Maintenance of the front-end illumination system of an older (pre-1963/64) Ortholux.

Introduction and Scope

These maintenance notes cover what I will take the liberty to call the "front-end" illumination system of the Leitz Ortholux microscope. It is situated in the foot of the microscope stand and consists of the following three or four components (Figure 1): The dust protection glass with its filter holder, the mirror, the swing-out lens (a.k.a. the swing-in lens), and, in pre-1959 Ortholux microscopes, the diascopic (transmitted) vs. episcopic (vertical) illumination switch. 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. This was done as an adaptation to being able to use the newer 600 and 400 series of condensers. Up to that time 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. These maintenance notes apply only for pre-1963/64 Ortholux microscopes, i.e., those that do not 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 or functionally 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.

Mirror: An octagonal mirror (Figure 18) angled 45° in the microscope foot directs the illumination beam from the lamp up to the microscope condenser. Similarly as with the swing-out lens, you may find that the mirror is hazy or dusty. As a first-surface mirror it is very sensitive to 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.

Diascopic vs. episcopic illumination switch: A lever included on Ortholux microscopes up to 1959 that uses another mirror to switch the illumination path from the lamp, either for transmitted or for vertical illumination. It appears to be very rugged mechanically, but its two associated mirrors may be dirty and require cleaning. The illumination switch is briefly described in Appendix 2: The diascopic vs. episcopic illumination switch; I regret that currently I'm not ready to provide any maintenance notes for it.

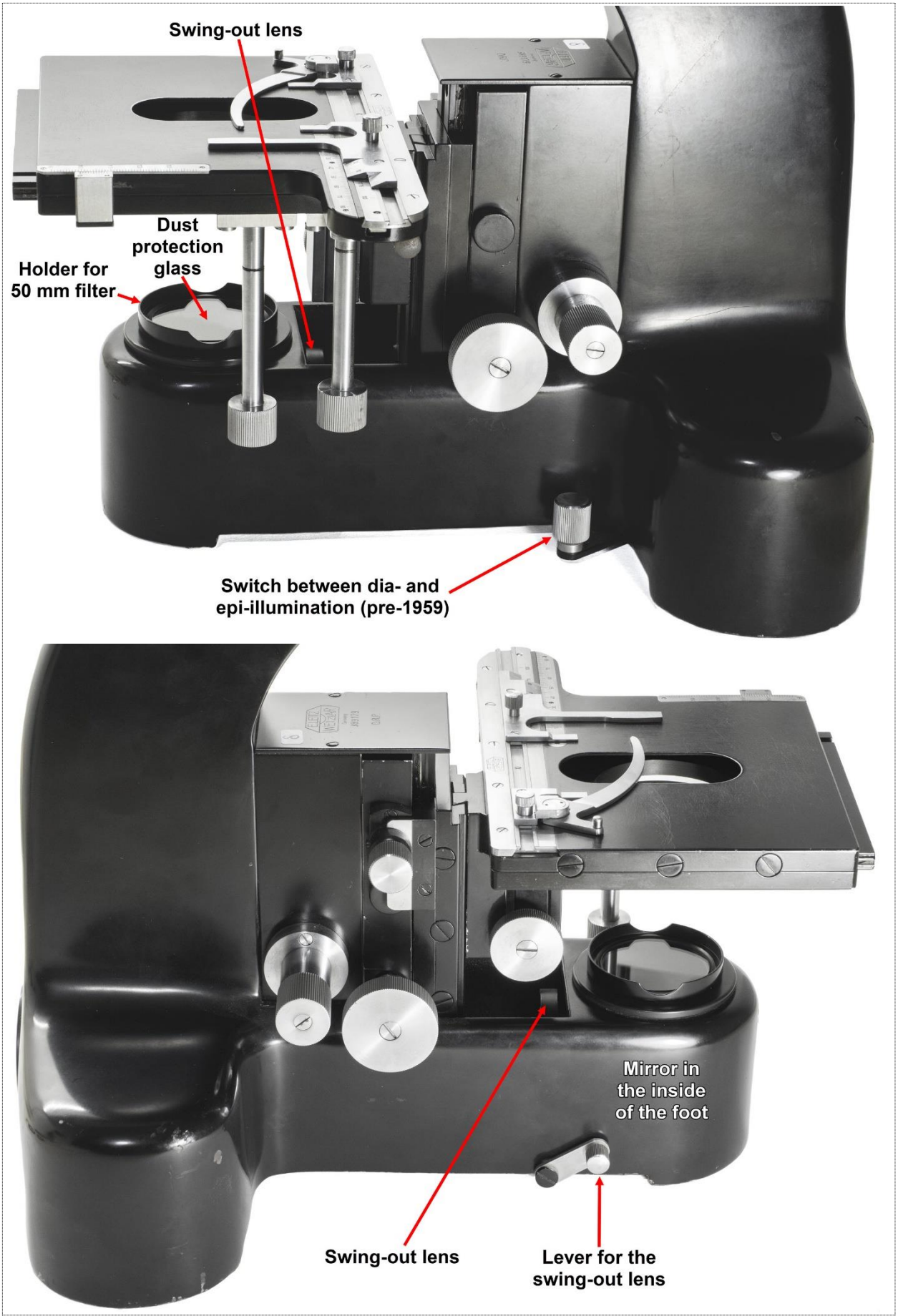

Figure 1: The foot of the Ortholux microscope stand (pre-1963/64 model.)

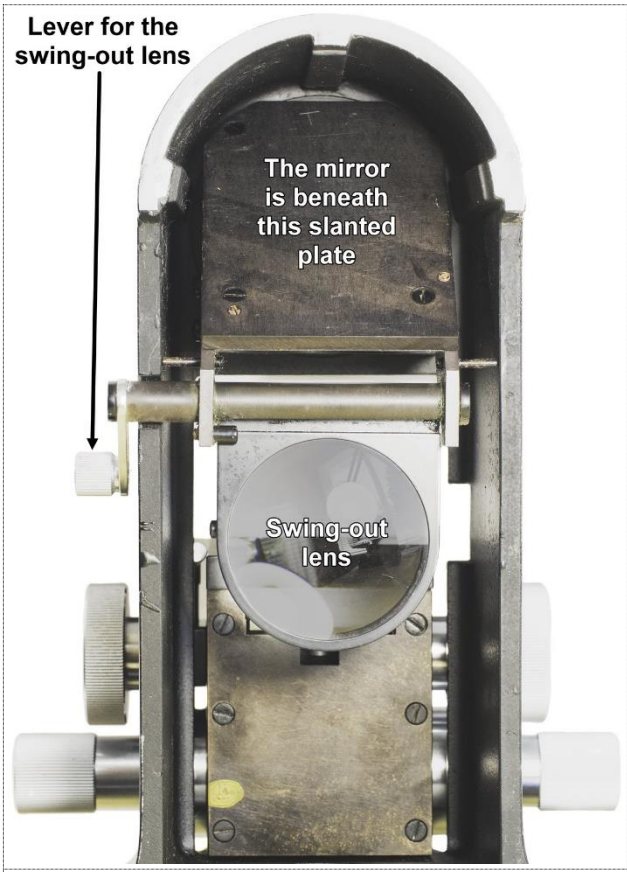

Figure 2: View into the underside of the foot of a pre-1963/64 Ortholux microscope.

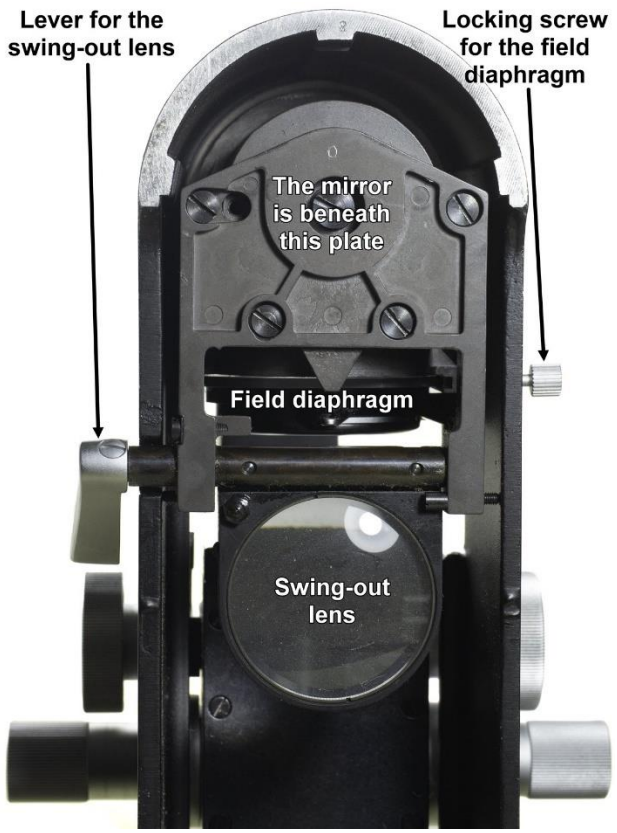

Figure 3: View into the underside of the foot of a post-1963/64 Ortholux microscope.

Lastly, a warning if you find out that you will need to remove the mirror & swing-out lens holder (as described in subsection 3) for your maintenance work. The alignment of the mirror & swing-out lens holder (where the mirror is the critical component) is important for the microscope's proper 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 almost unavoidable that some miscollimation is introduced if the mirror & swing-out lens holder is removed, serviced, and then put back again. It means that you will need to conclude the work by performing a collimation as described in subsection 6 below. This task requires some preparation and extra equipment.

Maintenance Notes

1. Remove the filter holder and clean its dust protecting glass

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 may be somewhat stuck but should anyway not be too difficult to remove by simultaneously turning it back-and-forth and pulling it upwards.

It seems that typically the dust protecting glass is permanently attached (Figure 4) in the filter holder. 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 entire filter holder with the dust protecting glass by submerging and cleaning it in lukewarm water with dishwashing liquid, refer to Appendix 1: Cleaning of optical glass with dishwashing liquid.

View from above

View from the underside

Figure 4: The filter holder with its dust protecting glass.

2. Clean the swing-out lens

The swing-out lens (Figure 5 and Figure 6) 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 by three M2.5x7 screws (indicated with green circles in Figure 6, each screw supplied with a 7.0 x 2.9 x 0.2 mm washer) to an axle which allows the lens 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, Figure 6 and Figure 7.)

