Fixing a Seized Diopter Adjustment on a Leitz “Black Era” Eyepiece Tube

Introduction

The interpupillary distance, i.e., the distance between the centers of the eye pupils, is different for different persons. For the observer’s convenience it is very important that binocular microscope heads have provisions for adjustment of the interpupillary distance. As expected, all binocular or trinocular microscope heads from Leitz “Black Era” include such provisions, although the mechanical designs may differ (Figure 1.)

Figure 1: Three Leitz binocular/trinocular microscope heads from the “black era” with different interpupillary distance adjustment mechanisms.

Top head: Interpupillary distance adjustment by a graduated knob.
Middle head: Interpupillary distance adjustment by a lever with a scale.
Bottom head: Interpupillary distance adjustment by manually pulling apart the eyepiece tubes against a scale (the scale is not visible in this image.)

A disadvantage with some of the early binocular heads was that changing the interpupillary distance had an undesired side effect – it also changed the microscope’s mechanical tube length (which should be 170 mm for Leitz microscopes from this era.) And as we know, keeping the prescribed mechanical tube length is essential, particularly for dry objectives with high numerical apertures.

Adding a diopter adjustment function to compensate for interocular differences in visual acuity (i.e., “sharpness differences” between the observer’s eyes) was another feature introduced for the observer’s convenience. This was accomplished by making one of the eyepiece tubes focusable. The focusing mechanism consisted of an eyepiece tube mounted in a helicoid thread (Figure 4.) By turning the eyepiece tube, it could be

shortened or lengthened by typically 8-12 mm to change the focus of the eyepiece and thereby even out any differences between the observer's eyes.

There are three types of heads with focusable eyepiece tubes on Leitz "Black Era" microscopes:

I. A head where only one of the eyepiece tubes is focusable. This allows for diopter adjustment as mentioned above. The focusable eyepiece tube typically only has a simple zero-point index (Figure 2.)

II. A head where both eyepiece tubes are focusable and have a numerical scale (Figure 3.) This combines the diopter adjustment function with a second function that allows for compensation of the mechanical tube length change that occur due to the setting of the head's interpupillary distance. The user sequence is a) adjust the head for your interpupillary distance, b) read the numerical value on the interpupillary distance scale, c) turn both eyepiece tubes so their scales show the same number as the interpupillary distance, and d) if required, make any required diopter adjustment on the eyepiece tube that is used with your "weakest" eye.

Figure 2: Focusable eyepiece tube for a head with only a diopter adjustment. The scale is a simple zero-point index that indicates where the focusable eyepiece tube has the same length as the other eyepiece tube with the fixed length.

Figure 3: Focusable eyepiece tube for a head with combined diopter and interpupillary distance adjustments. The scale is numerical in units of mm interpupillary distance. After the head has been adjusted for the user's interpupillary distance, the reading from its scale is transferred to both eyepiece tube scales by turning the tubes as required. The image shows an eyepiece tube adapted to an interpupillary distance of 59½ mm.

III. A head where both eyepiece tubes are focusable but only have simple zero-point indices (Figure 2) and no numerical scale. Here the user can choose to do the diopter adjustment on any of the eyepiece tubes, but in the absence of the scales there is unfortunately no support for any mechanical tube length compensation due to the interpupillary distance setting.

Leitz “Black Era” microscopes are now 50-90 years old. If a microscope of this age hasn’t been maintained, or if it has been left unused for a long time, it shouldn’t be a surprise that its focusable eyepiece tubes have become sluggish or even completely seized due to aged and hardened lubricants. These maintenance notes describe how to fix a sluggish or seized eyepiece tube focusing.

Figure 4: View of the helicoid thread in an focusable eyepiece tube.

Figure 5: One of several similar binocular microscope head models from Leitz’ “black era”.

The eyepiece tube with the diopter adjustment (on the left side in this image) is recognized by its knurled focusing knob. The other eyepiece tube (on the right side) has a fixed length.

The yellow arrows point to two of the four screws that attach the eyepiece tube to the head.

Figure 6: Eyepiece tube with diopter adjustment after removal from the binocular microscope head.

