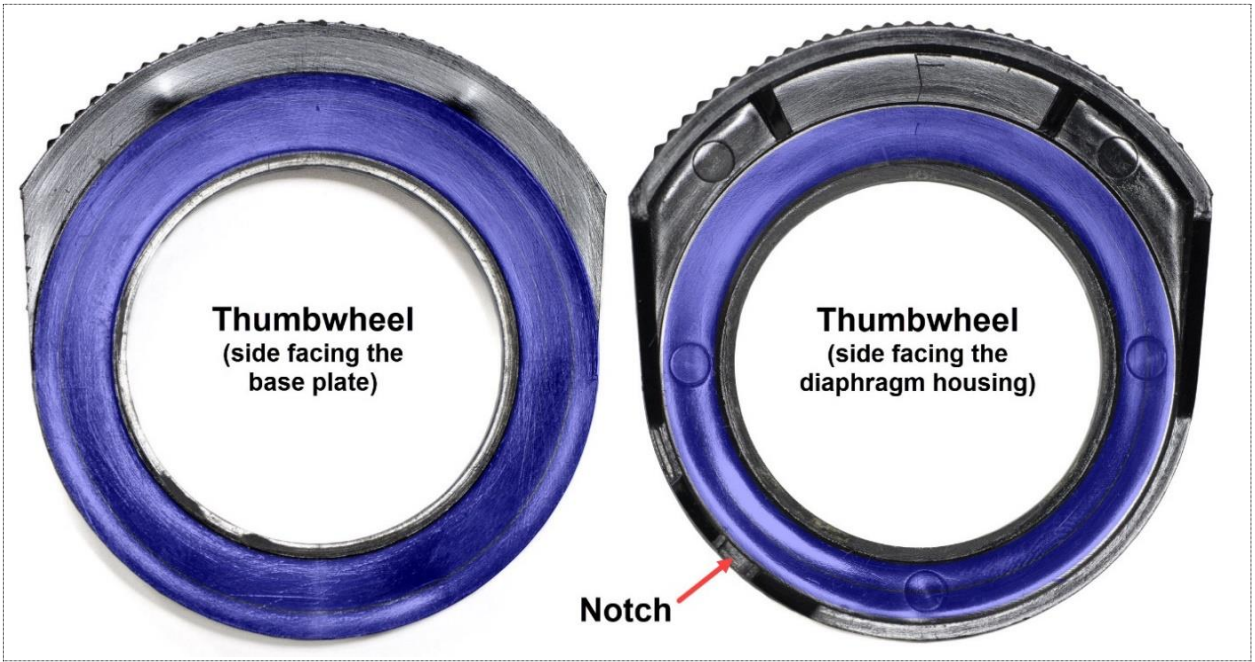

Figure 11: Both sides of the thumbwheel. The sliding surfaces that should be greased are indicated by blue shadowing.

Reassemble the field diaphragm unit using the four M2x5 screws, refer to Figure 4, Figure 5, Figure 9 and Figure 10 for proper assembly.

Turn the thumbwheel back and forth several times to distribute the grease evenly (if applied.) Use cotton swabs to wipe of any visible excess of grease.

4. Clean the dust protecting glass in the filter holder

The filter holder with the dust protecting glass is attached by a simple sleeve mount in the Ortholux microscope's foot (Figure 1.) The filter holder can easily be removed by simultaneously turning it back-and-forth and pulling it upwards.

If the dust protecting glass is not too dirty, you may be able to clean it with a simple standard lens cleaning protocol, perhaps using lens cleaning solution and cotton swabs or lens paper. In more serious cases it may be necessary (and gentler) to clean the glass by submerging and cleaning it in warm water with dishwashing detergent.

Figure 12: A filter holder where the dust protecting glass is cemented in the holder. (View from the holder's underside.).

In some Ortholux filter holders the dust protecting glass is permanently attached (Figure 12) in the holder. Here the cleaning procedure is simple; just soak and clean the entire filter holder with the glass in the detergent solution and then wipe

it all dry with lens paper or a clean microfiber cloth. In other filter holders the glass disc is attached with a threaded locking ring (Figure 13.) In this case the glass disc must be removed from the filter holder before the cleaning, otherwise there is serious risk for corrosion due to trapped water. Here's a short description of the procedure:

On the underside of the removed filter holder (Figure 13) use an adjustable camera lens spanner with flat screwdriver type tips (Figure 14) to unscrew the threaded locking ring that holds the glass disc attached. Be very careful not to slip – camera lens spanners are notoriously prone to slipping and causing damage.

