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

Scope

These maintenance notes cover what could be called the "front-end" illumination system of the Leitz Ortholux microscope. It is situated at the front end of the microscope foot and consists of 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 used as a contrast to the "back-end" illumination system which 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 used with the versatile Berek condenser ("*Zweiblendenkondensor*" in German) that provided its own field diaphragm. However, to be able to properly use the new 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 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 they 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 lifting it out after its locking screw 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 position that prevents the diaphragm unit from being removed from the microscope foot.

Mirror: An oval 45° mirror 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. It is a first-surface mirror and therefore 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 it is unprotected and exposed to the environment.

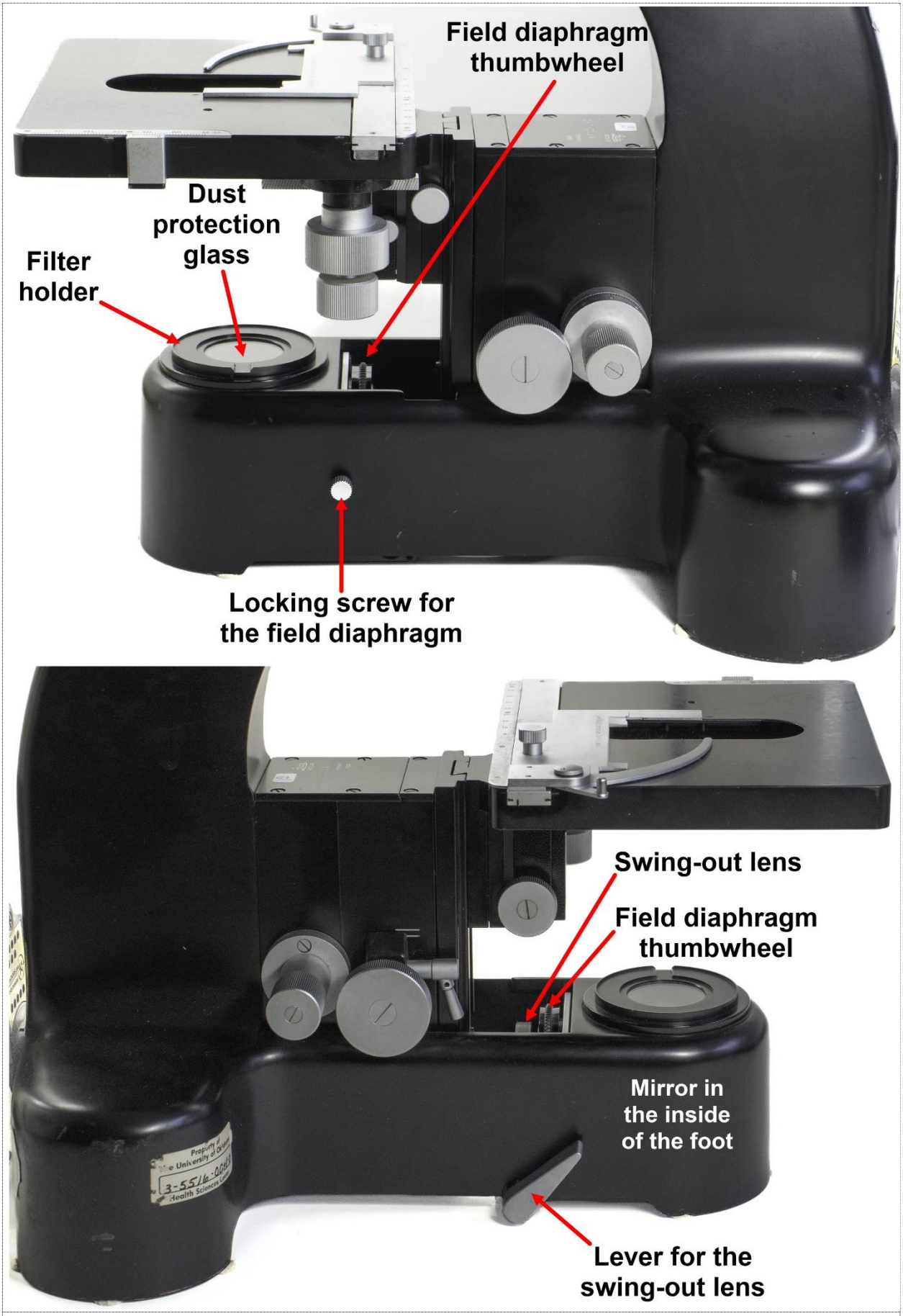

Figure 1: The foot of the Ortholux microscope (post-1963/64 model.)