Camera Lens Spanner

With some luck the locking ring on the top of the eyepiece tube (Figure 6, Figure 7 and Figure 9) will be only loosely attached and can carefully (it's made of soft brass) be removed with one or two 2 mm screwdrivers that should fit onto the slots on the face of the locking ring. If that doesn't work, the locking ring can more reliably be removed with the help of a suitable camera lens spanner (Figure 8.) These spanners come in several different designs, we need one with the following properties: The spanner shafts should be curved inwards (as in Figure 8), otherwise the tips will not be able to reach into the slots which are very close to the eyepiece tube. Next, the spanner tips (of the "flat-tip" type, like a regular screwdriver) should be enough narrow (max. 2.0 mm) and thin (max. 0.7 mm) to fit into these slots. It may be necessary to grind the tips to make them to fit into the slots.

Figure 7: Closeup view of the front of the locking ring. The red arrows point to the two narrow slots into which the lens spanner tips must fit.

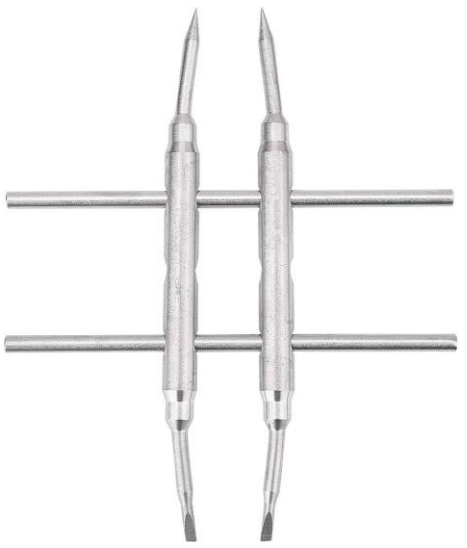

Figure 8: Camera lens spanner. "Flat-tips" pointing downwards.

Grease

Due to the proximity of the helicoid thread to sensitive optical parts (the eyepieces and the prisms in the head) some discretion is required for the choice of grease. Specifically, greases that tend to creep along surfaces or that may emit semi-volatile compounds that may haze the optical surfaces should be avoided.

Helimax-XP is an often used and recommended helicoid grease that provides very smooth focusing movements. However, for the eyepiece tubes I prefer a thicker grease with more resistance to prevent inadvertent changes of the focus settings.

It is important to thoroughly remove all traces of old grease before applying fresh grease. Typically, I clean with pieces of cloth or cotton swabs wetted with white spirit, in some cases I soak the parts in the solvent.

Grease for helicoid threads should be applied very sparsely as very thin layers. Too much of the grease will make it to creep and possibly contaminate sensitive optical glass surfaces.

Maintenance Notes

Figure 9 shows an exploded view of an eyepiece tube with diopter adjustment.