Figure 13: A filter holder where the dust protecting glass is attached by a threaded locking ring. (View from the holder's underside.)

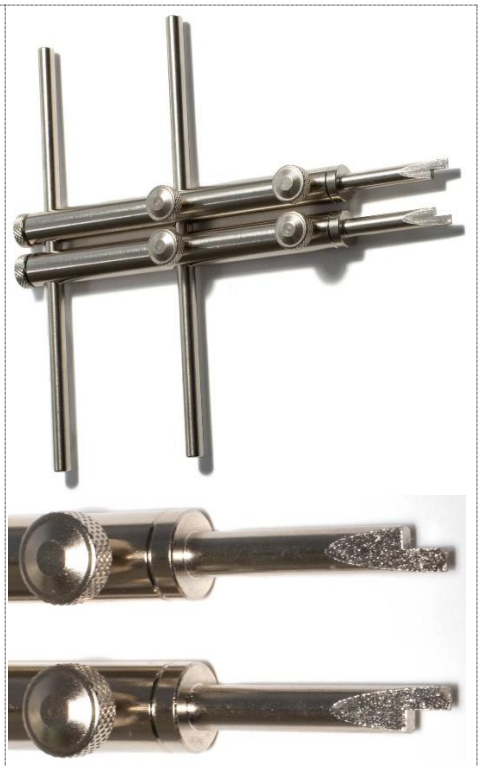

Figure 14: Camera lens spanner. Below is a closeup of the flat screwdriver type tips.

Clean the liberated glass disc using warm water with dishwashing detergent or by any other cleaning protocol that you may prefer. Carefully wipe the glass surfaces dry with lens paper or a clean microfiber cloth.

Reassemble the glass disc in the filter holder with the locking ring. Tighten the locking ring only very lightly.

Put back the filter holder into its bayonet mount in the foot of the microscope.

If the locking ring is too difficult to safely remove from the filter holder, then you could still try to clean the entire filter holder including the glass disc by immersing it in the aqueous detergent solution if you follow up with a water removal step. After completed cleaning in the detergent solution rinse the filter holder thoroughly with lukewarm water. Shake off as much as possible of the water and then carefully wipe the filter holder dry with lens paper or a clean microfiber cloth. Immerse the filter holder completely in a vial with 99% isopropanol and leave it there over the night. Carefully shake off the

isopropanol and wipe the filter holder dry with lens paper or a clean microfiber cloth. Dry the filter holder in the air, preferably at an elevated temperature to speed up the evaporation of any isopropanol that remains trapped in the locking ring thread.

5. Clean the swing-out lens

To access the swing-out lens for cleaning, the entire mirror and swing-out lens holder must first be removed from the microscope foot, refer to subsection 2.

The swing-out lens (Figure 15) is a plano-convex lens with the convex side facing the back of the microscope, i.e., towards the lamp. The lens sits in a black aluminum frame that is attached to an axle which allows it to be folded in and out of the illumination path with the help of a lever on the side of the microscope foot (Figure 1.) An adjustable stop screw (Figure 15) ensures that the lens is precisely vertical in its swing-in position; the screw is sealed with lacquer to preserve its factory setting. A small knob on the side of the frame (Figure 15) rubs against a spring on the mirror and swing-out lens holder (Figure 7) to hold the lens steady when it is in its swing-in position.