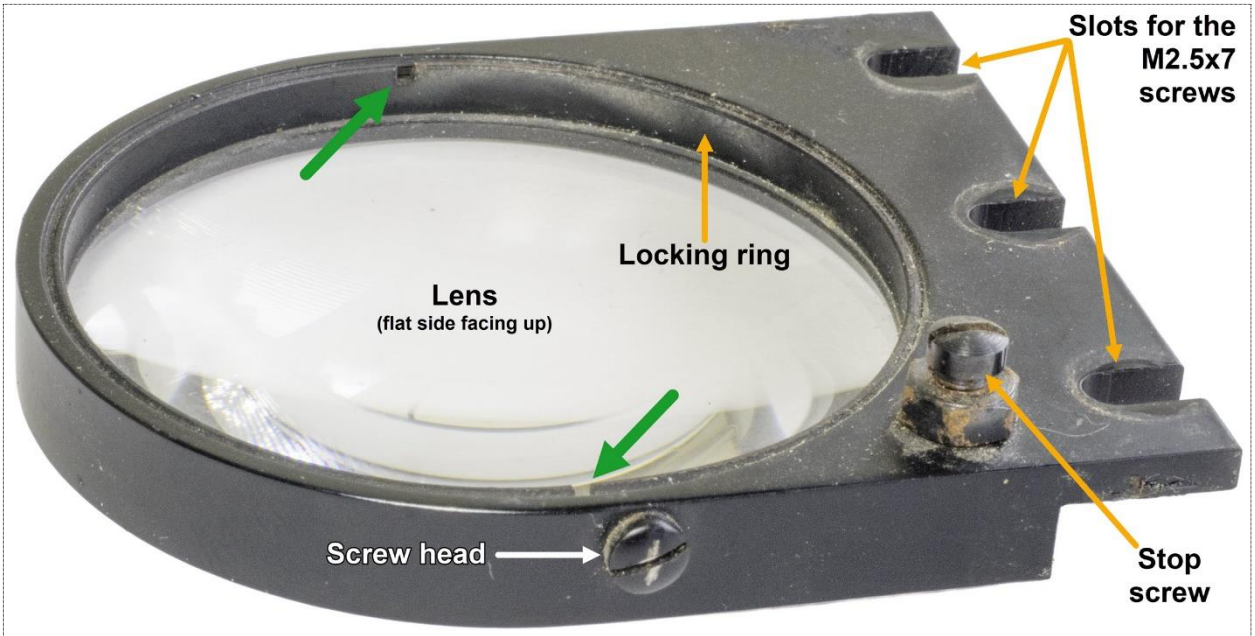

Figure 5: The swing-out lens after removal from the mirror & swing-out lens holder.
The green arrows point to the lens locking ring's spanner notches.

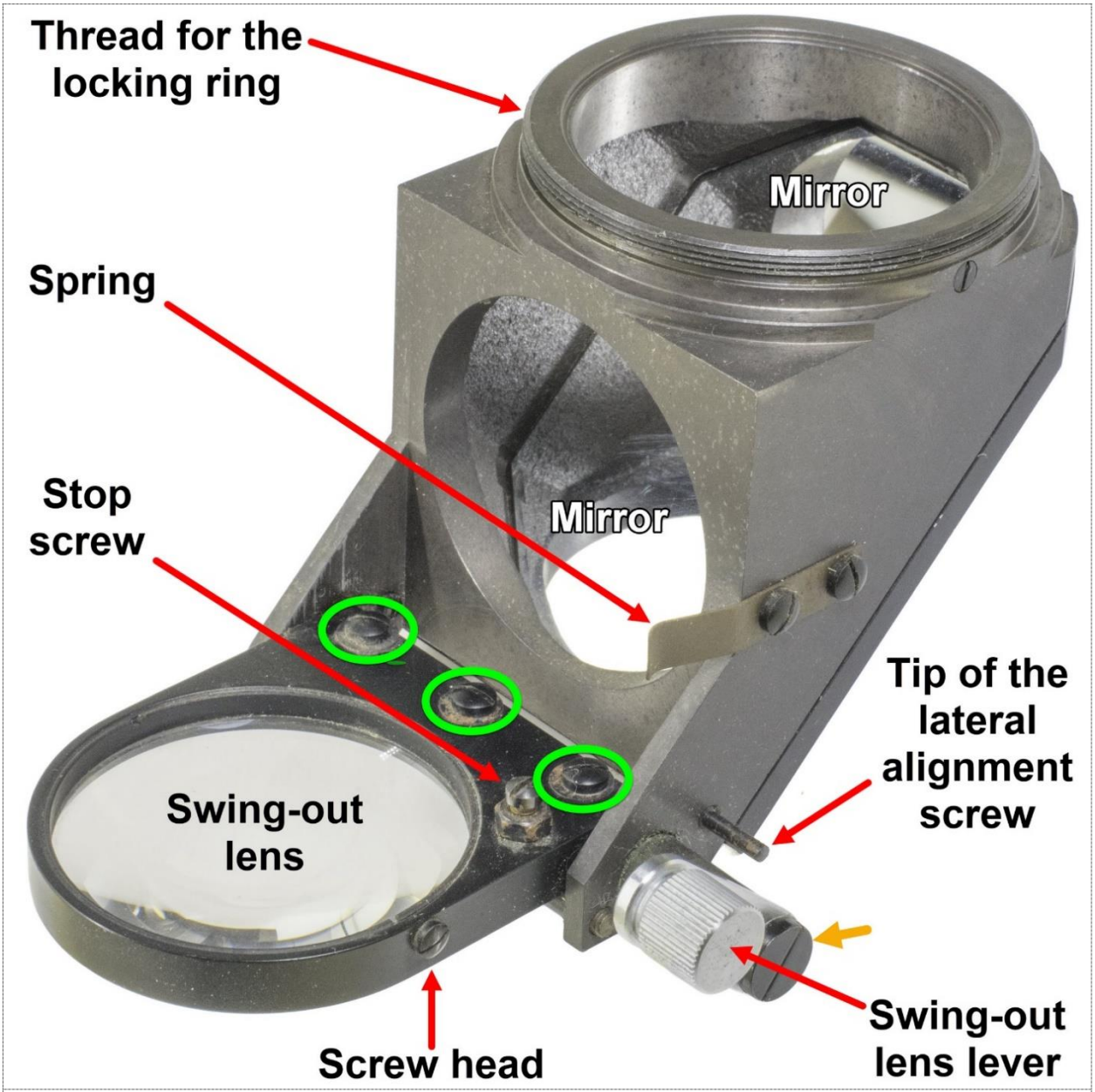

Figure 6: The removed mirror & swing-out lens holder - view obliquely from above. The lens is here in its swing-out position. The green circles indicate the screws that attach the swing-out lens to its axle.

An adjustable stop screw (M3x7, Figure 5 and Figure 6) ensures that the lens is precisely vertical in its swing-in position. The stop screw is protected against loosening with a plain M3 counter-nut.

The head of a small M2x1.5 screw on the side of the frame (Figure 5 and Figure 6) rubs against a spring on the mirror & swing-out lens holder (Figure 6) to keep the lens steady while it is in its swing-in position.

Figure 7 shows yet another stop screw (M3x4 with an elongated head) for the swing-out lens. This screw also sits in the mirror & swing-out lens holder; its purpose is to protect the swing-out lens by preventing it from being folded down beyond its horizontal swing-out orientation. There is no need to adjust or remove this stop screw.

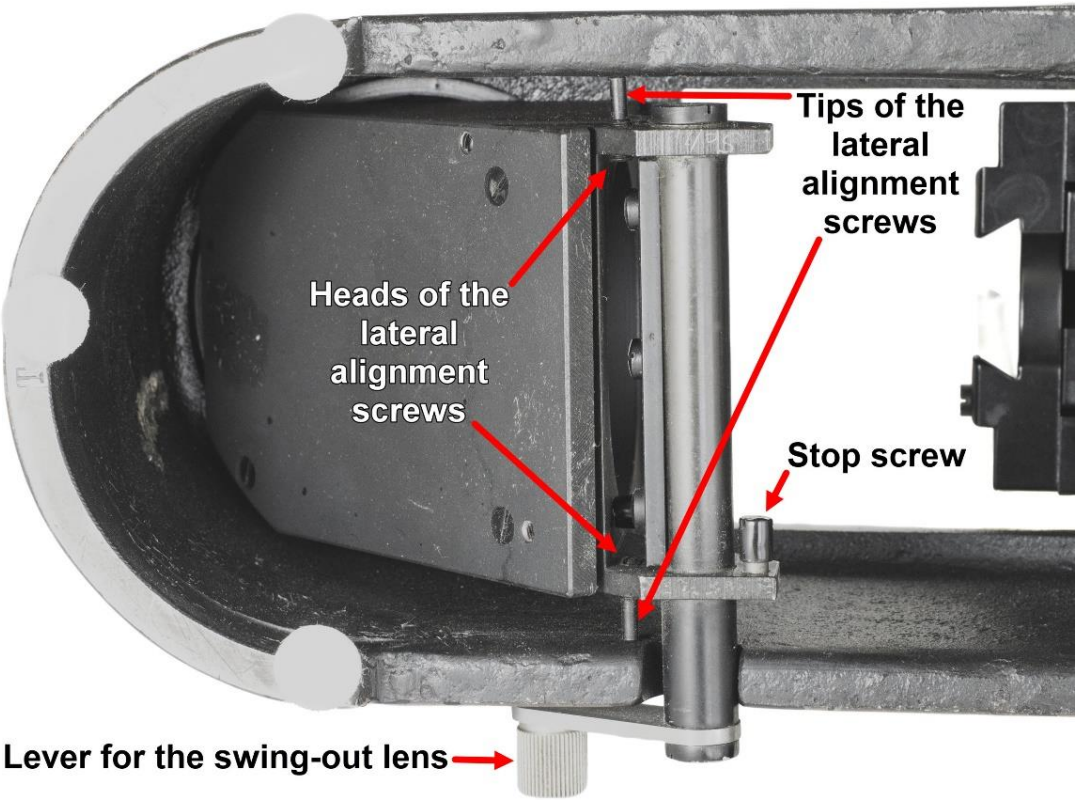

Figure 7: The mirror & swing-out lens holder viewed from the underside of the microscope foot.

Naturally, it is easier to access and clean the swing-out lens if the mirror & swing-out lens holder first has been removed from the microscope. We will however start here by assuming that you decided against removing the holder (which would save you from the extra work to collimate the holder as outlined in subsection 6.) If the swing-out lens is only lightly dirty, you may be able to clean it while it still sits in the microscope. Fold down the lens out from the illumination path and into its horizontal position to access both of its sides for cleaning using your preferred lens cleaning protocol – you will need to put the microscope on its side to access the lens' underside. Be careful not to use too much lens cleaning solution and don't let it seep into the thread of the locking ring – once there, it may cause corrosion before it eventually evaporates.

If you find that the space in the microscope foot is too constrained for adequate lens cleaning, you could remove the swing-out lens frame from the mirror & swing-out lens holder while the latter still is attached in the microscope. Fold down the lens into its horizontal position. Loosen (but don't remove) the three black M2.5x7 screws (indicated with faint green circles in Figure 6) that hold the black aluminum lens frame attached to the axle and pull out the lens frame from the loosened screws (Figure 5.)