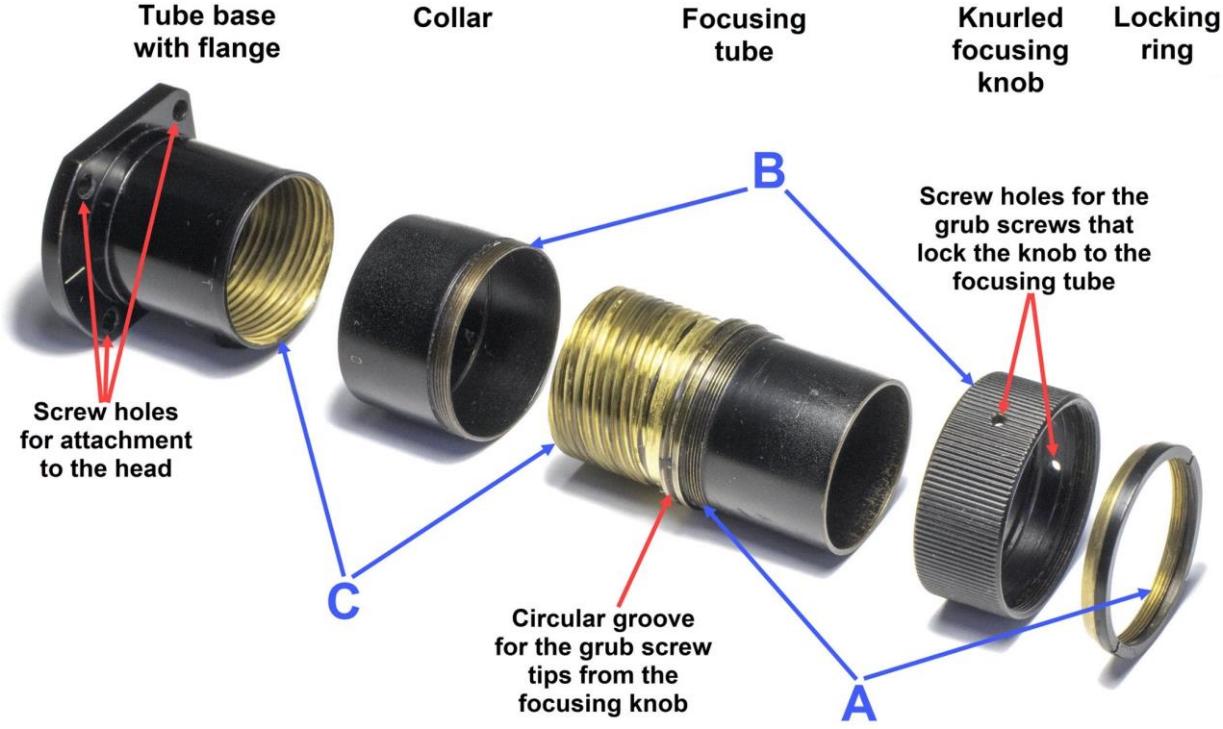

Figure 9: Exploded view of an eyepiece tube with diopter adjustment.
Letters A, B and C indicate which threads belong together. C is a helicoid thread.

There is an important procedure difference whether the diopter adjustment is only sluggishly moving or if it is completely stuck. In the first case the focusing mechanism can be disassembled, cleaned, and relubricated without removing the eyepiece tube from the microscope head (but instead it is important to make sure that no dust, dirt, or solvent can get into the head and compromise the internal optics.) If, on the other hand, the diopter adjustment is stuck, then it is necessary to remove the eyepiece tube from the head and soak it in solvent. The problem is however that any time an eyepiece tube has been removed from the head it must be re-collimated when it is put back to ensure that its optical axis still coincides with the other eyepiece tube's optical axis. If the collimation check and adjustment is omitted, there is a significant risk of eyepiece miscollimation that can cause visual fatigue and even double vision.

1. Remove the head from the microscope. It is easier and safer to work with the head if it is not attached on the microscope.

2. Remove the eyepieces and store them protected from dust.

3. ***(This step applies only if both of the head's eyepiece tubes are focusable.)***
   When both eyepiece tubes are focusable they typically have numerical scales as in Figure 3, but some older eyepiece tubes may only have the simpler zero-point index as in Figure 2. Before the tubes are disassembled, we should record how the scales are aligned with the turning of the eyepiece tube knobs. These readings will be useful for restoring the original scale alignments after the eyepiece tubes have been taken apart, cleaned, greased, and reassembled.

If the eyepiece tube scales are numerical as in Figure 3: Make a note about the scale readings when the eyepiece tubes are turned into their most extended position (where the scale reading will typically be somewhere near 52) and in their least extended position (will typically be around 75.) Record the numbers to the nearest ½ scale unit. Estimate the number if the index line points outside of the scale numbering. Ideally both eyepiece tubes should yield the same numbers.
If the eyepiece tubes only have the simple zero-point indicator: The absence of numerical scales makes it unnecessary to save any alignment record.

4. ***(This step applies only if the eyepiece tube focusing is stuck and must be removed from the head.)*** Remove the entire stuck eyepiece tube after unscrewing the four M2x6 screws that attach the eyepiece tube to the microscope head (Figure 5.) Cover the microscope head to protect it from dust.

5. Unscrew and remove the locking ring from the focusable eyepiece tube (thread A in Figure 9) as described in section Camera Lens Spanner above. The locking ring is made from soft brass and is therefore vulnerable to scratches and damage.

6. Remove the three tiny, headless M2 grub screws that lock the knurled focusing knob to the focusable eyepiece tube Figure 9.) Use a screwdriver not wider than 1.5 mm to avoid damage to the inner threads in the screw holes.

7. Remove the focusing knob by unscrewing it from the collar (thread B in Figure 9.)

8. ***(This step applies only if the eyepiece tube focusing is stuck and was removed from the head.)*** Put the remaining parts of the eyepiece tube (the focusing tube, the collar, and the tube base) into a glass vial with a solvent that is suitable for dissolving grease (for example, white spirit.) Leave it to soak for a few hours or for several days, until the stuck focusing tube can be turned on its helicoid thread (thread C in Figure 9). Don't use force, the helicoid thread is sensitive to abuse, and the tube is made of soft brass - let the solvent do the work even if it may take several days.