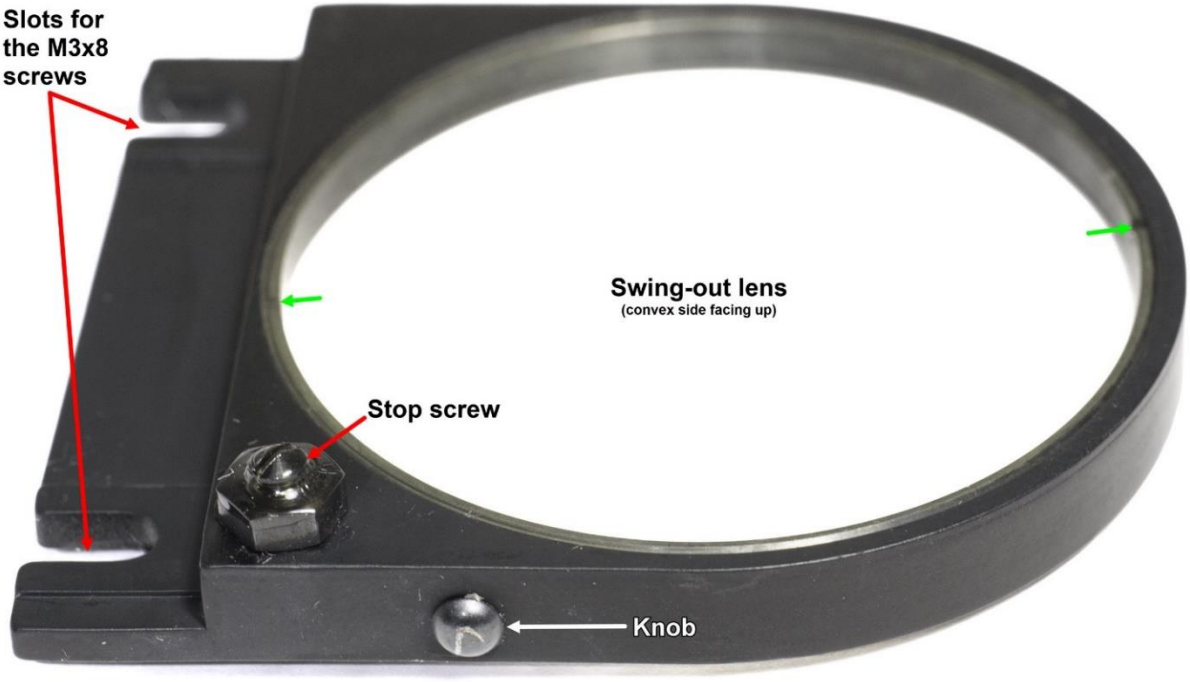

Figure 15: The swing-out lens after removal from the mirror and swing-out lens holder.
The green arrows indicate the lens locking ring's spanner notches.

To remove the swing-out lens loosen the two black M3x8 screws (indicated with yellow circles in Figure 7) that attach the black aluminum lens frame to its axle. Pull out the lens frame from the loosened screws.

Similarly as with the dust protecting glass (subsection 4 above) the lens is attached to the frame with a threaded locking ring. Gently try to unscrew the locking ring with an adjustable camera lens spanner (Figure 14.) The spanner is prone to slip, particularly in this case because of the larger diameter of the locking ring. To avoid damage of the lens, use your judgement, and don't try too hard to loosen the ring.

If you manage to remove the lens, clean it with your preferred lens cleaning protocol. Reassemble the lens in the frame with the locking ring – remember that the lens' convex side should face the locking ring. Tighten the locking ring only very lightly.

If you can't remove the lens from the frame, hold the frame with the stop screw (Figure 15) between your fingers and immerse only the lens part of the frame in lukewarm water with dishwashing detergent. While immersed, lightly brush the lens surfaces with a clean, soft, good quality brush. Avoid wetting the stop screw. Rinse the lens with lukewarm water. To displace the water from the locking ring thread, use a pipette or dropper to repeatedly flush the lens surfaces with 99% isopropanol. Avoid wetting the stopping screw (Figure 15) with the solvent; the screw's lacquer protection may dissolve and become compromised. Carefully wipe the frame and the lens dry, use lens paper or a clean microfiber cloth for the lens surfaces. Dry the frame with the lens in the air, preferably at an elevated temperature to speed up the evaporation of any isopropanol that remains trapped in the locking ring threads.

Reattach the lens frame with the lens to the flattened side of the axle (Figure 7) using the two M3x8 screws. The lens' convex side should face away from the mirror and towards the microscope lamp.

Check that the lever swings the lens in and out of the illumination path as expected.

6. Clean the mirror

To access the mirror for cleaning the entire mirror and swing-out lens holder must first be removed from the microscope foot, refer to subsection 2. The mirror cleaning is also easier to do if the swing-out lens has been removed from its axle (refer to subsection 5 above.)

Bear in mind that the mirror is of the first-surface type, which means that the reflecting metal deposit is unprotected on the mirror's surface. This makes the surface particularly sensitive to scratching, which can easily result from careless cleaning.