If the lens still is too dirty to be adequately cleaned, then you could escalate by removing the lens from the frame before the cleaning. The lens is attached in the frame by a 3 mm wide, threaded locking ring (Figure 5.) First remove the small screw (tagged as "screw head" in Figure 5) from the side of the lens frame. (I'm not entirely sure, but the screw may reach down to the locking ring and restrain it.) Then carefully unscrew the locking ring from the lens frame. A bespoke and sturdy spanner that perfectly fits the two notches in the locking ring would be the preferred tool for this, but as amateurs, we will need to get by with one of the common and more affordable camera lens spanners (Figure 8.) Make sure that the camera lens spanner has flat screwdriver-like tips that snugly fit into the locking ring notches. Be

very careful not to slip with the spanner – camera lens spanners are not very rigid and therefore notoriously prone to slipping and causing damage. Use your best judgment and don't try too hard to loosen the ring - you need to be able to stop before slipping! Based on some limited trials I noticed that heating the frame in an oven at 75°C (165-170°F) facilitated the release of a stuck locking ring.

Figure 8: An example of a suitable camera lens spanner. To the right is a closeup of the required flat screwdriver type tips.

If you manage to remove the lens, clean it with your preferred lens cleaning protocol (or with the procedure outlined in Appendix 1: Cleaning of optical glass with dishwashing liquid.) Gently dry the lens and reassemble it in the frame with the locking ring – remember that the lens' flat side should face the locking ring. Tighten the locking ring only very lightly. Reattach the small "screw head" screw.

If you can't safely remove the lens from the frame, you could try the following cleaning "hack". Remove the small "screw head" screw and the stop screw including the nut (Figure 5) from the frame. Clean the entire frame with the lens as described in Appendix 1: Cleaning of optical glass with dishwashing liquid. Carefully blot (avoid rubbing the lens) the frame and the lens with lens paper or a clean microfiber cloth to remove any visible water. Immerse the entire frame in a beaker with 99% isopropanol (a.k.a. isopropyl alcohol) and let it soak over the night. Continue the soaking for another few hours or a day with a fresh portion of 99% isopropanol. The isopropanol soakings will remove most of the trapped water in the locking ring threads and shorten the drying time. Carefully blot 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 remaining isopropanol trapped in the locking ring threads. Reattach the small "screw head" screw and the stop screw with its nut (Figure 5) to the frame.

Once the lens is clean (and back in the lens frame, refer to Figure 5) reattach the frame with the lens to the flattened side of the axle (Figure 6) using the three M2.5x7 screws including the washers. The lens' convex side should face away from the mirror and towards the microscope lamp. Make sure that the washers sit between the screw heads and the lens frame and not between the lens frame and the axle.

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

A possible issue related to the swing-out lens is that the swing-out lens lever may be sluggish due to aged grease in the axle's plain bearing surfaces. To clean and regrease the bearings the two screws in the axle's opposite ends (one of the screws indicated with an orange arrow in Figure 6 and Figure 16) need to be released. Unfortunately there are three obstacles; 1) to access the screws you will need to remove the mirror & swing-out lens holder from the microscope foot (which means that you will need to collimate it after reassembly), 2) the screw drives (i.e., the screwdriver slots in the screw heads) are extremely narrow and you may find it difficult to find a suitable screwdriver, and 3) the screws appear to be attached quite tightly. If you are not willing or able to remove the screws, you can anyway make the lever somewhat lighter to turn by treating the two plain bearings with small amounts of penetrating oil (WD-40, CRC 5-56, or similar.)

3. Remove the mirror & swing-out lens holder from the microscope

The mirror & swing-out lens holder (Figure 6, Figure 7 and Figure 16) must be removed to access the mirror if it requires cleaning. Be aware that if you remove the mirror & swing-out lens holder, then you will need to conclude your work by performing a collimation as described in subsection 6 below.

As indicated by the somewhat awkward name I have given it, the mirror & swing-out lens holder's purpose is to hold the illumination mirror and the swing-out lens fixed in the microscope's illumination path. The holder is attached to the foot of the microscope stand with a wide, threaded locking ring (Figure 11) and further stabilized with two lateral alignment M3 screws (Figure 7.)

To remove the mirror & swing-out lens holder make sure that the filter holder with the dust protecting glass (Figure 4) has been removed as described above in subsection 1. Unscrew the black, circular cover from the microscope foot (Figure 9.) If it is too difficult to get a good finger grip of the cover, improve the friction by using rubber gloves or by using a rubber sheet between the cover and your fingers.

Next, remove the bayonet mount for the filter holder/dust protecting glass disc (Figure 10) from the microscope foot by simply pulling it up.

The locking ring (Figure 11 and Figure 13) that holds the mirror & swing-out lens holder firmly attached in the microscope foot is now accessible for removal. The ring has threads both on its outside and its inside; the inside threads catch the corresponding threads on the upper end of the mirror & swing-out lens holder (Figure 6), while the outer threads catch the threads on the inside of the cover (Figure 9) that we just removed.

Unscrew the locking ring from the microscope foot. Similarly as mentioned for the lens locking ring in subsection 2 above, we would ideally use a sturdy bespoke spanner perfectly fitting into the two locking ring notches. Finding such a spanner would be like searching for the holy Grail, so we will again need to get by with one of the common camera lens spanners (Figure 8.) Make at least sure that the spanner has flat screwdriver-like tips that snugly fit into the locking ring notches. And again, be very careful not to slip with the spanner and cause damage. If the locking ring is stuck, it may help to treat the thread between the locking ring and the rim of the mirror & swing-out lens holder (Figure 11) with a small amount of penetrating oil (like WD-40 or CRC 5-56) and allow it to work for a few hours. But be sure to thoroughly wipe off any remaining penetrating oil from the locking ring before attempting to release it with the spanner.

Figure 9: The black cover before and after removal from the microscope foot.

Figure 10: The bayonet mount before and after removal.

Figure 11: The locking ring before and after removal.

Figure 12: The empty microscope foot after the mirror & swing-out lens holder has been removed.

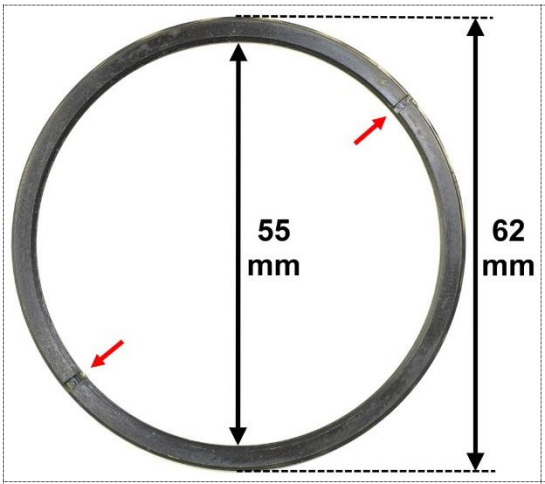

Figure 13: The locking ring.

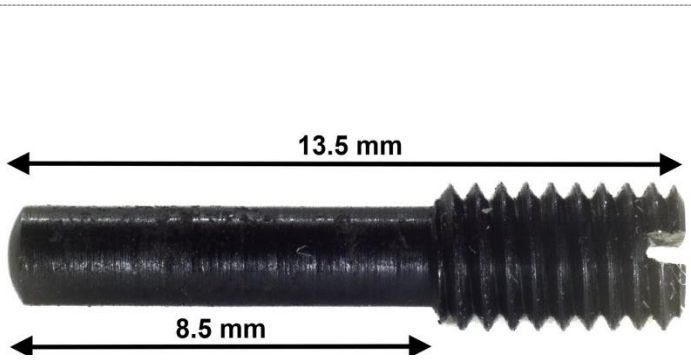

Figure 14: Closeup of one of the two lateral alignment M3 screws.

If the locking ring still resists, a final effort to consider would be to try a “turbo-charged” release. It is however an approach that easily could end with a disastrous spanner slipping leading to damaged locking ring notches and with the mirror & swing-out lens holder stuck forever in the microscope. Due to the high probability for damage, I can’t recommend it; it truly should be seen as a last desperate resort. It is a combination of softening the thread with penetrating oil, heating the locking ring with an electric heat gun, and using brute force with the camera spanner.

Start by treating the thread between the locking ring and the rim of the mirror & swing-out lens holder (Figure 11) with penetrating oil (WD-40, CRC 5-56, or similar) and allow it to work for a few hours. Make sure that the oil doesn’t creep into the mirror & swing-out lens holder.

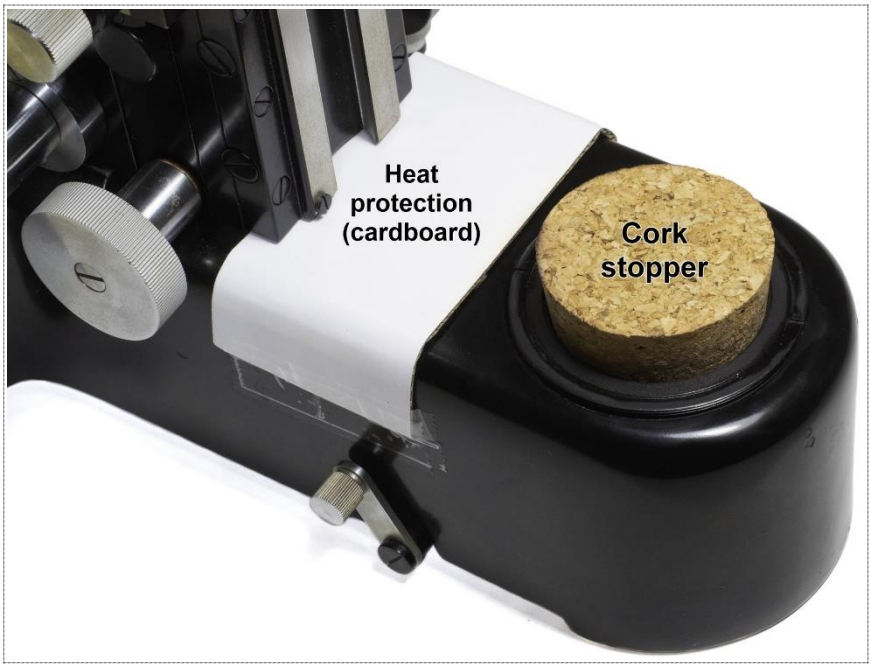

Figure 15: Ortholux microscope foot prepared for heating with an electric heat gun.

Prepare the microscope foot to protect its inside from the hot air blown by the heat gun (Figure 15.) Fold a piece of cardboard over the square opening on the foot and fasten it with office tape. Put a suitably sized cork stopper into the opening of the mirror & swing-out lens holder - the opening’s inner diameter is 45 mm. Make sure that the stopper doesn’t reach all the way down to the fragile and sensitive mirror – if required, cut off a part of its underside. There is a small guide pin just below the rim of the mirror & swing-out lens holder (the pin is faintly visible in Figure 11 on the left side of the opening) that you will need to negotiate with the stopper. (The purpose of the pin is to ensure that the filter holder/dust protecting glass is properly seated in the microscope foot.)

Thoroughly wipe off the penetrating oil from the locking ring. Finish by wiping with cotton swabs or a piece of cloth wetted with solvent to remove any remaining oil from the surface.

Use an electric heat gun to warm the locking ring. Heat it until it is too hot to the touch, but don’t over-do it. Keep the heating time as short as possible to spare the microscope foot from excessive heating.