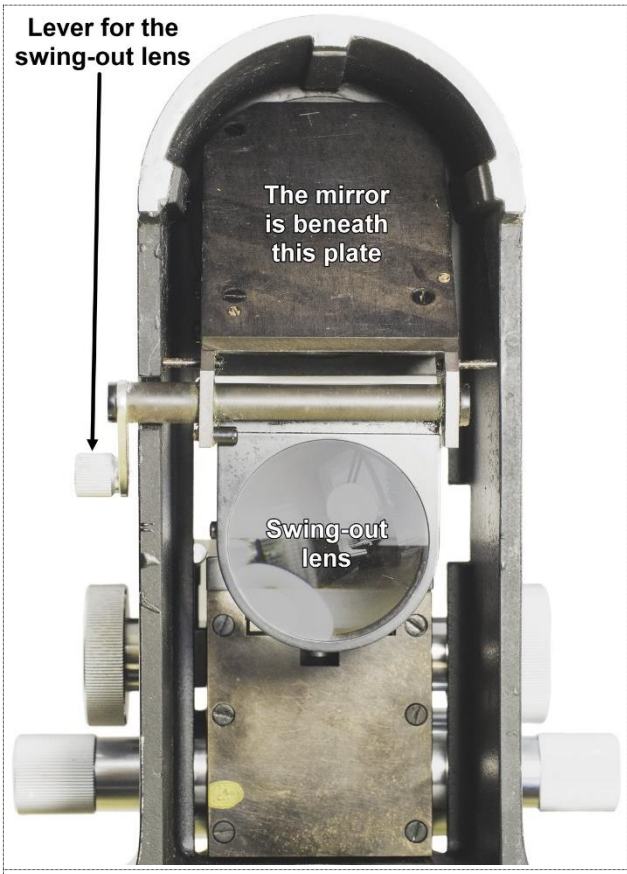

Figure 2: View into the underside of the foot of a pre-1963/64 microscope.

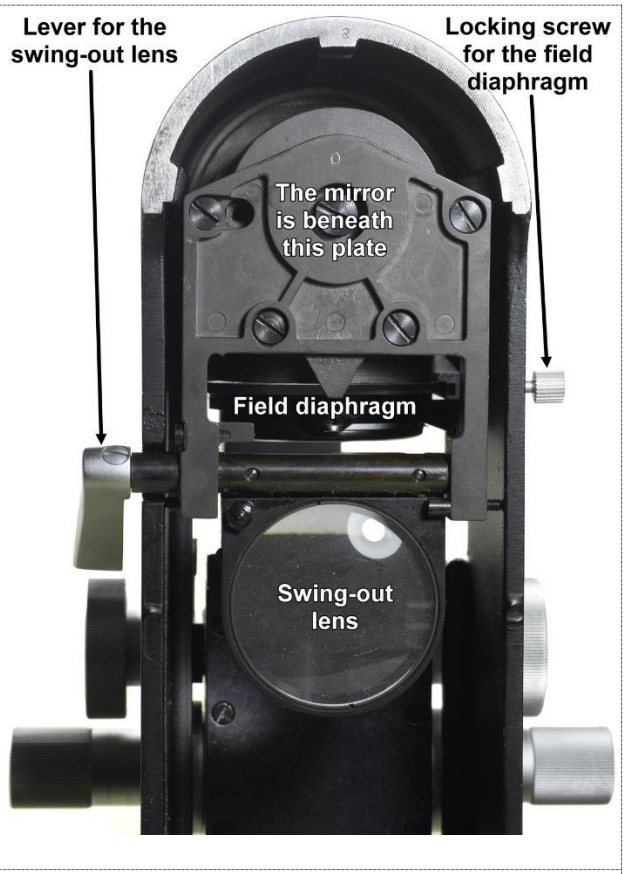

Figure 3: View into the underside of the foot of a post-1963/64 microscope.

Maintenance Notes

1. Remove the field diaphragm

Let's start will 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 lift out the field diaphragm unit from its slot in the microscope stand. 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 from being removed. You will then instead need to remove the field diaphragm unit from the underside of the microscope foot. And to do this you first need to remove the mirror and swing-out lens holder (Figure 6 and Figure 7.)

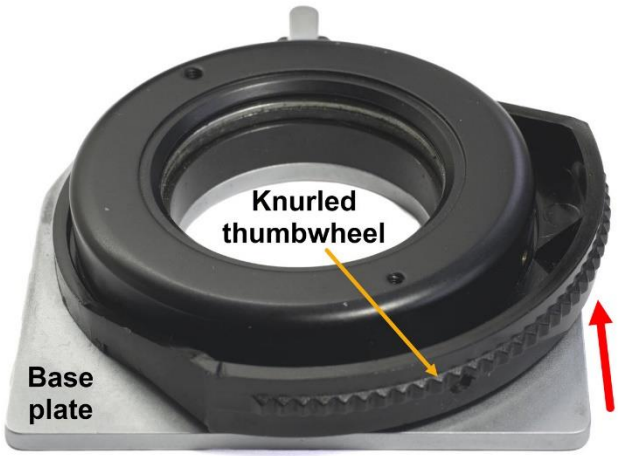

Figure 4: The removed field diaphragm unit. The diaphragm is in its maximally open position – the knurled thumbwheel reaches outside of the width of the base plate (red arrow) which hinders the unit's normal removal from the microscope.