Good optical cleaning protocols is a boundless topic. For first-surface mirrors I can only provide some suggestions based on very limited experience. Please feel free to explore any better options that you can think of.

Ideally, I would prefer to clean a first-surface mirror with a soft brush while having the mirror immersed in lukewarm aqueous detergent solution. For the Ortholux mirror it would however require separating the mirror from its holder, and that is just not a good idea because then one would face the difficult task to re-collimate the mirror in the illumination path (refer to subsection 2.) Instead, my suggestion is to use a different cleaning protocol, one that we could call the "gentle wet lens paper" method. It is a modification of a procedure that you can view on a MicrobeHunter Microscopy YouTube video provided by the well-known microscope enthusiast Oliver Kim.

Start by using a camera air blower or a compressed air can to blow off as much as possible of any loose dust on the mirror surface. Then prepare several 15-20 mm wide lens paper strips by cutting up sheets of any good quality lens paper. Put the entire mirror and swing-out lens holder in a vise (or prop it up) with the mirror's surface horizontal and facing up. Slowly drag the strips over the mirror surface as described in the video after wetting the strips with a drop of lens cleaning solution. Unfortunately, lens paper strips tend to soften and rip apart when they are dragged across the mirror surface using purely aqueous lens cleaning solutions. It seems however that using a 70% isopropanol solution doesn't weaken the lens paper while still providing excellent cleaning. You will need to repeat the lens paper

dragging a couple of times to cover the entire mirror surface, every time with a fresh lens paper strip and a fresh drop of lens cleaning solution. I will not try to describe any procedural details; the video illustrates it better than any words can. The main concern is to avoid pressing the paper on the mirror surface, just let it lightly and slowly glide over the surface under its own weight. Depending on the nature of the dirt on the mirror you may also need to try other cleaning liquids, like methanol or toluene.

7. Put back the mirror and swing-out lens holder into the microscope foot

If applicable, reattach the swing-out lens to the axle on the mirror and swing-out lens holder as described in subsection 5.

Before attaching the holder in the microscope foot remember that you also will need to reattach any washers/shims according to your notes (refer to subsection 2 above) from when you disassembled the holder.

Attach the mirror and swing-out lens holder in the microscope foot using its four M4x10 screws (Figure 6.) Any washers/shims should obviously be put back around these screws and between the microscope foot and the holder. Don't yet entirely tighten the M4 screws, leave them just enough tight to barely allow the holder to be turned (rotated) as much as the play in the screw holes allows. Tighten both of the alignment screws (Figure 6) by exactly 1 turn to recreate the holder's original alignment as it was when you removed it (subsection 2.) Now fully tighten the four M4x10 screws.

Optionally, consider collimating the holder according to Appendix 1: Collimate the mirror and swing-out lens holder.

Reattach the field diaphragm unit into the microscope foot. Clamp it in the microscope foot with its locking screw.

References

Wolfgang Lehmann's comprehensive site about the Ortholux microscope:
https://www.leitz-ortholux.de

Oliver Kim's ("Microbehunter Microscopy") YouTube video about gentle lens cleaning:
https://www.youtube.com/watch?v=NNOrqdU4KXY&t=472s

Carl Hunsinger's YouTube video about collimating the substage of an Olympus BH-2 microscope:
https://www.youtube.com/watch?v=Y5PvIOeYYNI

Appendix 1: Collimate the mirror and swing-out lens holder

To collimate the mirror and swing-out lens holder means to exactly align it in the microscope's common optical path. I have entered this procedure as an appendix because 1) the collimation is a somewhat challenging task, 2) it requires some special equipment, 3) the "front-end" illumination system in the Ortholux microscope appears quite robust which makes any significant miscollimation improbable, and 4) most amateur microscopists should not need to worry about any minor miscollimation of the mirror and swing-out lens holder.

In short, the collimation is done by slight adjustments of the mirror and swing-out lens holder (Figure 6) after the four M4x10 screws have been loosened. Shims can be attached if required for larger adjustments.

Required equipment:

- A basic LED flashlight, with a circular, smooth head and an outer head diameter of 20.0 mm (Figure 16.) The outer diameter of the head is quite important to make the flashlight fitting snugly in the Ortholux nosepiece's 20.0 mm tube lens mount (Figure 21 and Figure 22.) Slight deviations from 20.0 mm are acceptable as long as the flashlight still can be solidly attached and centered in the mount by other means, for example, with tape or pieces of vinyl tubing. The flashlight must not have any lens in the front for focusing of the beam (but a reflector is OK).