Without delay, use a camera spanner as described in subsection 2 above to release the locking ring. This is the difficult and potentially damaging part. Put the microscope in a hold where it sits fixed and steady no matter how much muscle force you throw on it. Make sure that the spanner fits well in the locking ring’s notches. Get a good and steady grip on the spanner, press it hard down against the locking ring, avoid shaking, and use as much force as you dare to release it.

I have only done this “turbo-charged” locking ring release on one Ortholux microscope. It was a conscious decision acknowledging that it could end with damage. The locking ring released just as I thought that I had reached my maximal muscle capacity. I attribute 90% of the outcome to beginner’s luck.

After the locking ring has been successfully removed, loosen the lateral alignment screws (Figure 7 and Figure 14) and carefully remove the entire mirror & swing-out lens holder (Figure 6 and Figure 16) from the microscope foot (Figure 12.) Be careful with the sensitive surface of the mirror. Also be prepared that the lateral alignment screws are difficult to reach with a screwdriver - the screwdriver will need a thin shank and must also be held slightly angled. However, using a screwdriver angled invalidates the basic advice to always use a well-fitting screwdriver - using it at an angle may subject the screw head to damaging forces, and grub screw heads are particularly vulnerable to break. Therefore, instead of using a well fitting 2.4 mm screwdriver, you should switch to an undersize screwdriver, perhaps 1.8 mm.

4. Clean the mirror

To access the mirror for cleaning the entire mirror & swing-out lens holder must first be removed from the microscope foot (refer to subsection 3) and then the mirror plate (Figure 16) must be removed from the holder. 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 outer surface. This makes the surface particularly sensitive to scratching, which can easily result from careless cleaning.

Unless you have good reasons, don't change or loosen the two small mirror alignment screws that are indicated with red circles in Figure 16 and Figure 17. To facilitate the final collimation that we will need to do, it makes sense to avoid unnecessary tampering with the mirror adjustments that Leitz made at manufacturing.

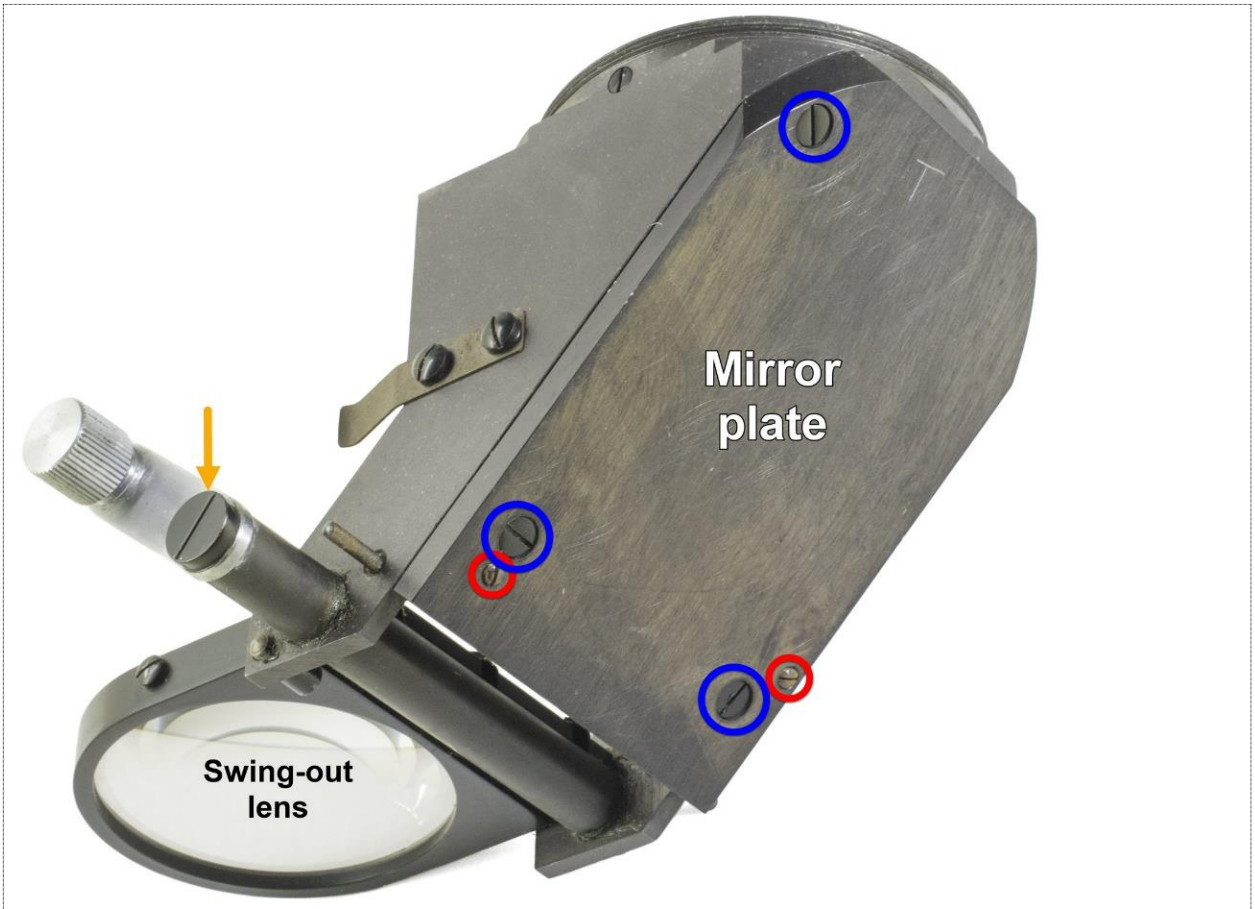

Figure 16: The removed mirror & swing-out lens holder - view obliquely from below. The lens is in its swing-out position. The blue circles indicate the screws that attach the mirror plate to the holder. The red circles indicate grub screws that support the mirror collimation.

To remove the mirror plate (with the mirror attached) from the mirror & swing-out lens holder remove the three M2.5x6 screws (indicated by blue circles in Figure 16 and Figure 17) on the backside of the mirror plate and carefully pull off the mirror plate. Below the most distant of the screws (indicated with a green arrow in Figure 17) there will be one or perhaps two small washers (o.d. 5.0 mm, i.d. 3.5 mm, thickness 0.4 mm if one washer, or 0.2 mm each if two washers) sitting between the mirror plate and the mirror & swing-out lens – don't lose them. The washers are important for the collimation because they add a small gap between the mirror plate and the mirror & swing-out lens holder thereby allowing adjustment of the mirror plate by slightly tilting it while attached in the holder.

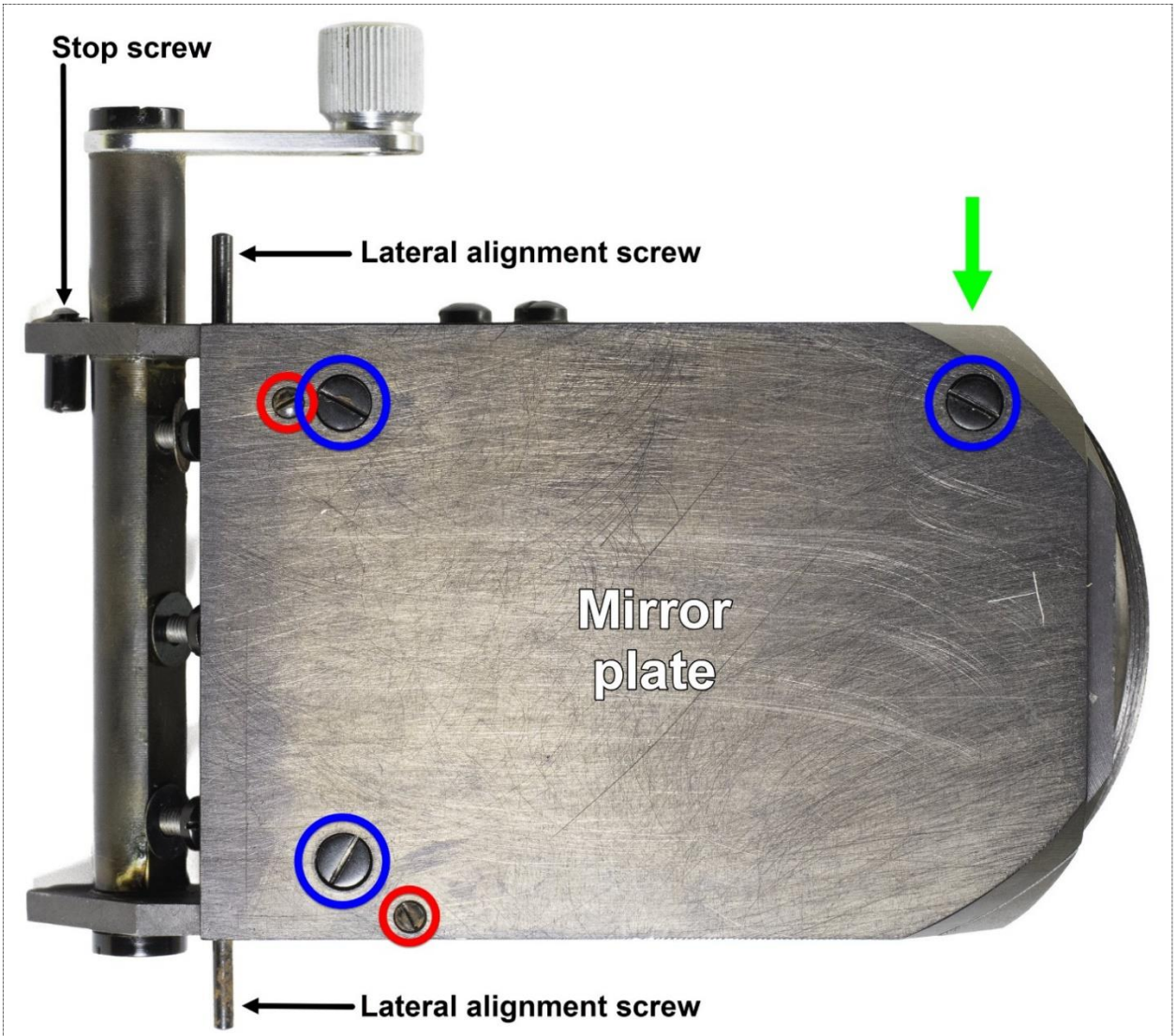

Figure 17: The mirror plate still attached on the mirror & swing-out lens holder.

Two grub screws (with red circles in Figure 16, Figure 17 and Figure 18) are important for the collimation of the mirror plate in cooperation with the adjacent screws with blue circles. While the screws with the blue circles attach and press the mirror plate against the mirror & swing-out lens holder, the grub screws force the mirror plate away from the holder. On one Ortholux the grub screws were easy to remove, but on another Ortholux they were stuck and almost impossible to remove without breakage. Possibly in the latter case the grub screws were secured by Leitz with some threadlocker. The grub

screws will be much easier to remove if the threadlocker is softened by treating the screw heads with a drop of solvent (isopropanol or acetone) for a few minutes.

