Leitz Trinocular Head FSA (512 815/20) - Maintenance Notes

Introduction

Leitz microscope head FSA (sometimes FSA 42/30 or FSA/20), catalog no. 512 815/20, is a trinocular Jentsch type microscope head designed for microscopes with 160 mm mechanical tube length and for eyepieces that have an outer barrel diameter of 23.2 mm. Apparently “F” in the “FSA” designation indicates that the head includes a photo tube, and “A” indicates that the head automatically compensates to retain the tube length 160 mm when the interpupillary distance is changed. The number “20” after the slash in the catalog no. probably indicates the head’s maximal fow (field-of-view) index. Note that in their English documentation Leitz used “tube” rather than “head”.

Figure 1: View of the microscope head before the eyepieces have been removed.

The head has a viewing angle of 30°. It is adjustable for interpupillary distances with a scale that covers the range of 54-75 mm. To maintain the designated mechanical tube length (160 mm) for any chosen setting of the interpupillary distance, a mechanism automatically corrects the tube length by rearranging the prisms in the head. The head's magnification factor is 1.0x.

On the upper side of the head is a knob for an optical beam splitter with three different choices for distributing the image between the binocular observation tubes and the photo tube:

Beam splitter symbol	Image beam distribution
→	100 % to the eyepieces
↱	50 % to the eyepieces, 50 % to the photo tube
↑	10 % to the eyepieces, 90 % to the photo tube

The eyepiece tubes are not individually adjustable for varying eye diopters – this can instead be accomplished by using at least one eyepiece that has built-in focus/diopter adjustment. These eyepieces are recognized by including the letter "M" in the designation, e.g., "Periplan 10x/18 M" (where is the symbol for high eyepoint eyepieces, which are eyepieces particularly suitable for eyeglass wearers.) The head is attached to the microscope via a circular 42 mm dovetail mount. The phototube has an inner diameter of 38 mm.

Scope

Some common problems seen with the FSA (catalog no. 512 815) heads:

- Damage due to shocks and blows. With its heavy prisms and protruding eyepiece tubes the head is vulnerable to rough handling. Shipping damage due to reckless parcel handling and inadequate packaging is common and typically result in broken mechanism parts (Figure 2) and/or dislocated or even chipped prisms (Figure 3 and Figure 4.) Such damage is difficult or even impossible to repair. Similar damage may also of course happen if a head accidentally has been dropped on the floor. Another issue is eyepiece tubes that, perhaps inadvertently, have been bumped out of collimation resulting in double vision in the microscope. Eyepiece miscollimation can however often be adjusted.
- Sluggish or seized moving parts. The cause is grease that has aged to become a gummy, semi-solid mass. The eyepiece/phototube beam splitter mechanism, the horizontal slide with its ball bearings, and particularly the interpupillary distance slides are typically affected.
- Compromised lenses, prisms and windows. Various issues well known to microscopists: Dust, dirt, scratches, breakage, haze, fungus, delamination, etc.

These maintenance notes describe the disassembly, cleaning, greasing and reassembly of the Leitz FSA trinocular head, catalog no. 512 815. It has several moving parts that may need cleaning and regreasing. In parts the notes may also be applicable for other contemporary Leitz microscope heads.

It seems that Leitz may have used the head designation FSA during several years for a series of externally similar heads. Be aware that there may be significant design differences between these FSA head variants.

After reassembly of a serviced binocular/trinocular microscope head it must be checked and adjusted for eyepiece collimation.