Figure 16: An example of an LED flashlight where the outer diameter of the head is 20.0 mm.

- A hollow 100X oil immersion objective used as a pinhole aperture that acts as a reference point for the microscope's optical path. It can be made by removing all internal lenses from a defunct 100x oil immersion objective leaving only an empty opening where the front lens has been. The front lens can be removed from its mount after softening the lens cement for several hours in a solvent like acetone or toluene. The pinhole aperture should be as narrow as possible, that's why a 100x oil immersion objective is most suitable.
- A collimation target (Figure 17.) Use an inkjet printer to print the collimation target (refer to Appendix 2: The collimation target) on a white Letter or A4 paper sheet at 100% scale. Use office tape to affix an approximately 5 x 15 cm (2 x 6") strip of wax paper (a.k.a. sandwich paper) to symmetrically cover the target on the paper printout. Try to get the wax paper to lay as flat as possible on the paper sheet. Now print the collimation target again on the combined paper/wax paper sheet. The idea is to print on the wax paper while it is aligned over the target on the paper printout and to use the paper sheet to safely guide the wax paper through the printer. Remove the printed wax paper from the paper sheet and allow the ink on the wax paper to dry for at least an hour (some drying time is required because wax paper doesn't absorb ink like regular paper.)

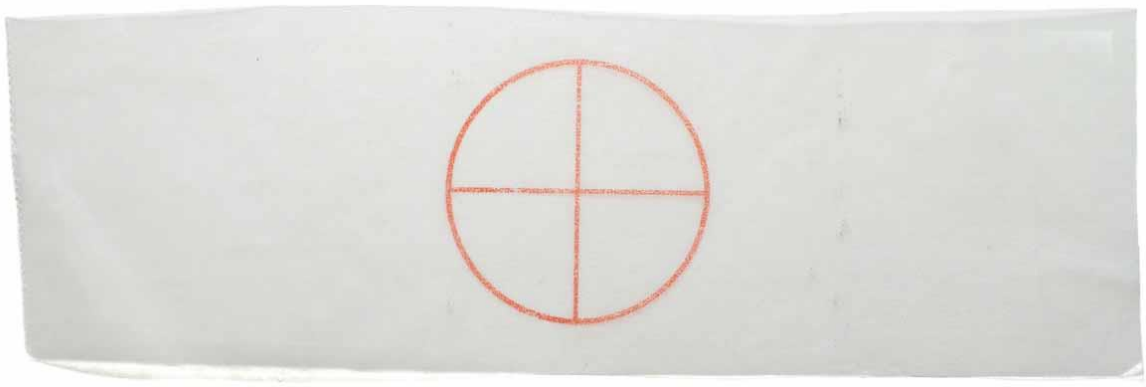

Figure 17: The semi-transparent wax paper strip with the printed collimation target.

- Thin M4 washers, 4 mm inner diameter and 7 mm outer diameter, steel, brass or plastics. Having both 0.05 mm and 0.1 mm thick washers would be optimal, but if 0.05 mm washers are difficult or impossible to obtain, then 0.1 mm washers will have to do. 0.5 mm washers may also be useful in some cases.

Procedure:

Remove the lamphouse from the backside of the microscope.

Use tape to attach the wax paper collimation target over the lamphouse port on the backside of the microscope (Figure 18 and Figure 19.) The target must be aligned symmetrically and centered over the lamphouse port. Shine some light from the inside of the lamphouse port to facilitate the centering of the target.

Figure 18: The empty lamphouse port on the backside of an Ortholux microscope.

Figure 19: The lamphouse port symmetrically covered with the collimation target wax paper printout.

Attach the pinhole aperture (the hollow 100x oil immersion objective) to the microscope's nosepiece.

Remove the head from the microscope, but leave the nosepiece attached (Figure 20.)

Carefully remove the tube lens (a.k.a. telan lens) from the nosepiece (Figure 20.) It is attached in a 20.0 mm sleeve mount (Figure 21) and may be somewhat difficult to remove. A combination of turning it back and forth while at the same time pulling it up should get it released. Be careful not to dirt or

scratch the lens surfaces and don't damage the lens case by manipulating or holding it with a tool without protection. To get a better finger grip around the tube lens it helps to wrap a wide rubber band over its periphery.