Figure 5: The removed field diaphragm unit. The 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 above, the mirror and swing-out lens holder must also be removed from the microscope stand if the field diaphragm is stuck in a way that prevents it from being lifted out from its slot.

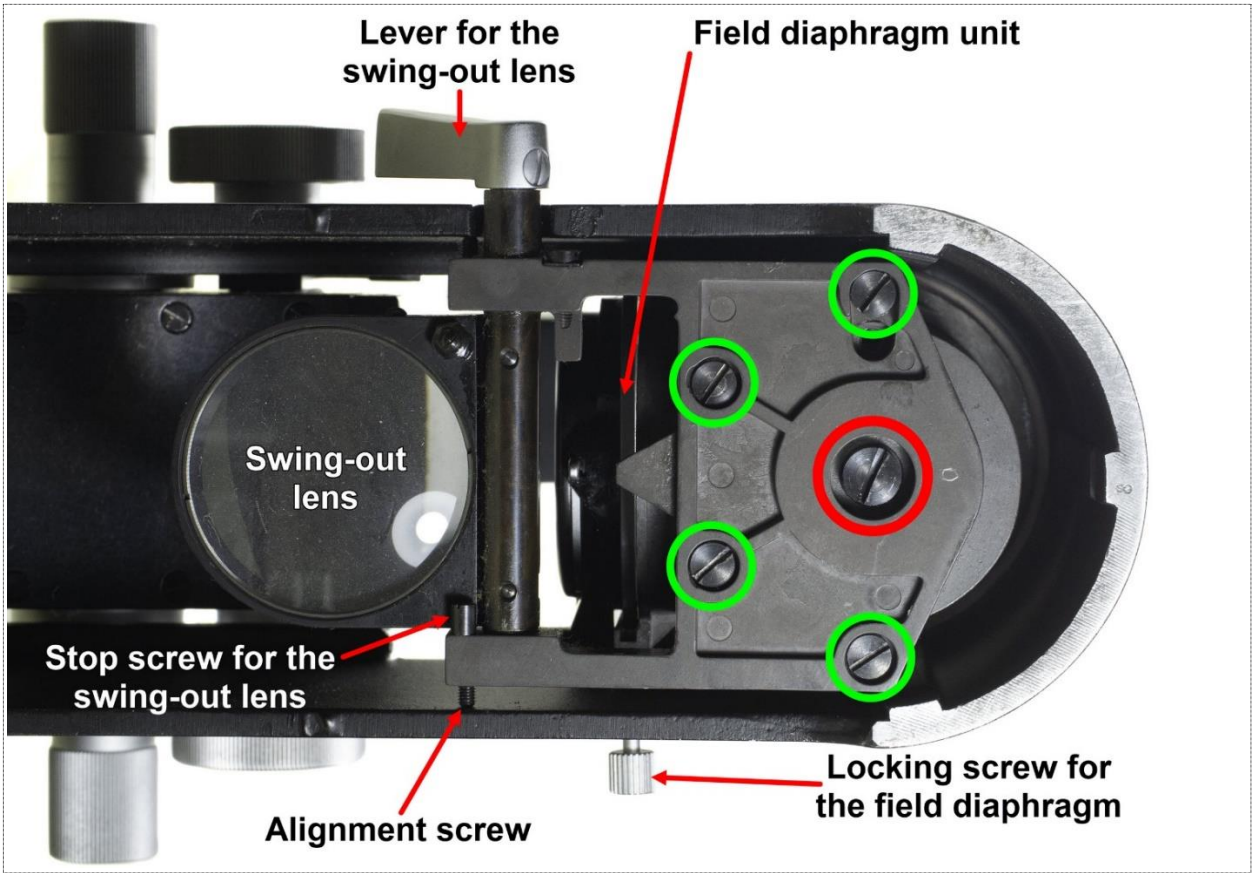

Figure 6: The mirror and swing-out lens holder viewed from the underside of the microscope foot.

The mirror and swing-out lens holder (Figure 6 and Figure 7) is attached to the 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 useful for alignment (collimation) of the holder with the microscope's optical axis. The red circle in Figure 6 indicates the screw that attaches the mirror to the holder. Loosening it allows for a more extensive collimation/adjustment of the mirror. I believe that it is best to avoid attempting this because it appears nearly impossible to access and adjust the mirror while it is attached in the microscope foot. My guess is that Leitz performed this as an initial adjustment in some special alignment jig prior to assembling the mirror into the microscope. Then, if required, some final fine-tuning was done by alignment of the entire mirror and swing-out lens holder (as allowed by the play in its four screw holes.)