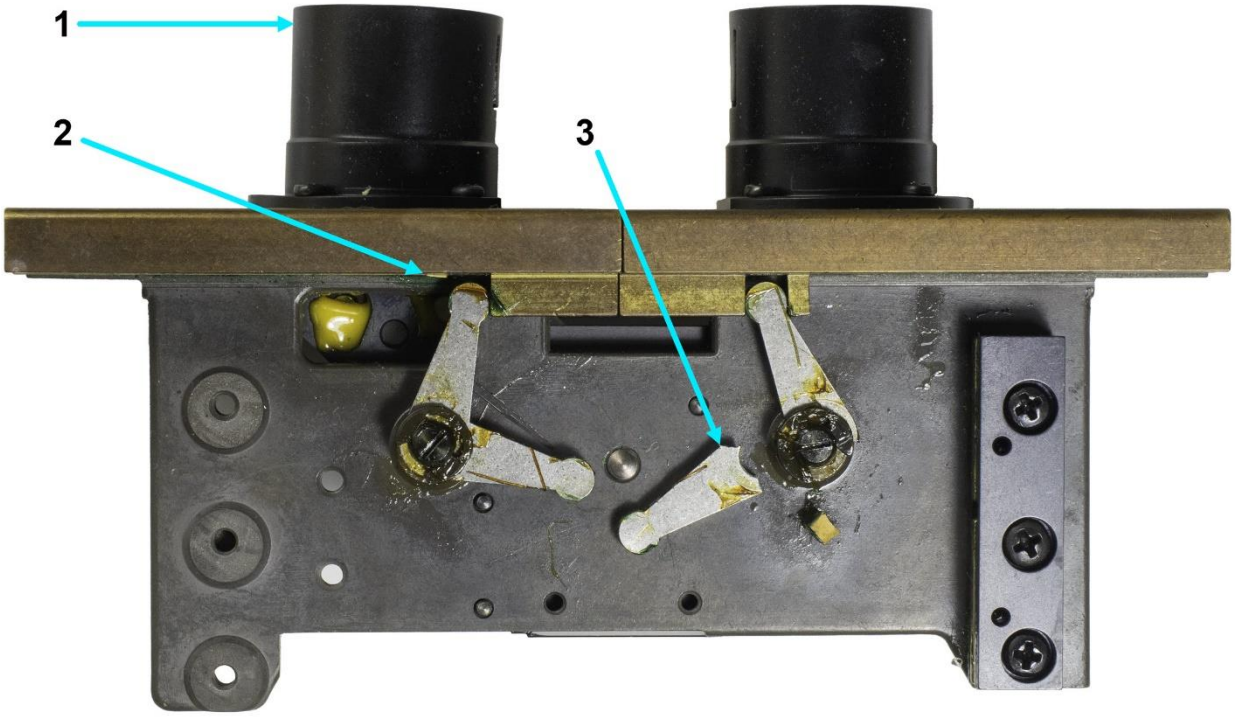

Figure 2: Examples of irreparable mechanical damage on an FSA head:
1: Eyepiece tube that has received a blow from the side and has become bent inwards.
2: Brass knob broken off from the eyepiece shield. (Compare with the corresponding intact knob on the other eyepiece shield.)
3: Broken lever. (Compare with the corresponding intact lever on the left side.)

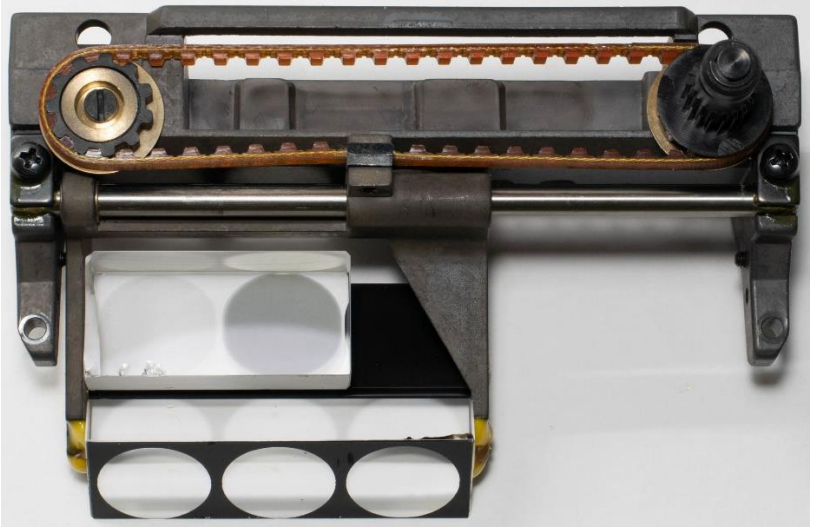

Figure 3: Cracked prism in an FSA head.

Figure 4: Closeup of the cracked prism in Figure 3.

Maintenance Notes

1. Remove the head from the microscope.

Remove all eyepieces from the head.

The head is attached to the microscope by a circular dovetail mount. Release the head by pulling back the lever next to the mount on the microscope stand and lift off the head.