Attach the flashlight to the nosepiece's tube lens mount. The flashlight should be firmly attached in the mount, while it still should be possible to tilt its rear end at least a couple of millimeters (as illustrated in Figure 22.)

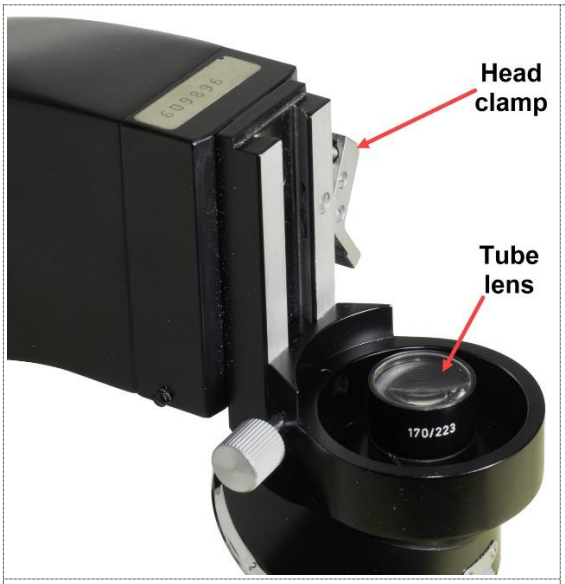

Figure 20: Ortholux nosepiece with its tube lens.

Figure 21: Ortholux nosepiece with removed tube lens.

Figure 22: Ortholux nosepiece with attached flashlight.

Flip up the swing-out lens (Figure 1 and Figure 6) into the microscope's illumination path.

Prop up the microscope for the work. (I put the microscope on its side on the table supported by a few books, but it certainly can be done in different ways.) For safety and convenience ensure:

1) That you have good access to the underside of the microscope foot so you are able to access and adjust the screws that hold the mirror and swing-out lens holder.
2) That you are able to comfortably watch the wax paper collimation target on the backside of the microscope while you adjust the mirror and swing-out lens holder.
3) That the flashlight is accessible and steadily attached in the nosepiece's tube lens mount, so it doesn't lose its alignment while you work.

If you would like to document your efforts, also setup a camera with a macro lens on a stand and arrange for suitable lighting to be able to take photos of the target with the dot.

Switch on the flashlight in the nosepiece and observe the appearance of the light dot projected on the wax paper collimation target. If the content inside of the light dot is not symmetric (it is actually an image of the flashlight's LED, Figure 23) then the flashlight must be better aligned in the optical path. With the flashlight head remaining firmly attached in the nosepiece's tube lens mount, slightly tilt the back end of the flashlight (Figure 22) until the light dot looks symmetric (Figure 24.)

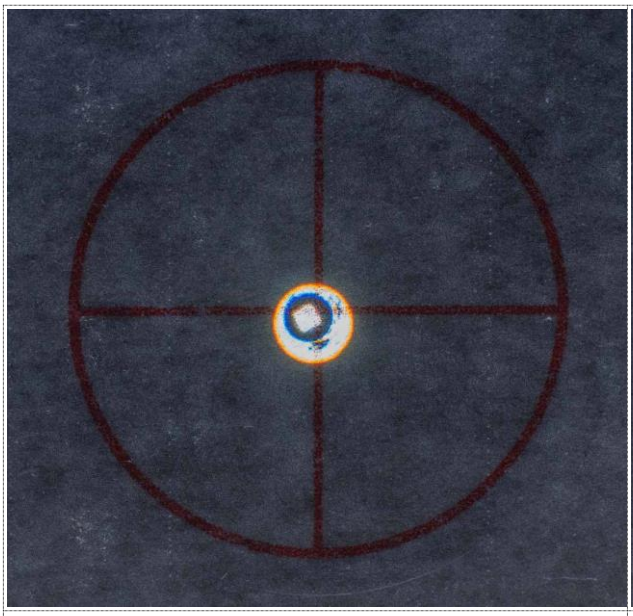

Figure 23: Light dot on the collimation target indicating that the flashlight is misaligned. The content inside of the light dot is not symmetric.