I'm not sure about the purpose of the thin screw labeled "Alignment screw" in Figure 6. Its tip touches the inside of the microscope stand, so perhaps it's there to support the alignment of the holder, or alternatively it may just be there to keep the holder steady when the swing-out lens level is operated.

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.

Remove the mirror and swing-out lens holder by unscrewing the four M4x10 screws (indicated with green circles in Figure 6.) Be careful not to touch or scratch the sensitive surface of the mirror (Figure 7 and Figure 8.) The field diaphragm unit can now easily be removed from the underside of the micro-scope foot. The mirror and the swing-out lens are now also accessible for cleaning.

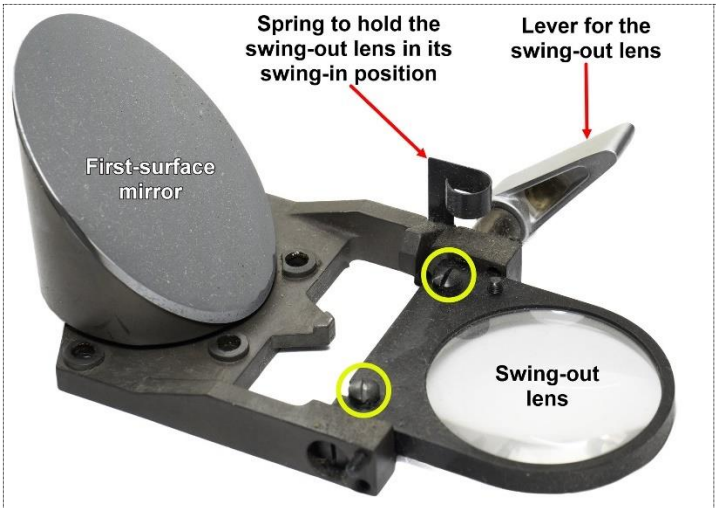

Figure 7: The removed mirror and swing-out lens holder. The lens is in its swing-out position. The yellow circles indicate the screws that attach the swing-out lens to its axle.

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

3. Clean the field diaphragm from old grease

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.)

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.

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

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.

To release a stuck or sluggish field diaphragm soak the field diaphragm housing (the part on the right side of Figure 10) 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 finding out that soaking with 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 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.

Finally 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 both sliding surfaces of the thumbwheel (Figure 11.)

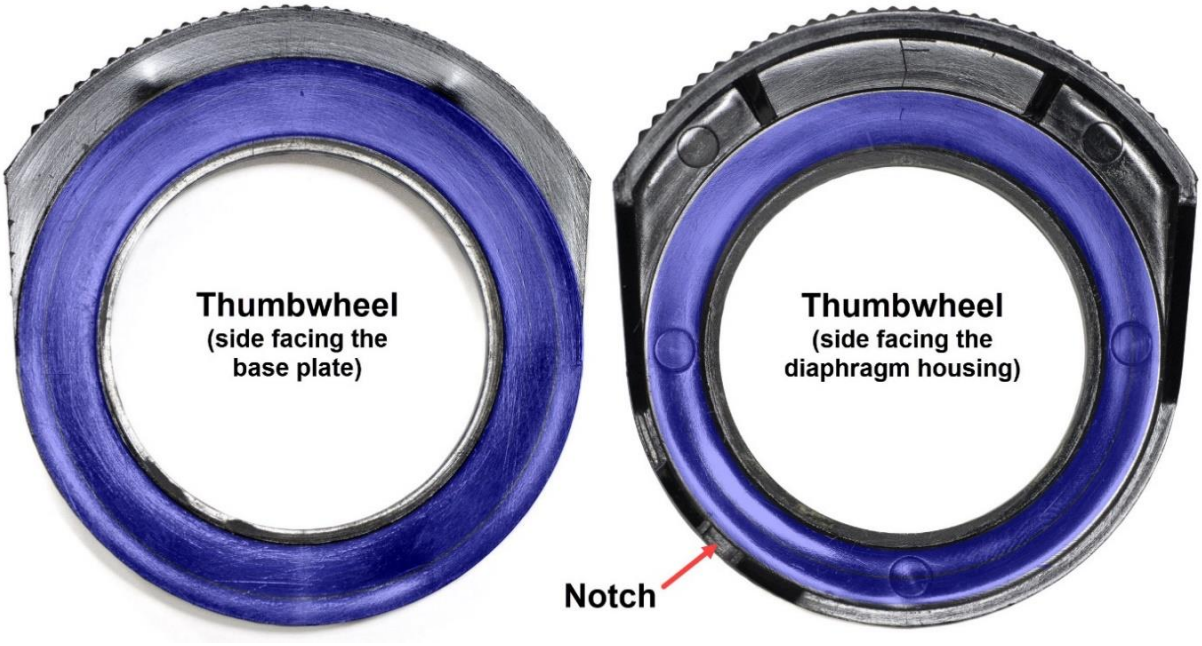

Figure 11: Both sides of the thumbwheel. The sliding surfaces that should be greased are indicated by blue shadowing.