Figure 18 shows the mirror plate after it has been removed from the mirror & swing-out lens holder.

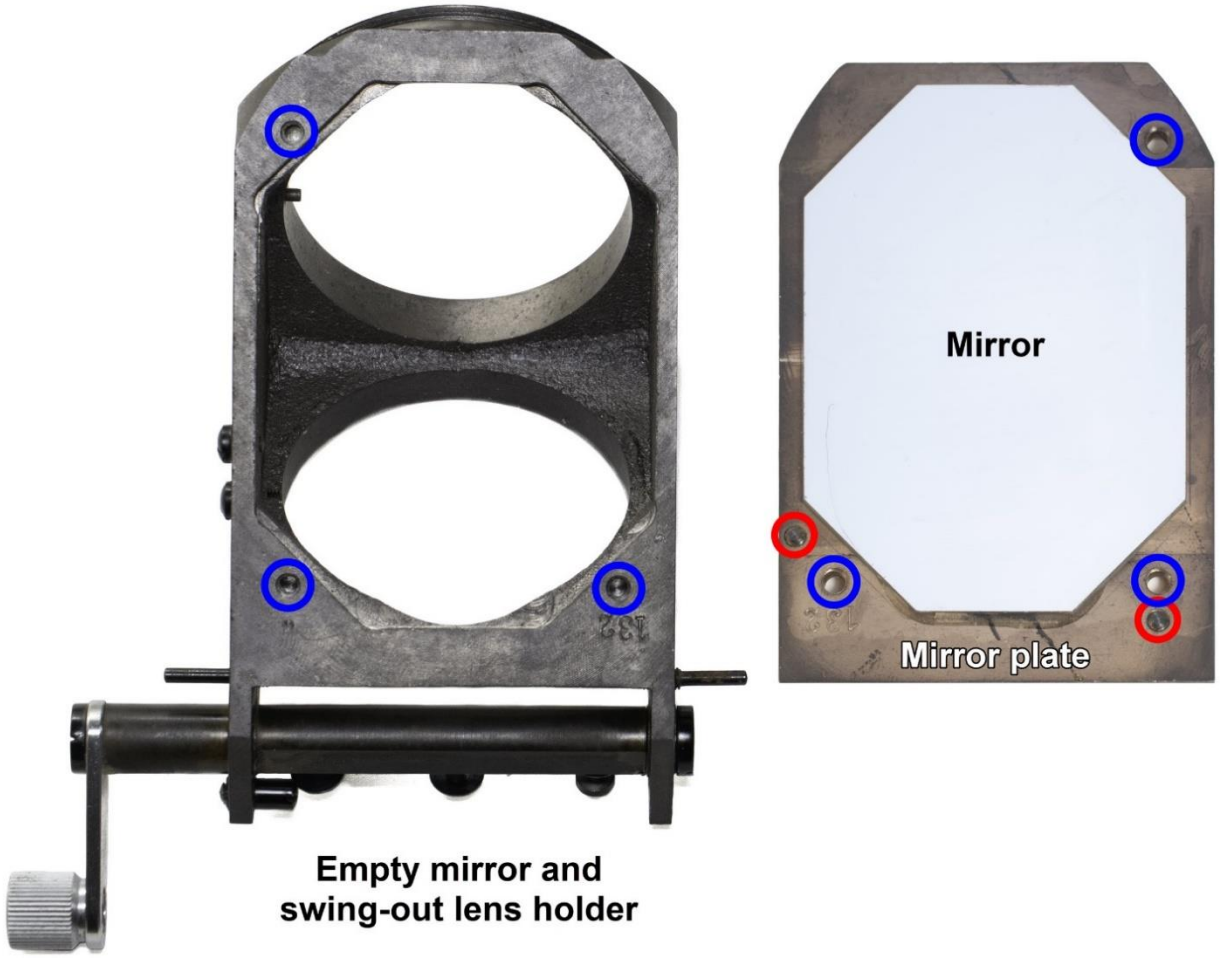

Figure 18: The mirror & swing-out lens holder with the removed mirror plate and mirror. The blue and red circles indicate the same screws/screw holes as in Figure 16 and Figure 17.

Good optical cleaning protocols is a boundless topic, here even more complicated by the first-surface mirror's vulnerability to scratches. Furthermore, the way the mirror is permanently cemented to the mirror plate makes it difficult to avoid getting lens cleaning solution (which typically is water based) into certain constrained spaces (e.g., into the narrow space between the mirror and the mirror plate, see Figure 19, or into the mirror plate's screw threads) where it may cause corrosion before it eventually evaporates. I'll propose two mirror cleaning protocols based on my very limited experience. Please feel free to explore any better cleaning options that you may think of.

Figure 19: View from the side of the mirror that is cemented to the mirror plate. Due to the cement layers, there may be a very narrow (0.1-0.3 mm) gap between the mirror and the mirror plate.

Mirror cleaning protocol #1

The mirror is brushed with a soft brush while being immersed in lukewarm water with dishwashing liquid. The procedure is efficient and gentle to the mirror's sensitive surface, but the disadvantage is that the water will inevitably penetrate into the narrow spaces mentioned above and may remain trapped for a long time.

The procedure is outlined in Appendix 1: Cleaning of optical glass with dishwashing liquid. After the cleaning use blotting paper to remove as much as possible of the trapped water in the narrow gap between the mirror and the mirror plate.

Mirror cleaning protocol #2

This protocol that we could call the "gentle wet lens paper" method 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 from the mirror surface. Then prepare several 15-20 mm wide lens paper strips by cutting up sheets of any good quality lens paper. Clamp the mirror plate 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, the 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 as much 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.

With the mirror surface clean (and hopefully unscratched) reassemble the mirror plate to the mirror & swing-out holder. Don't forget to put back the washer/shim where it originally was between the mirror plate and the mirror & swing-out lens holder. Tighten the three M2.5x7 screws, but not too tightly.

Digression: A loose mirror

I don't know whether it is a common or rare occurrence, but in one Ortholux microscope that I received the mirror was loose - it could be heard rattling in the microscope foot. Obviously, the mirror had become detached from the mirror plate to which it was cemented with some type of glue (probably epoxy cement, see Figure 20.) It's anyone's guess whether this happened due to aged or inadequate glue, or due to rough handling of the microscope. Leitz apparently used varying methods to glue the mirror to the mirror plate, so be prepared that it may look differently on your Ortholux.

Should you experience this misfortune, you will need to reglue the mirror to the mirror plate before attaching it to the mirror & swing-out lens holder. Helpfully Leitz had engraved the contours of the mirror on the backside of the mirror plate (faintly visible in Figure 21) to aid proper mirror positioning. There is however very limited space to fit the mirror within the cutouts that are provided for it in the mirror & swing-out lens holder (see Figure 18.) It is therefore important that the mirror is cemented properly on the mirror plate: 1) Use minimal amounts of epoxy cement so it doesn't flow outside of the

mirror periphery, and 2) make sure that the mirror is positioned on the mirror plate so it nicely fits into the cutouts in the mirror & swing-out lens holder.

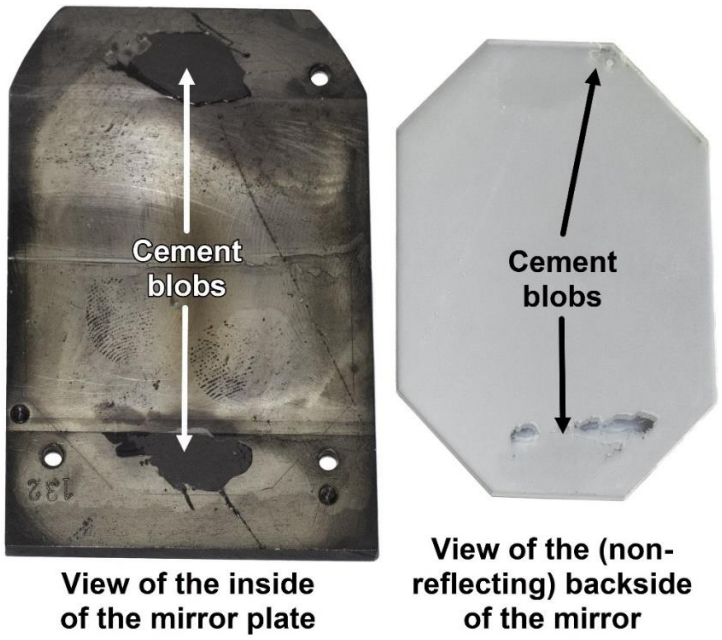

Figure 20: A mirror that has been detached from the mirror holder.

Figure 21: The mirror side of the mirror plate showing the faint engraved mirror contour.

Take the opportunity first to clean the mirror using the protocol outlined in Appendix 1: Cleaning of optical glass with dishwashing liquid.

Prepare the epoxy cement and apply small blobs on the terminal sides of the mirror plate (see Figure 20.) Try to estimate the blob size so the cement isn't squeezed outside of the mirror edges when the mirror is pressed onto the mirror plate. Attach the clean mirror to the cement on the mirror plate (protect the surface by wearing clean disposable nitrile gloves), center the mirror within the engraved contours on the mirror plate, and press the mirror gently down against the cement. Should the cement overflow, then immediately wipe off any excess with cotton swabs wetted with acetone.

Without delay, put the mirror plate on the table with the mirror facing up. Attach the mirror & swing-out lens holder over the mirror plate making sure that the mirror goes into the holder's mirror cutouts (the cutouts can be seen in Figure 18.) Take up the combined mirror plate with the mirror & swing-out lens holder from the table, keep holding the parts joined and horizontal, and look from the underside to check that all screw holes (of the three "blue" screws in Figure 17) are aligned in both parts. If they are not exactly aligned, push the mirror & swing-out lens holder sideways over the mirror plate until they become aligned. The idea is to push the mirror into its proper place on the mirror plate while the cement still is soft and unhardened. Unfortunately, the cutouts are not very generously sized, and if the mirror positioning is off, then it may be impossible to attach the mirror plate properly to the mirror & swing-out lens holder once the cement had hardened.

Carefully remove the mirror & swing-out lens holder from the mirror plate and leave the mirror plate on the table until the cement has hardened completely.

5. Put back the mirror & swing-out lens holder into the microscope foot

If not already attached, reattach the swing-out lens to the axle on the mirror & swing-out lens holder by reversing the steps described in subsection 2.

Fold up the swing-out lens into its swing-in position (i.e., vertical.) If required, adjust the stop screw (Figure 5) to ensure that the lens is exactly vertical relative the adjacent side of the mirror & swing-out lens holder when the lens is stopped in its swing-in position. Secure the stop screw by tightening the nut against it.

Put the microscope on its side so you have access to its underside.