The head contains several optical components, mainly prisms, which need to be protected from dust, fingerprints, grease and solvent droplets released during cleaning. It is recommended to wear disposable nitrile rubber gloves when any parts containing prisms are removed or attached to the head. Protection measures often conflict with comfortable maintenance work, so we leave it to you to find a workable compromise.

2. Clean the head's dovetail mount.

The head's dovetail mount (Figure 5) may have accumulated some old grease and dust.

Use cotton swabs and solvent (white spirit) to clean the mount. Be careful not to splash solvent on the glass window in the mount.

This is also a good time to clean the corresponding mount in the microscope.

Figure 5: The dovetail mount on the head's underside.

3. Remove the eyepiece shields and the eyepiece tubes.

Remove both eyepiece shields (Figure 1), each attached on the front of the head with four M2x8 Philips screws. Now the eyepiece slides for the interpupillary distance adjustment and the eyepiece tubes are accessible (Figure 6.) The eyepiece slides move horizontally on greased dovetail rails.

Figure 6: The front of the microscope head after the eyepiece shields have been removed. The eyepiece slides for the interpupillary distance adjustment (the two brass plates in the front) and the eyepiece tubes are now accessible.

Remove both eyepiece tubes from the interpupillary distance adjustment slides - each of the tube is attached with four M2x5 Philips screws (Figure 6 and Figure 7.)