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.) It can easily be removed by simultaneously turning it back-and-forth and pulling it upwards.

On the underside of the removed filter holder (Figure 12) use an adjustable camera lens spanner with flat screwdriver type tips (Figure 13) 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.

Clean the liberated glass disc using your preferred lens cleaning protocol. 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.

Figure 12: The filter holder viewed from its underside.

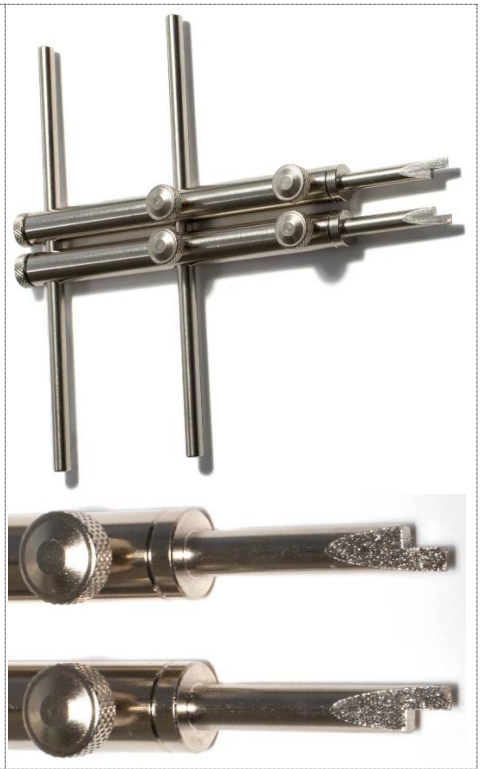

Figure 13: Camera lens spanner. Below is a closeup of the flat screwdriver type tips.

If the locking ring is too difficult to remove from the filter holder, then the entire filer holder including the glass can alternatively be cleaned by immersing it all in warm water with dishwashing detergent and while immersed lightly brushing the glass surfaces with a clean, soft, good quality brush. Rinse with warm water. To remove any water in the thread of the locking ring (where it could cause corrosion) immerse the filter holder completely in a vial with 99% isopropanol and leave it there over the night. Carefully wipe the filter holder dry, use lens paper or a clean microfiber cloth for the glass surfaces. Dry the filter holder in the air, preferably at an elevated temperature to speed up the evaporation of the isopropanol that is trapped in the locking ring threads.

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

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 14) is a plano-convex lens with the convex side facing the back of the microscope, i.e., towards the lamp. It sits in a black aluminum frame that is attached to an axle which allows it to be moved 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 14) 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 14) 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.

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 13.) The spanner is prone to slip, particularly in this case because of the larger diameter of the locking ring. To avoid damage, use your judgement, and don't try too hard to loosen it.

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.