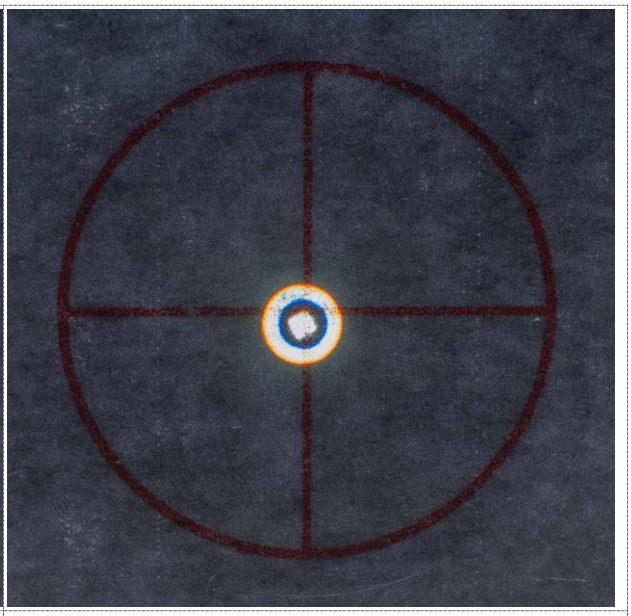

Figure 24: Symmetric light dot after proper alignment/tilting of the flashlight.

Loosen the four M4x10 screws that hold the mirror and swing-out lens holder (Figure 6, and indicated by letters A, B, C and D in Figure 27) and leave them just barely loose. Also loosen the two alignment screws (Figure 6, and the blue arrows in Figure 27) by 1-2 turns using a 1.4 mm screwdriver. Be careful not to loosen the screw that holds the mirror (with a red circle in Figure 6, or with the letter E in Figure 28.) You should now be able to move the mirror and swing-out lens holder sideways (as much as is allowed by the play in the screw holes) while it still sits snugly attached in the microscope foot. Move the holder sideways and turn it in different directions (as indicated by the yellow arrows in Figure 27) while observing where the light dot moves on the alignment target. The goal is to keep the light dot just in the center of the target (Figure 25 vs. Figure 26) while successively tightening the four M4x10 screws and the two alignment screws to lock in the collimation.

The collimation adjustments done so far will be quite limited because the play in the screw holes is only a few tenths of a millimeter.

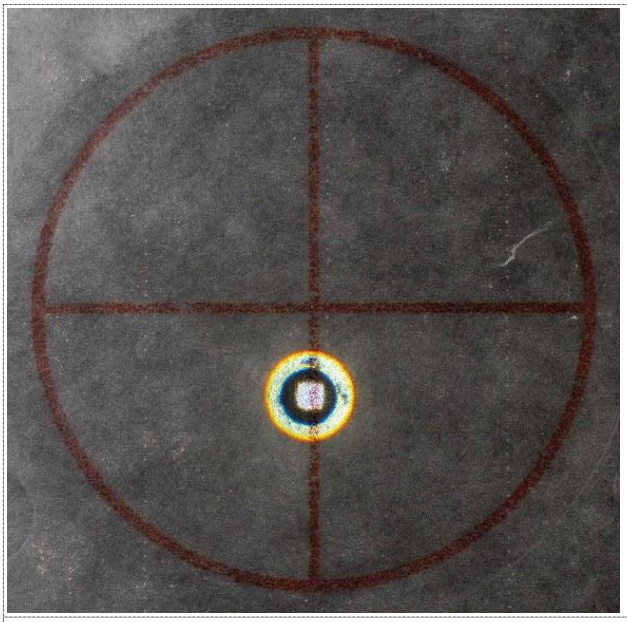

Figure 25: The light dot is clearly off the target which indicates that the mirror and swing-out lens holder needs collimation.