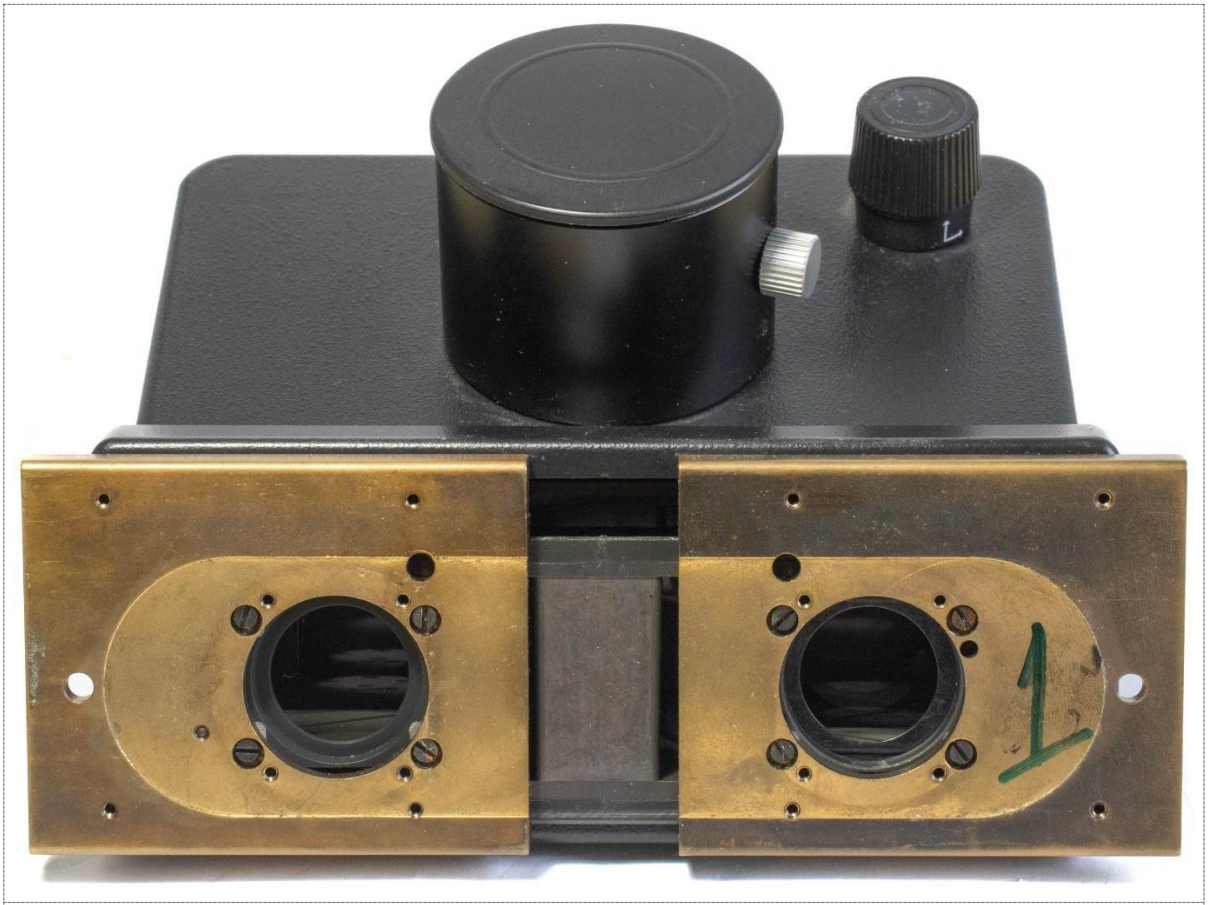

Figure 7: The eyepiece slides on the front of the microscope head after the eyepiece tubes have been removed.

4. Remove the phototube and the head cover.

To access the internals of the head we need to remove the phototube, the beam splitter knob and the head cover.

Remove the beam splitter knob by pulling it straight upwards.

Remove the phototube from the head base. It is attached with four M3x8 Philips screws that are accessible from the inside of the phototube. The screws sit very close to the inner walls of the phototube which makes them somewhat difficult to reach with the screwdriver. Having a narrow screwdriver shank helps.

Remove the head cover (Figure 8); it is attached to the head base with two M2.5x6 Philips screws on each side of the head and with two tall thread forming Philips screws () on the bottom of the head base.