Reattach the mirror & swing-out lens holder into the microscope foot with the locking ring (Figure 11.) To fit the holder, you may need to further release the lateral alignment screws (Figure 17) to retract their tips. Be gentle with the locking ring to avoid cross threading when it is screwed onto the mirror & swing-out lens holder. Tighten the locking ring lightly only – aim to get the mirror & swing-out lens holder firmly attached to the microscope foot, while it still should be possible to turn it slightly back and forth sideways (although under some resistance) to allow for the collimation. To provide a good starting point for the collimation turn the mirror & swing-out lens holder so it sits centered in the inside of the microscope foot.

6. Collimate the mirror & swing-out lens holder

To collimate the mirror & swing-out lens holder means to exactly align it in the microscope's common optical path. The collimation is a somewhat challenging task and requires some special equipment (fortunately not too expensive.)

In short, the collimation is done by slight adjustments of the mirror plate and the mirror & swing-out lens holder (Figure 7) while they are attached in the microscope foot.

Required equipment:

- A basic LED flashlight, with a circular, smooth head and an outer head diameter of 20.0 mm (Figure 22.) 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 27 and Figure 28.) 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 with pieces of vinyl tubing. The flashlight must not have any lens in the front (but a flat glass disc is OK) for focusing of the beam (but a reflector is OK).

Figure 22: 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 damaged or

defunct 100x oil immersion objective leaving only an empty opening where the front lens has been. The front lens can be removed from objective 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 the most suitable.

- A collimation target (Figure 23.) Use an inkjet printer to print the collimation target (refer to Appendix 3: 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.)

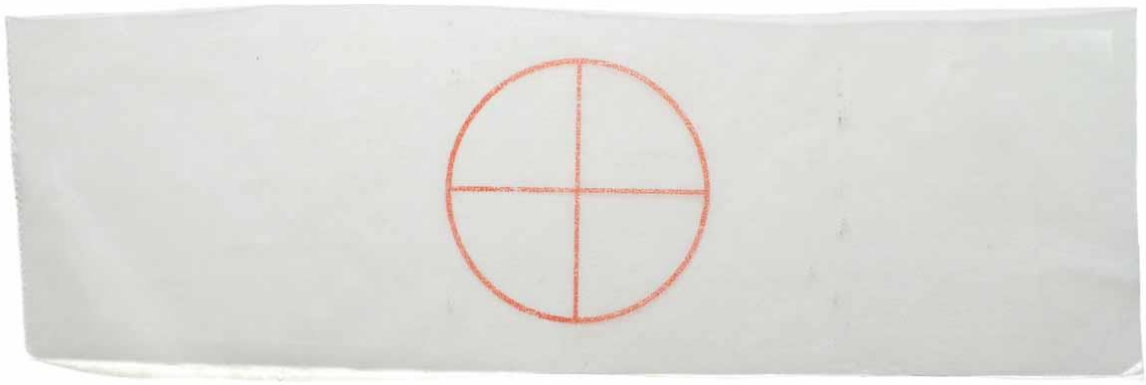

Figure 23: The semi-transparent wax paper strip with the printed collimation target.

- A set of metal or plastic M3 washers of varying thicknesses, say 0.2, 0.5 and 1.0 mm. Try to get washers where the outer diameter is as small as possible. It's OK to stack the washers, if convenient.

Procedure:

Remove the lamphouse from the backside of the microscope.

Make sure that your mirror & swing-out lens holder is attached with its locking ring in the microscope foot as described in subsection 5. Leave the locking ring only lightly tightened – the mirror & swing-out lens holder must be firmly attached (i.e., no play) in the microscope foot, but not firmer than it still should be possible to turn it slightly back and forth sideways (although under some resistance) to allow for the collimation.

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

Use tape to attach the wax paper collimation target over the lamphouse port on the backside of the microscope (Figure 24 and Figure 25.) The target must be aligned symmetrically and centered over the lamphouse port. Shining some light from the inside of the lamphouse port makes it easier to center the target.

Figure 24: The empty lamphouse port on the backside of an Ortholux microscope.

Figure 25: 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 26.)

Carefully remove the tube lens (a.k.a. telan lens) from the nosepiece (Figure 26.) It is attached in a 20.0 mm sleeve mount (Figure 27) 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 (made of soft brass) by manipulating or holding it with a tool without protection. To get a better finger grip around the tube lens it helps to use clean rubber gloves or 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 28.)

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 reach and adjust the mirror & swing-out lens holder and also at least some of the screws on the mirror plate,
2) that you are able to comfortably watch the wax paper collimation target on the backside of the microscope while you adjust the mirror & swing-out lens holder, and
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 projected light dot.

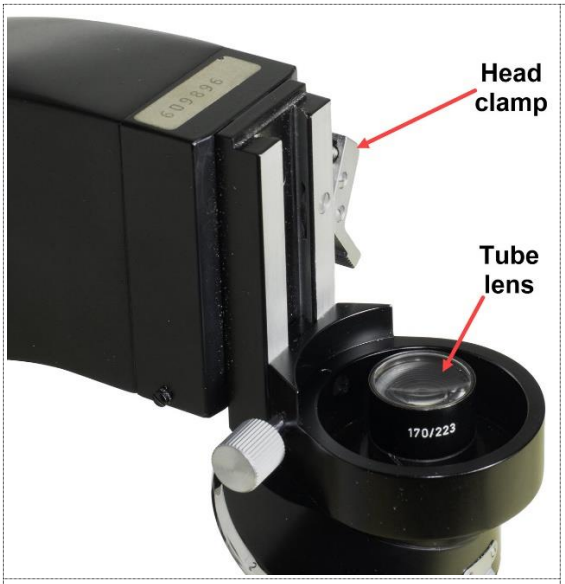

Figure 26: Ortholux nosepiece with its tube lens.

Figure 27: Ortholux nosepiece with removed tube lens.

Figure 28: Ortholux nosepiece with attached flashlight.

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 29) 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 28) until the light dot looks symmetric (Figure 30.)

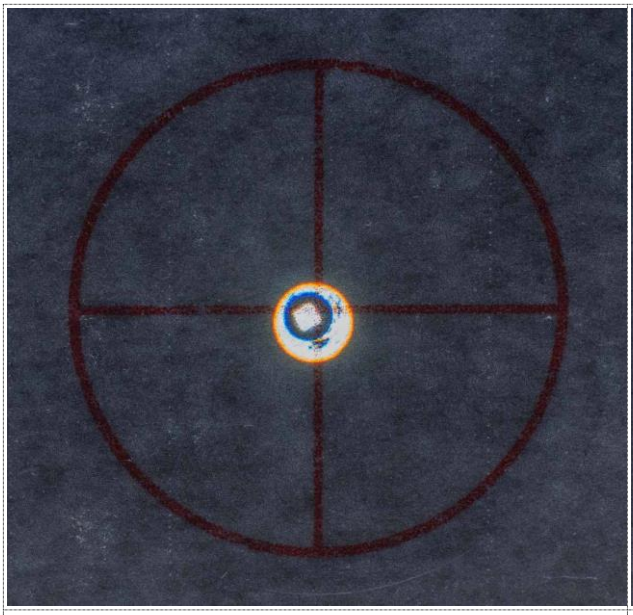

Figure 29: Light dot projected on the collimation target indicating that the flashlight is misaligned. The content inside of the light dot is not symmetric.

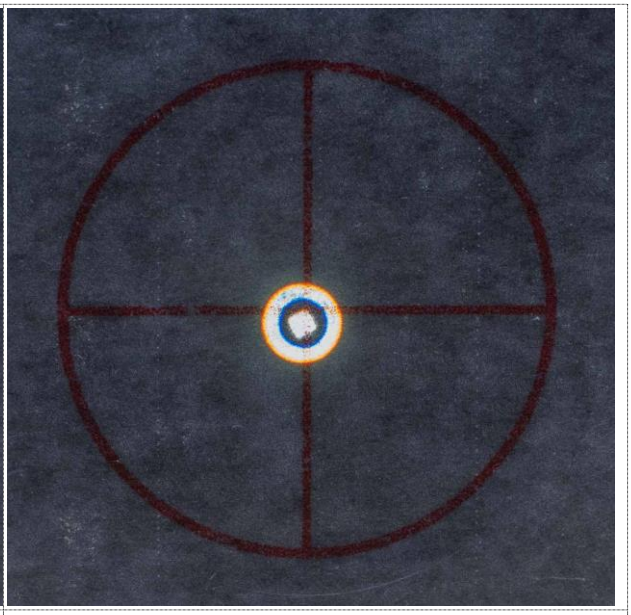

Figure 30: Symmetric light dot after proper alignment/tilting of the flashlight.

With everything now set up for the collimation, our goal is to adjust the mirror plate and the mirror & swing-out lens holder in the microscope foot until the light dot is in the center of the target (Figure 31 and Figure 32.)

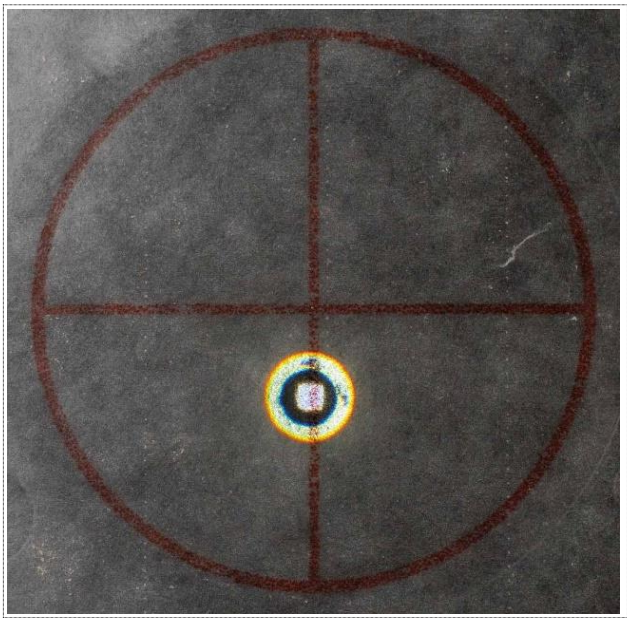

Figure 31: The light dot is clearly off the target which indicates that the mirror plate and/or the mirror & swing-out lens holder require adjustment.

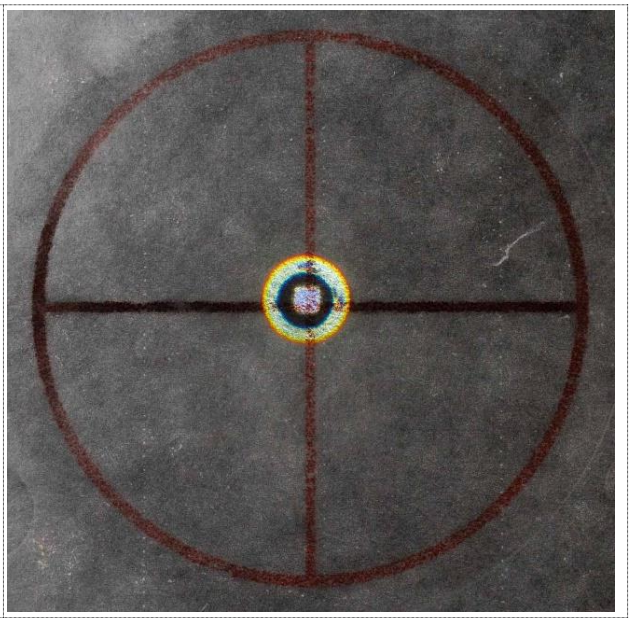

Figure 32: The light dot is in the center of the target after completed collimation. The dot is still off by ½ mm vertically, but I believe that this deviation is acceptable.