9. Remove the focusing tube from the tube base and put the now released collar to the side.

10. Clean the helicoid thread with a cloth wetted with a suitable solvent (e.g., white spirit.) If the tube base was left on the head, keep the head turned in such a way that no solvent, dirt, or dust can fall into the head.

11. If the helicoid thread still has remains of hardened grease, try to clean the thread with a hard toothbrush and hot water with dishwashing detergent. (But don't wash the tube base thread if it still is attached to the head.)

12. Lubricate the helicoid thread with a suitable grease, refer to section Grease above. Apply the grease very sparsely.

13. Put the collar (with its thread upwards) down over the tube base. Carefully attach the focusing tube to the tube base making sure that the helicoid threads catch easily and cleanly. Turn the focusing tube back and forth several times to distribute the grease. Leave the focusing tube screwed all the way down.

14. Attach the focusing knob by screwing it to the collar and tighten it lightly.

15. With a 1.5 mm screwdriver loosely attach the three M2 grub screws to the knurled focusing knob. Lightly push the focusing knob with the collar towards the tube base to ensure that the tips of the screws can reach into the focusing tube's circular groove as indicated in Figure 9. Tighten the grub screws very lightly until they reach into the bottom of the circular groove, and then release them by approx. ⅛ turn so the knob can slide on the focusing tube while still being attached to it.

16. Calibration of the scale on the side of the eyepiece tube. The scale needs to be aligned in a meaningful way with the extension of the focusable eyepiece tube. There are three different approaches depending on how the heads and eyepiece tubes are designed:

    Microscope head with one fixed and one focusable eyepiece tube (Figure 5 and Figure 6):

    Here the goal is to have the collar's zero mark in line with the zero bar on the tube base flange when the focusable eyepiece tube is set to the same tube length as the fixed eyepiece tube. On the fixed eyepiece tube measure the distance between the underside of the flange (that faces the head) and the rim (where the eyepiece goes.) Turn the focusing tube (not the knob, because the knob would only slide on the focusing tube) of the focusable eyepiece tube until it reaches the same tube length. Hold the focusing tube steadily in this position and turn only the focusing knob (the loose grub screws will slide in the focusing tube groove) until the collar's zero ("0") mark is just adjacent to the white zero bar on the tube base flange. Tighten the three grub screws (not too hard) to lock the knob to the focusing tube.

    Microscope head with two focusable eyepiece tubes with numerical scales (Figure 3):

    The goal is to align the scales in the same way as there were before the eyepiece tubes were disassembled. We will use the record taken in point 3. above. Do the following for both eyepiece tubes. Turn the focusing tube (not the knob, because the knob would only slide on the focusing tube) of the focusable eyepiece tube clockwise as far as it goes to reach the position where the tube length is at its minimum. Keep the focusing tube steadily in this position and turn the focusing knob only (with the loose grub screw tips sliding in the focusing tube groove) until the collar's scale index for the applicable previously recorded number aligns with the white bar on the tube base. Tighten the three grub screws (not too hard) to lock the knob to the focusing tube, turn the knob fully counterclockwise into the eyepiece tube's maximally extended position, and check that the scale reading now also agrees with the record.

    Microscope head with two focusable eyepiece tubes with simple zero-point indices (Figure 2 and Figure 6):

    The only important adjustment here is to make sure that the tube lengths are the same when both tubes' indices point to the zero marks. Do the following for both eyepiece tubes. Turn the focusing tube (not the knob, because the knob would only slide on the focusing tube) of the focusable eyepiece tube counterclockwise as far as it goes to reach the position where the tube length is at its maximum. Keep the focusing tube steadily in this position and turn the focusing knob only (with the loose grub screw tips sliding in the focusing tube groove) until the collar's zero mark is 180° opposite of white bar on the tube base. Tighten the three grub screws (not too hard) to lock the knob to the focusing tube.

17. Attach the locking ring by screwing it on the thread of the focusing tube. The ring tends to get stuck in the thread, therefore it is important to tighten it only very lightly. Don't use the spanner; as a suggestion, tighten it only with a pointed wooden toothpick. If the toothpick tip breaks, the ring is already more than enough tight.

18. If applicable, reattach the eyepiece tube to the microscope head. Check that the eyepiece tubes are collimated; adjust the collimation, if required.