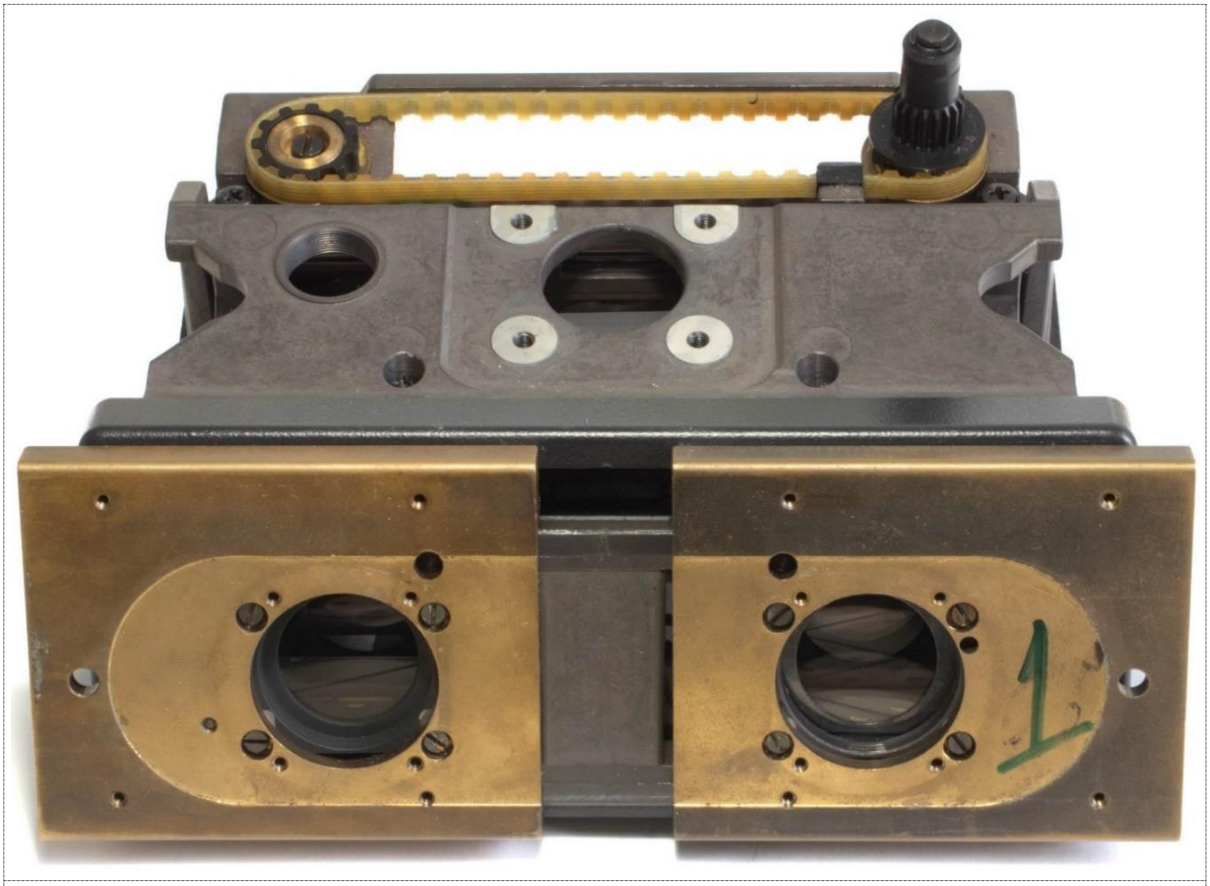

Figure 8: The microscope head after the head cover has been removed.

5. Remove the front of the head from the base.

The front of the head contains the eyepiece prisms, the slides for the interpupillary distance adjustment, and the mechanism that keeps the tube length constant when the interpupillary distance is changed.

The mechanism that keeps the tube length constant runs on linear ball bearings. It links the horizontal movements of the slides to a corresponding back-and-forth movement of the front of the head. It is illustrated in Figure 9 and Figure 10 below. When the slides are pulled maximally apart the front is sitting tightly on the head base (Figure 9.) As the slides are pushed together the front moves outwards from the head base (Figure 10.)

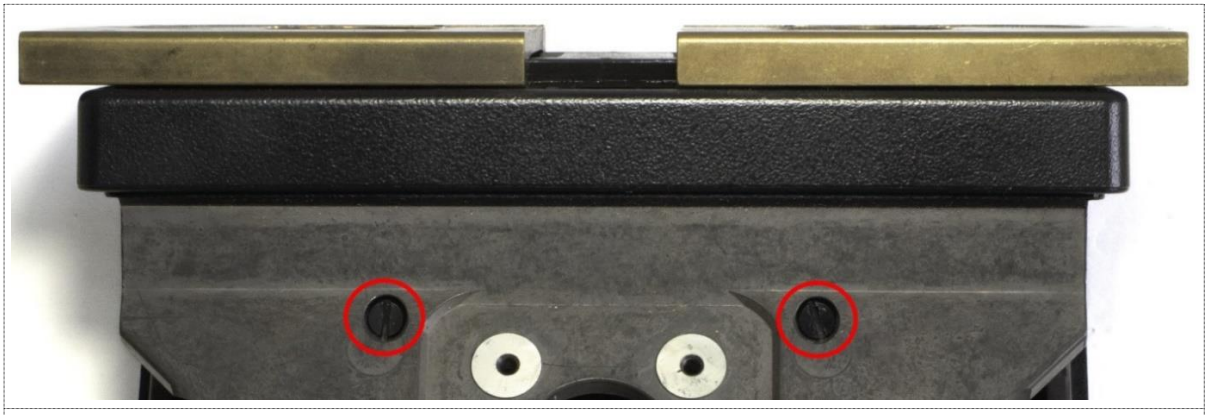

Figure 9: The front of the head seen from above. The slides have been pulled maximally apart and the front is sitting snugly on the head base. The red circles indicate two of the screws that attach the head front to the head base.