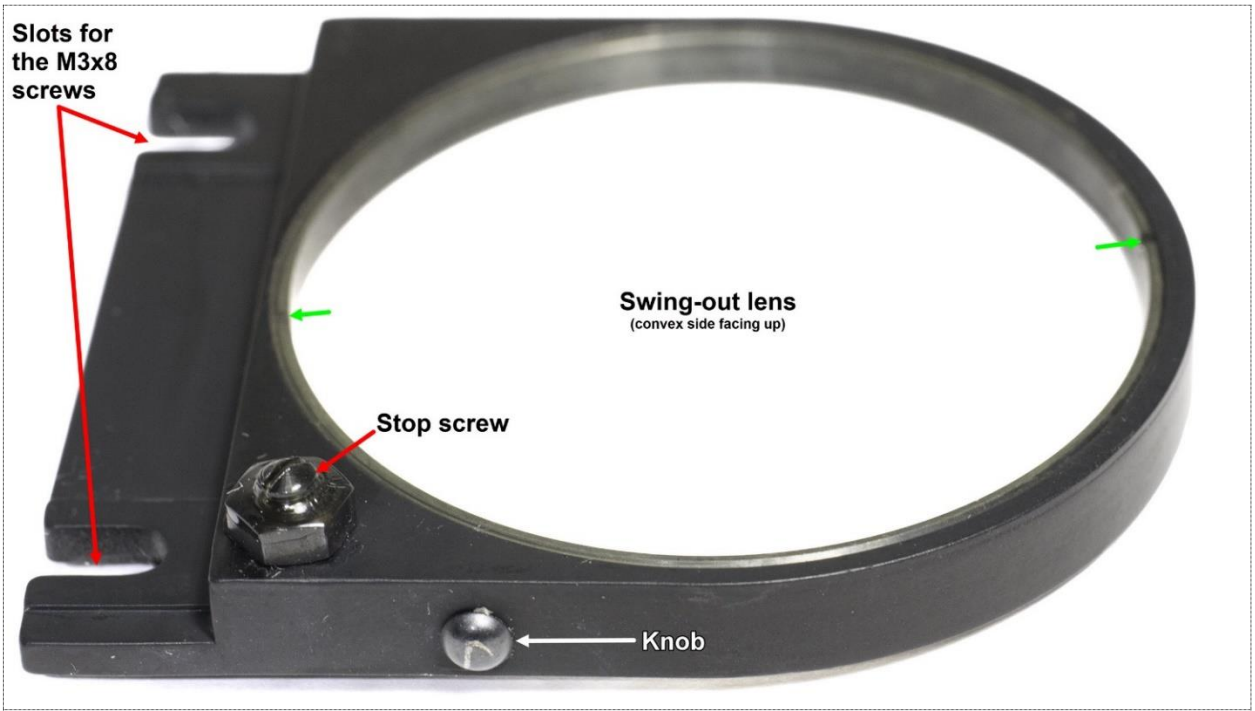

Figure 14: The swing-out lens after removal from the mirror and swing-out lens holder.
The green arrows indicate the lens locking ring's spanner notches.

If you can't remove the lens from the frame, hold the frame with the stop screw (Figure 14) between your fingers and immerse only the lens part of the frame in warm 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 warm 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 14) 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 the isopropanol that is 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 its 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 immersed in warm 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. Slowly drag the strips over the mirror surface as described in the video using drops of aqueous lens cleaning solution. You will need to repeat it several 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 describe any procedural details; the video illustrates it better than any words. 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 isopropanol 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.

Attach the complete mirror and swing-out lens holder to the microscope foot using the four M4x10 screws (Figure 6.) Don’t tighten the screws yet, leave them just barely loose. While lightly pressing the tip of the alignment screw (Figure 6) against the inside of the microscope foot, move the mirror and swing-out lens holder to try to center it as much as possible in the screw holes, and then tighten the screws.

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

References

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

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

Carl Hunsinger's YouTube movie 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 optical path. I have entered this 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.

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 are 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 15.) 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 20 and Figure 21.) 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, by 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 15: 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 16.) 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 (the drying time is required because wax paper doesn’t absorb ink like regular paper.)

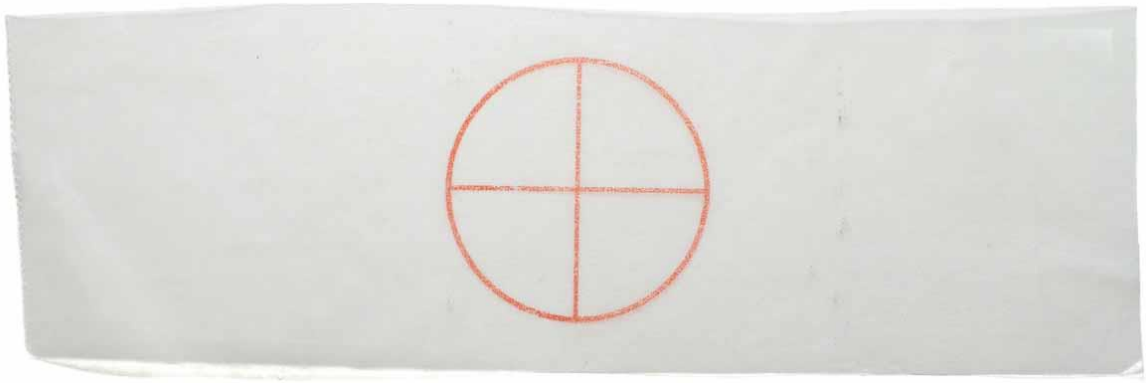

Figure 16: The semi-transparent wax paper strip with the printed collimation target.

- Thin 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.

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 17 and Figure 18.) 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 target’s centering.

Figure 17: The empty lamphouse port on the backside of an Ortholux microscope.

Figure 18: 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 19.)

Carefully remove the tube lens (a.k.a. telan lens) from the nosepiece (Figure 19.) It is attached in a 20.0 mm sleeve mount (Figure 20) 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 a lot 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, but it should still be possible to tilt its rear end at least a couple of millimeters (as illustrated in Figure 21.)

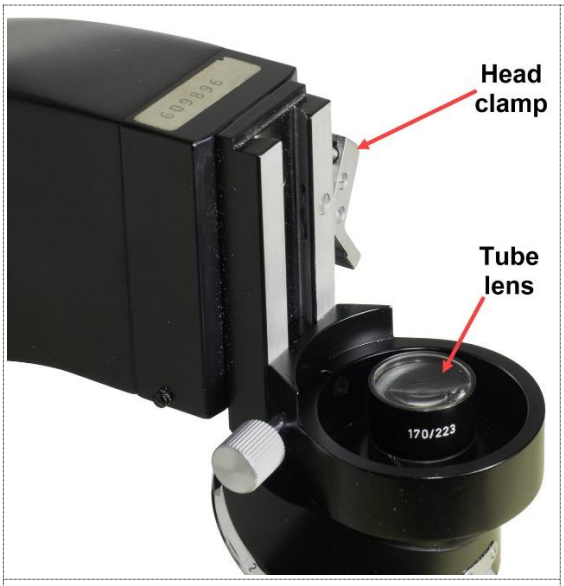

Figure 19: Ortholux nosepiece with its tube lens.