The collimation is an iterative procedure where we stepwise will make small adjustments while we closely pay attention to how the changes affect the light dot on the target. It will require some patience.

We will start to collimate vertically. Moving the light dot vertically (up or down) is done by adjusting both screw pairs tagged as “A” and “B” in Figure 33. Both of these screw pairs should be adjusted identically for the vertical light dot movement. The screws with the blue circles (Figure 33) tighten and attach the mirror plate against the holder, while the tips of the grub screws with the red circles push the mirror plate away from the holder (also check Figure 17 and Figure 18). It means that the blue and the red screws work against each other. Therefore, if you need to tighten the blue screw to force the mirror plate closer to the holder then you will also need to release the red screw correspondingly. And vice versa. Note that screw “C” (with the orange circle in Figure 33) can’t be accessed with a screwdriver while the mirror & swing-out lens holder sits in the microscope – it serves as the pivot point for the mirror plate’s adjustments. When you are done all screws should be tightened moderately only.

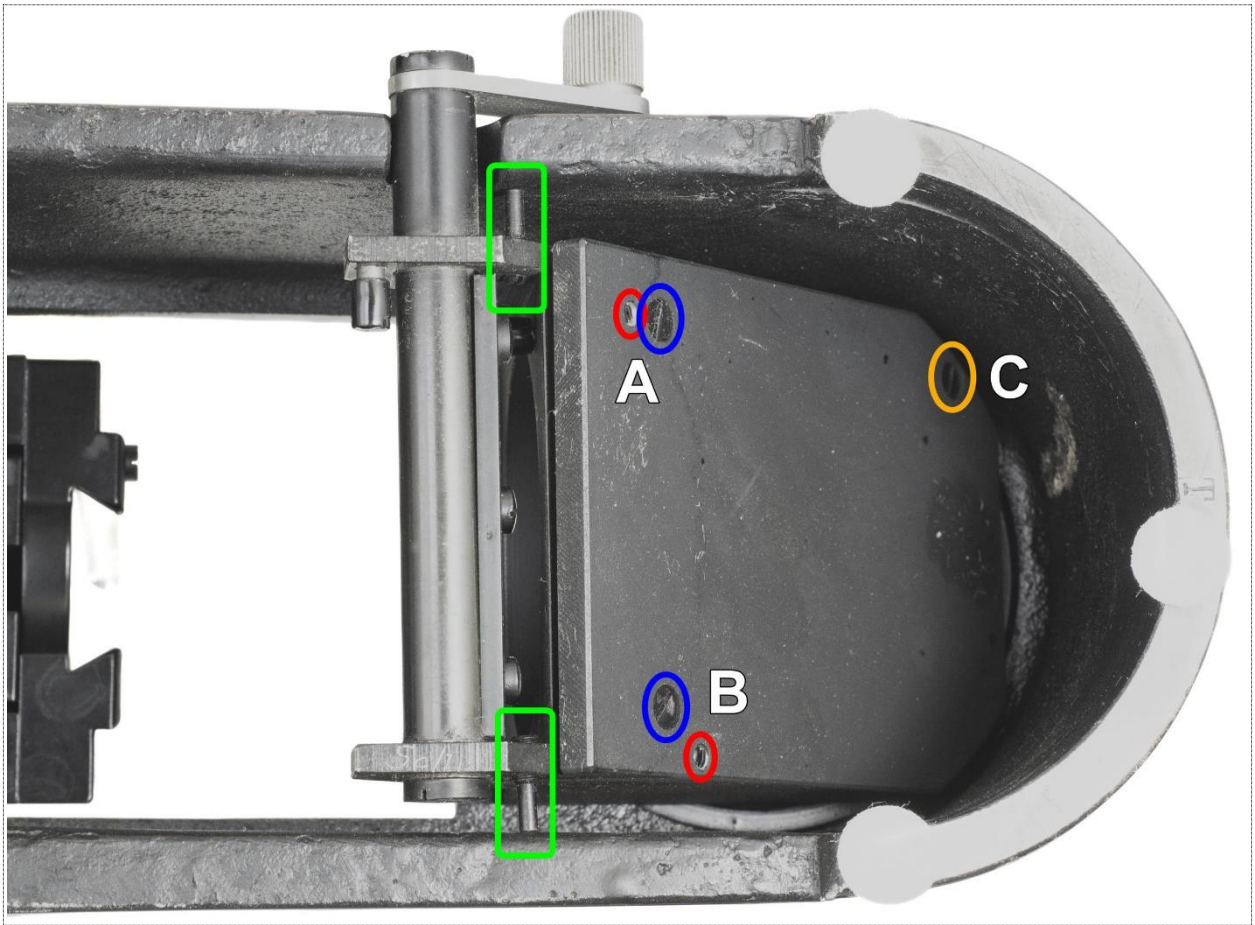

Figure 33: The mirror & swing-out lens holder viewed from the underside of the Ortholux microscope’s foot. Refer to the text for explanations.

If you find that your light dot remains below the target (like in Figure 31) and you are not able to adjust the “A” and “B” screw sets to move the dot all the way up to the target, then the remedy is to put a thicker washer below screw “C”. Unfortunately, screw “C” is not accessible when the mirror & swing-out lens holder is attached in the microscope foot, so we need to remove the holder. Remove the locking ring for the mirror & swing-out lens holder and then remove the entire holder from the microscope foot. Remove the mirror plate from the mirror & swing-out lens holder after unscrewing the three M2.5x5 “A”, “B” and “C” screws (with blue and orange circles in Figure 33.) Change the washer that sits below the “C” screw (with orange circle in Figure 33) between the mirror plate and the mirror & swing-out lens holder to a thicker washer. As a rough guideline, increasing the washer thickness by 0.1 mm will elevate

the light dot on the target by 1 mm. (In my case the light dot moved upward on the target by 7 mm when I changed the original 0.4 mm steel washer to a 1.0 mm nylon washer.) Reassemble the mirror & swing-out lens holder, attach it again in the microscope foot, and repeat the vertical collimation procedure until the light dot is exactly level with the target.

We are now ready to proceed with the horizontal collimation. Move the light dot horizontally (sideways) on the target by turning the mirror & swing-out lens holder that should sit snugly attached in the microscope foot. The holder swivels around the microscope's illumination exit port while attached to it by the locking ring (Figure 11.) Once the light dot is on the target horizontally, successively fix the holder by taking turns tightening the locking ring and both lateral alignment screws (indicated with green squares in Figure 33.) As explained in subsection 3 you should use an undersize (for example, 1.8 mm) screwdriver for the lateral alignment screws. Follow up all the time by checking that the light dot remains on the target. Leave the lateral alignment screws well tightened, but tighten the locking ring only moderately. Locking rings are much easier to tighten than release.

7. Finish the work

Remove the collimation target from the backside of the microscope.

Reattach the bayonet mount (note the notch that need to fit over a guide screw) over the locking ring (Figure 10), reattach the cover (Figure 9) with only a light tightening, and then reattach the filter holder with the dust protecting glass (Figure 4.)

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: Cleaning of optical glass with dishwashing liquid

This is a suggestion for a cleaning procedure for rugged and uncomplicated optical glass objects. The idea is to place the object in lukewarm water with dishwashing liquid (detergent), and, while immersed, gently brush its optical surfaces with a soft brush. Properly executed, the optical surfaces will be effectively cleaned while exposing them to minimal rubbing. The disadvantage is that the aqueous solution will penetrate into any crevices (joints, threads, etc.) from where it may be difficult to remove and where it possibly could cause corrosion or other problems. Use the procedure with discrimination.

Fill a small plastic bowl with lukewarm tap water and a squirt of dishwashing liquid (any commercially available liquid dish detergent for manual dishwashing should be suitable.) Immerse the object to be cleaned in the solution while avoiding, as far as possible, that the optical surfaces touch anything solid (not even the walls of the plastic bowl.) Let the object soak for 5-20 minutes. Lightly brush the optical surfaces with a very soft, clean brush (typically an artist's paintbrush.) Rinse the object thoroughly with

lukewarm tap water and then with distilled or deionized water (to avoid dry spots left by the tap water.) Optionally, a quick final rinse with 99% isopropanol may facilitate the removal of residual water and speed up the drying of the object, but be aware that some objects may be incompatible with the solvent. If required, carefully remove the last drops of water from the optical surfaces by lightly blotting (not rubbing!) with lens cleaning paper, cotton swabs, or a clean microfiber cloth. If applicable, use blotting paper to remove as much trapped water as possible from any narrow spaces or crevices. Leave the object to dry completely in the air, preferably at slightly elevated temperature.

Appendix 2: The diascopic vs. episcopic illumination switch

I have hidden away the description of the diascopic vs. episcopic illumination switch in this appendix because there are no maintenance notes for it. The reason for the absence of the maintenance notes is that any disassembly of the switch (or any of its two associated mirrors) would require a recollimation of the episcopic illumination path, and I just haven't been able to figure out how to do that.

The diascopic vs. episcopic illumination switch was built into Ortholux microscopes up until 1959. It directs the illumination path from the lamp to provide either transmitted (diascopic) or vertical (episcopic) illumination of the studied object. It is operated by a lever that laterally moves a mirror (angled at 45°) in and out of the illumination path (Figure 34 and Figure 35.)