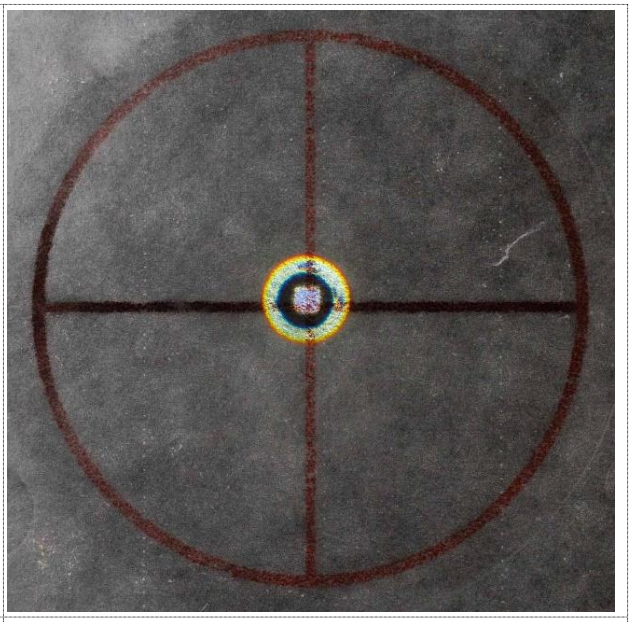

Figure 26: The light dot on the center of the target after collimation of the mirror and swing-out lens holder. The dot is still off by ½ mm, but I believe that this deviation is acceptable.

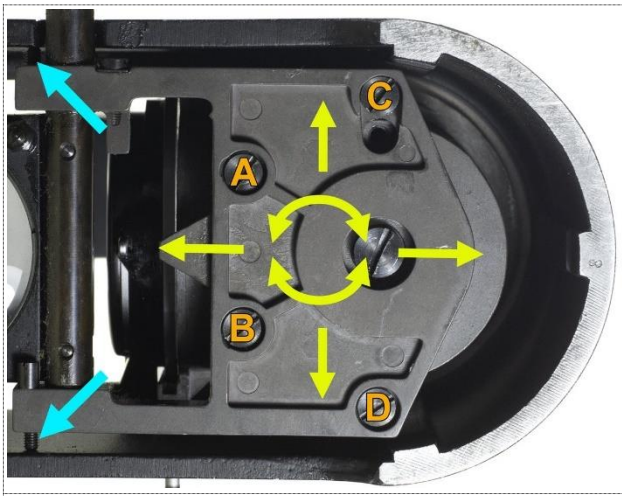

Figure 27: The yellow arrows indicate the directions where the mirror and swing-out lens holder can move when screws A, B, C and D are released. The sizes of the arrows are highly exaggerated; the movements are limited to fractions of a millimeter.

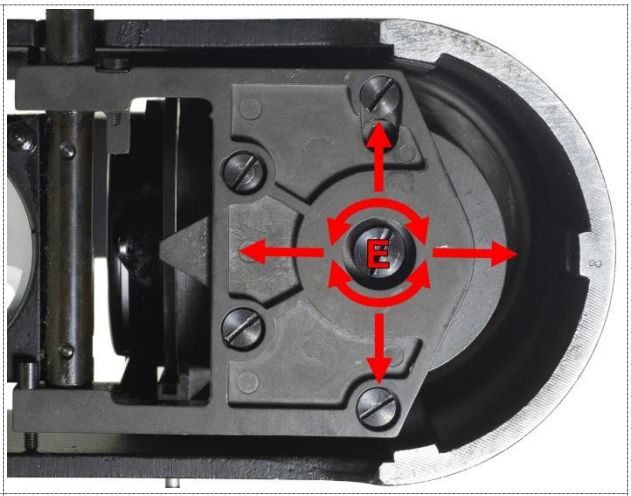

Figure 28: The red arrows indicate the directions in which the mirror can be moved after screw E has been released.

The collimation can however be escalated to a higher level by propping up the mirror and swing-out lens holder with shims or washers that are put over suitably selected screws A, B, C and/or D in Figure 27 – the washers should of course be placed between the holder and the microscope foot. With the help of basic geometry, it is not difficult to estimate where the washers need to go and how thick they need to be to move the light dot to the center of the target. If you, for example, need to move the dot 1 mm further down on the target, then you could add 0.1 mm thick washers to screws A and B in Figure 27.

Alternatively, you could achieve the same result by adding 1.0 mm washers to all four screws A, B, C and D. It will probably require a few trials back and forth, but with some effort you should be able to get the dot within 0.5 mm from the center of the target.

The last resort for the collimation (which I so far have hesitated to try out) would be to align only the mirror after loosening its single screw (with letter E in Figure 28.) As mentioned previously, this kind of collimation may be challenging to perform because of the difficulty to manipulate the mirror in a safe and controlled way while it sits attached in the microscope.

Final thought: Don't worry too much if you couldn't get the dot aligned exactly on the center of the target. Few users really need that level of perfection.

Appendix 2: The collimation target

The three concentric rings will help you to center the target over the microscope's lamp port