Figure 20: Ortholux nosepiece with removed tube lens.

Figure 21: 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 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 22) 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 21) until the light dot looks symmetric (Figure 23.)

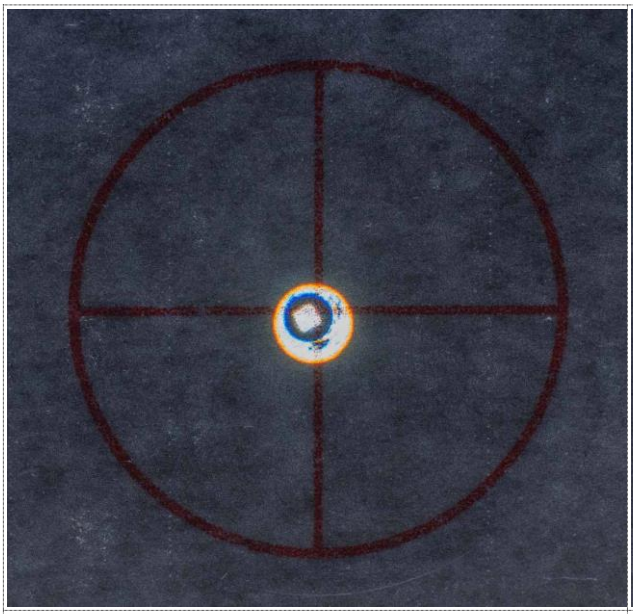

Figure 22: Light dot on the collimation target indicating that the flashlight is misaligned. The content inside of the light dot is not symmetric.

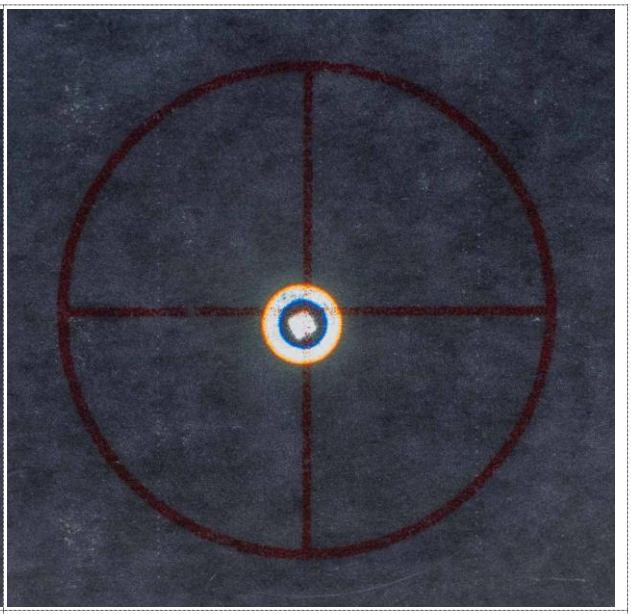

Figure 23: Symmetric light dot after proper alignment of the flashlight.

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 26) and leave them just barely loose. 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 27.) 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 26) while observing where the light

dot moves on the alignment target. The goal is to get the light dot just in the center of the target (Figure 24 vs. Figure 25) and then tighten the four M4x10 screws to lock in the collimation.

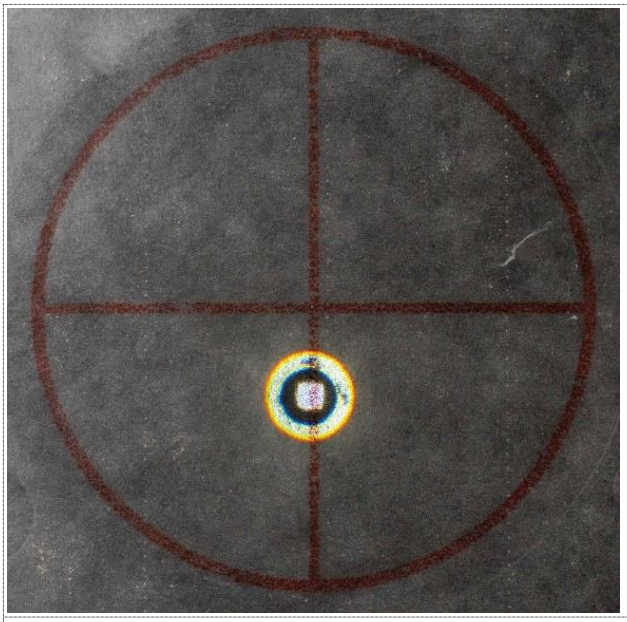

Figure 24: The light dot is clearly off the target which indicates that the mirror and swing-out lens holder needs collimation.