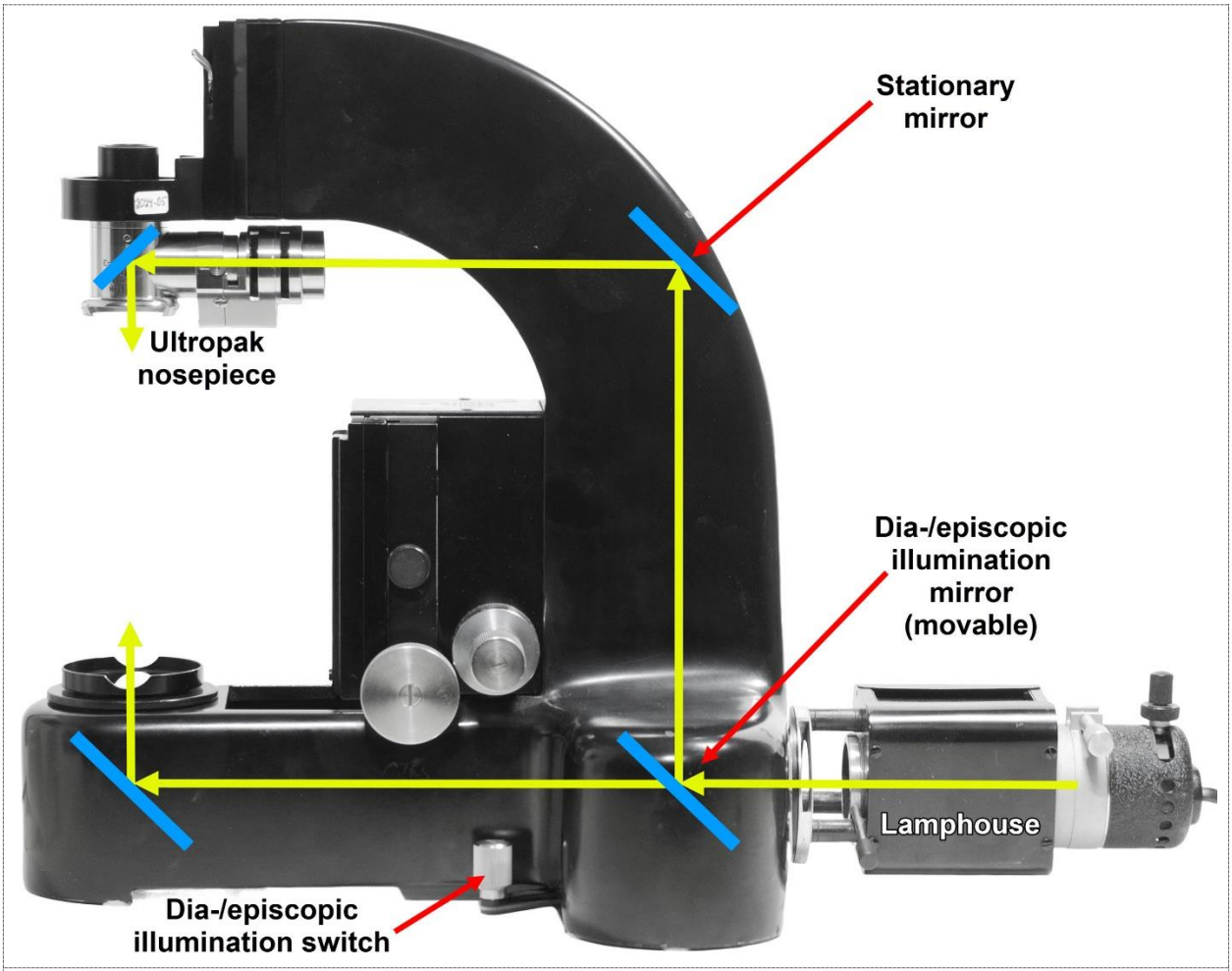

Figure 34: The illumination paths of a pre-1959 Ortholux microscope. The mirrors are drawn in blue color; the illumination paths are drawn with yellow arrows.

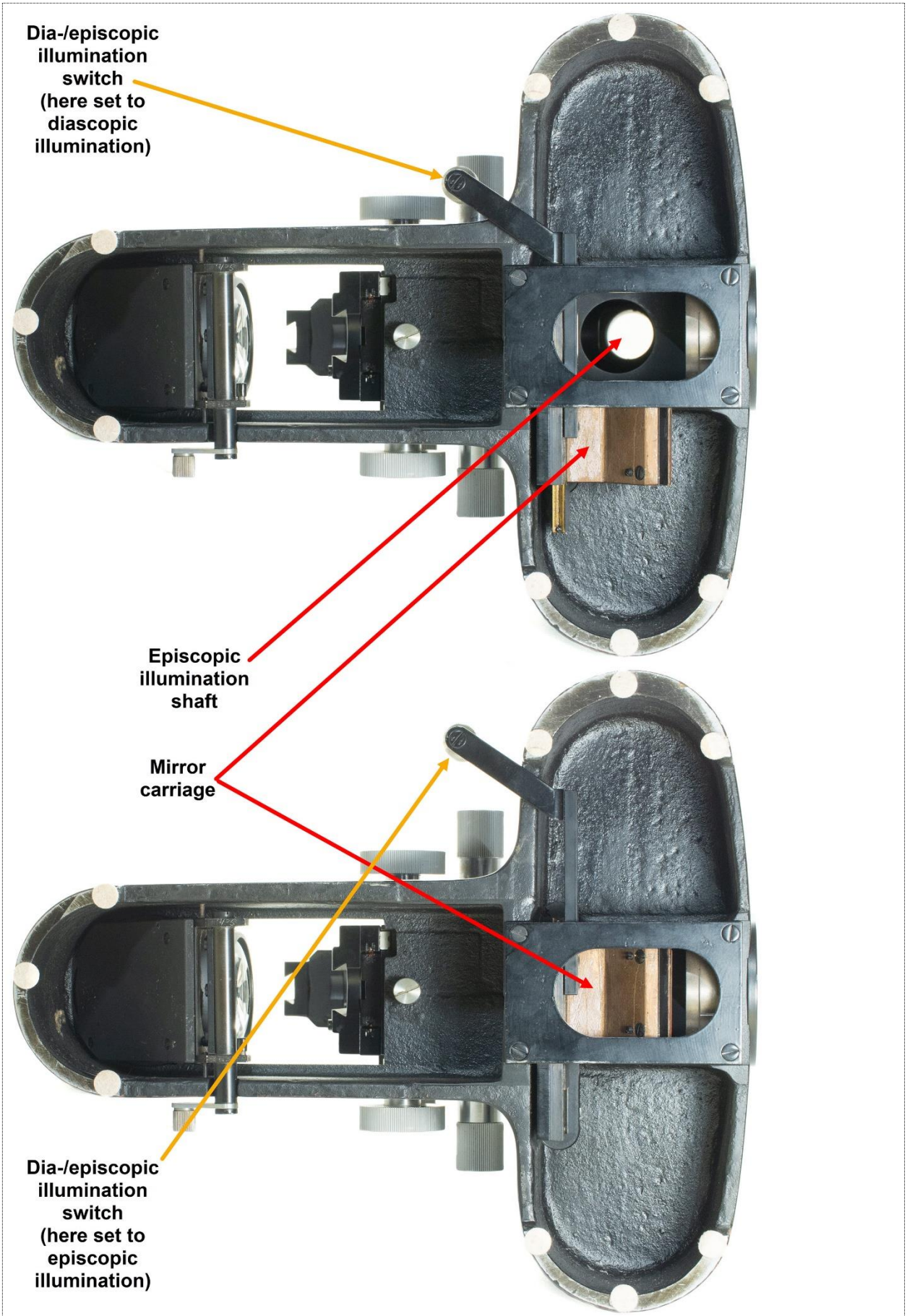

Figure 35: Pre-1959 Leitz Ortholux microscope viewed from the underside showing the dia-/episcopic mirror in both settings.

Later Ortholux microscopes completely separated the diascopic and episcopic illumination paths, whereby each path received its own lamphouse. This was probably driven by the advent of immunofluorescence techniques for medical research and diagnostics where the ability to use epifluorescence together with regular transmitted light observation required separate illumination paths with different lamps.

A wide variety of nosepieces and accessories were available for episcopic illumination; Figure 34 illustrates only one of these, a nosepiece for Leitz' series of Ultropak objectives intended for vertical illumination.

True to Leitz' tradition of craftsmanship the movable mirror carriage (Figure 35) runs on two linear ball bearings. The carriage has distinct detent stops for the diascopic and episcopic positions. Unfortunately, the mirrors can't be accessed for cleaning without removing them from the microscope.

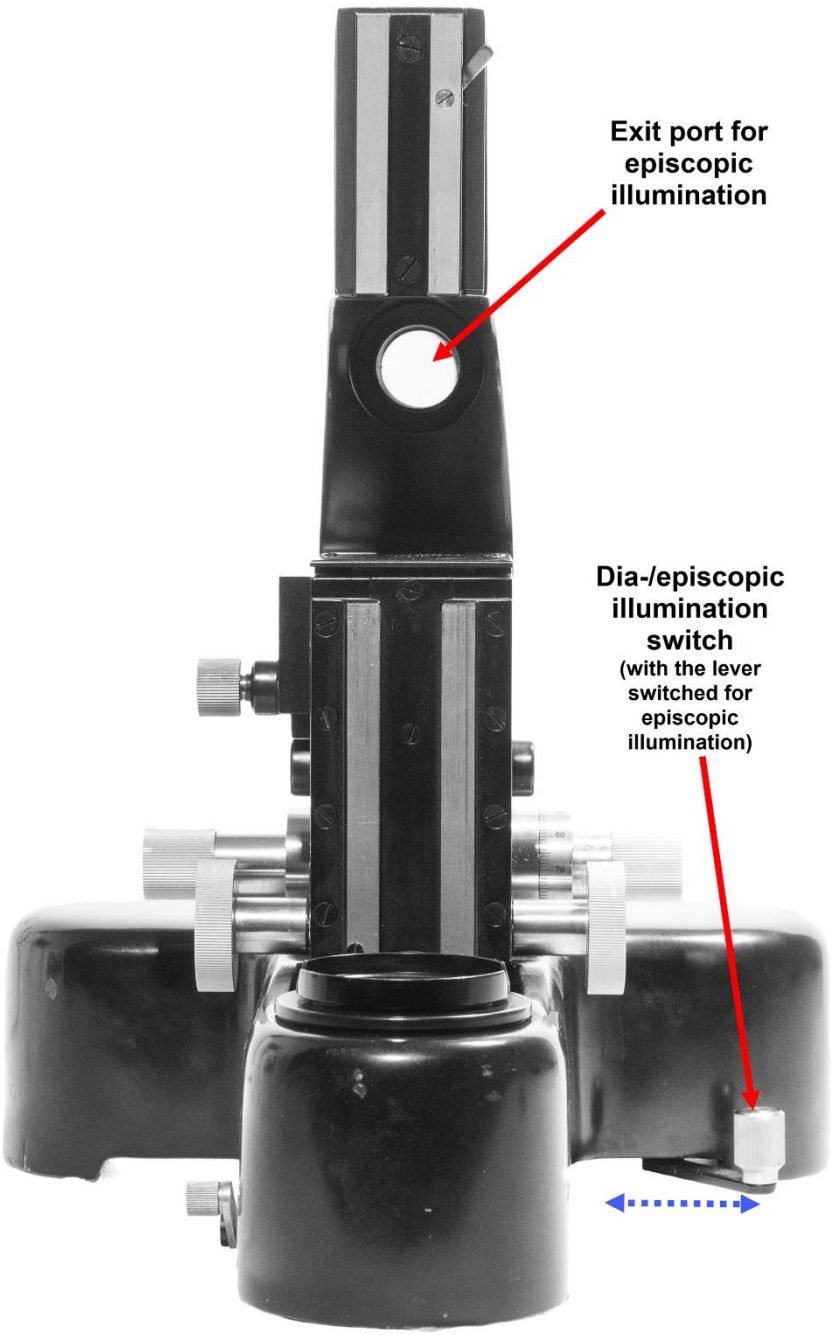

Figure 36: View from the front of a pre-1959 Ortholux microscope. The stage, nosepiece and head have been removed.

Appendix 3: The collimation target

The three concentric rings are supposed to make it easier to center the target over the microscope's lamp port.