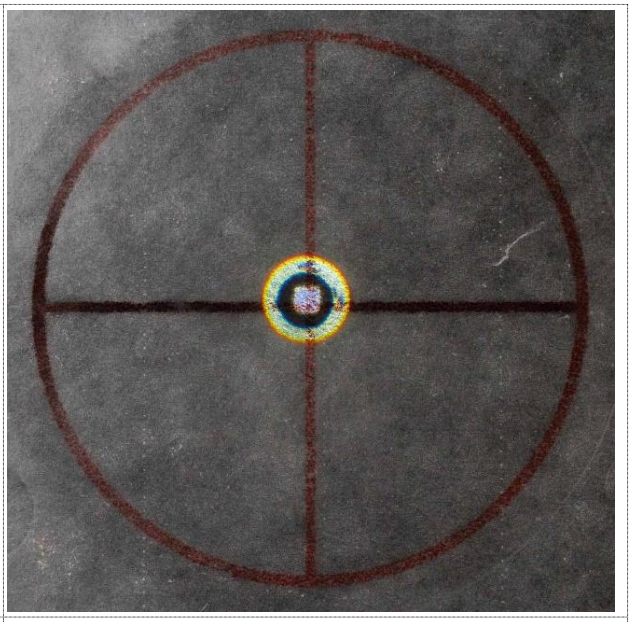

Figure 25: The light dot on the center of the target after collimation of the mirror and swing-out lens holder. The dot is still off by ½ mm, but I believe that this deviation is acceptable.

The collimation adjustments will however be quite limited because the play in the screw holes is only a few tenths of a millimeter. Note that you also may need to unscrew the alignment screw (blue arrow in Figure 26) – its tip rests against the inside of the microscope foot which further limits the collimation range.

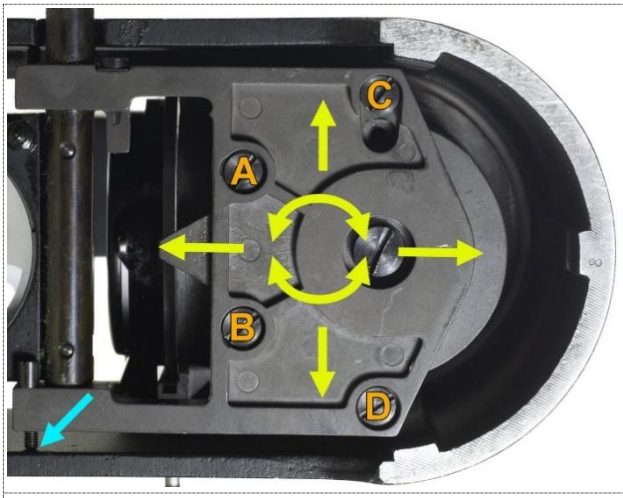

Figure 26: The yellow arrows indicate the directions where the mirror and swing-out lens holder can move when screws A, B, C and D are released. The sizes of the arrows are highly exaggerated; the movements are limited to fractions of a millimeter.

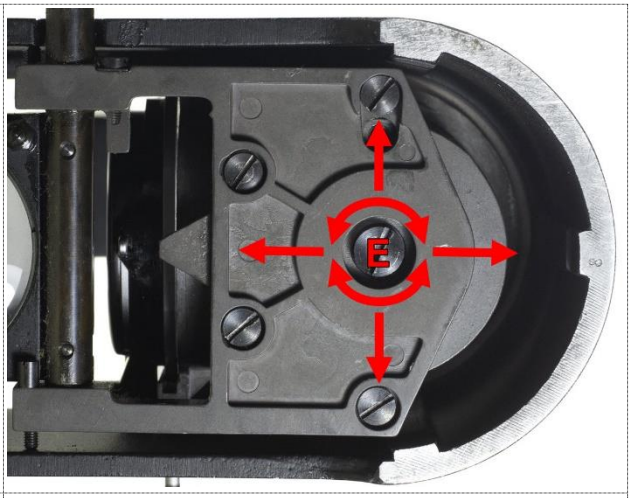

Figure 27: The red arrows indicate the directions in which the mirror can be moved after screw E has been released.

If you so far have been unable to align the light dot with the target, the next step is to prop up the mirror and swing-out lens holder with thin (0.05 or 0.1 mm) shims (washers.) This is done by attaching one or a few washers to suitably selected screws A, B, C and/or D in Figure 26 – the washers should of course be placed between the holder and the microscope foot. If you, for example, need to move the dot higher up on the target, then you would add washers to screws C and D in Figure 26. Using basic geometry, you can calculate that 0.1 mm washers placed there would raise the dot by approximately 1 mm on the target.

The last resort (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 27.) As mentioned previously, this 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