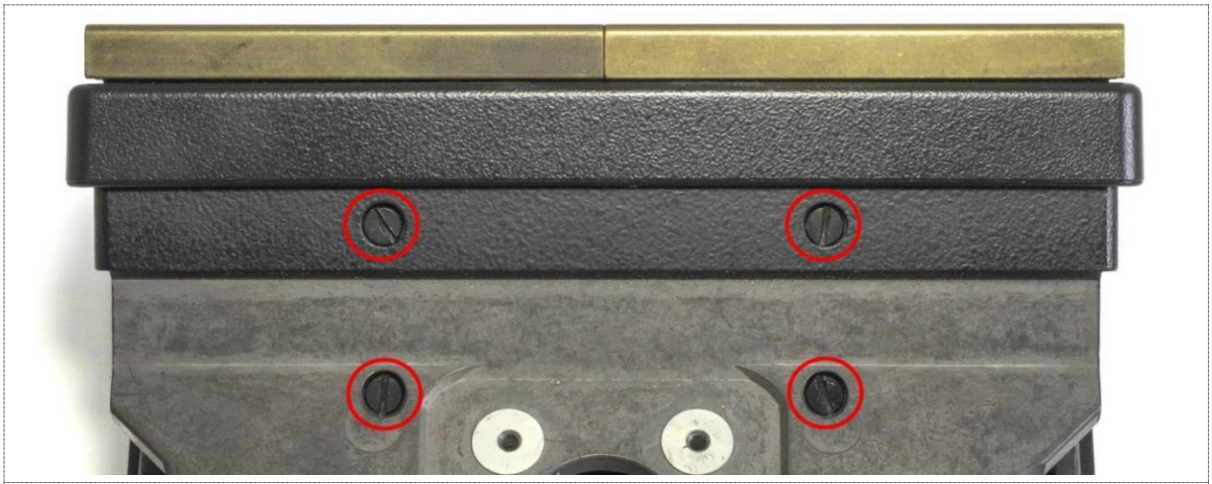

Figure 10: The front of the head seen from above. The slides have been pushed together making the head front to move outwards from the head base. This also reveals two more screws that attach the front to the base (all four screws with reds circles.)

Push the slides together to access the four M3x6 screws (Figure 10) that attach the front to the base. Remove the screws from the top of the head. Pull out the front very carefully to avoid damaging the prisms. Figure 11 shows the front from its backside.

Store the front temporarily in a dust free place.

Unscrew the two M3x4.5 Philips screws, each with a small 0.5 mm thick washer, that hold the front shell attached to the front of the head and remove the shell.

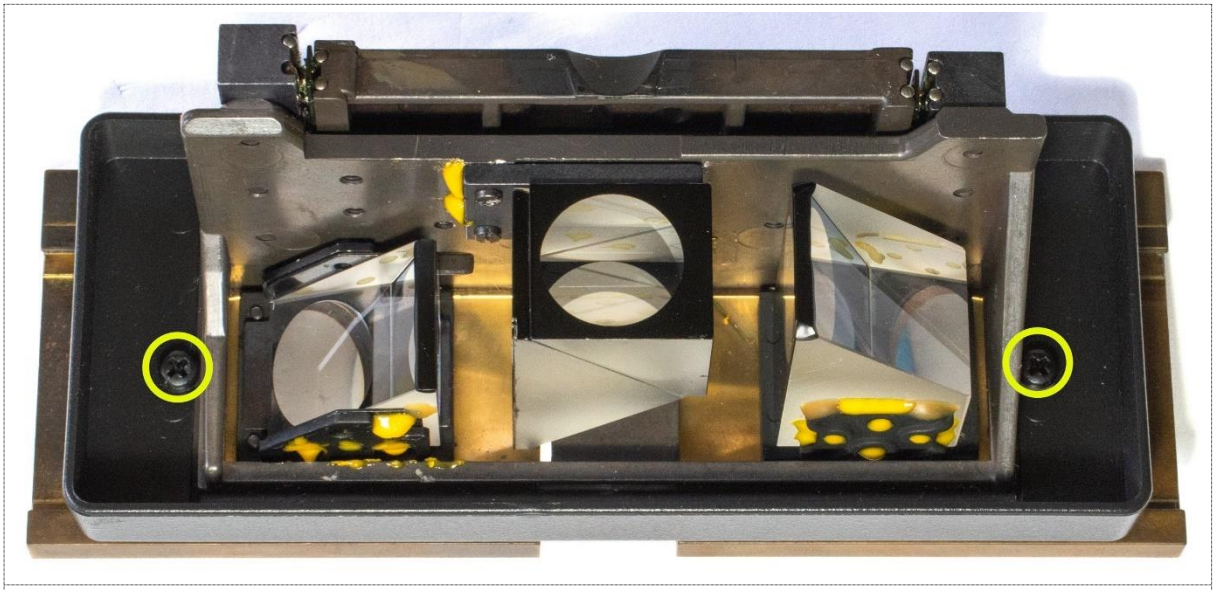

Figure 11: The front of the head viewed from the backside. The prisms that direct the optical paths to the eyepieces are attached by yellow epoxy cement blobs. The slide and the linear bearings for the movement of the head front are on the very top of the image. The yellow circles indicate the screws that attach the front shell to the head front.

6. Remove the beam splitter module from the head's base.

The beam splitter module is attached to the head base with four M3 screws with 2.5 mm hex (Allen) heads. Two of the screws are M3x8 and the other two are M3x12 (Figure 12.)

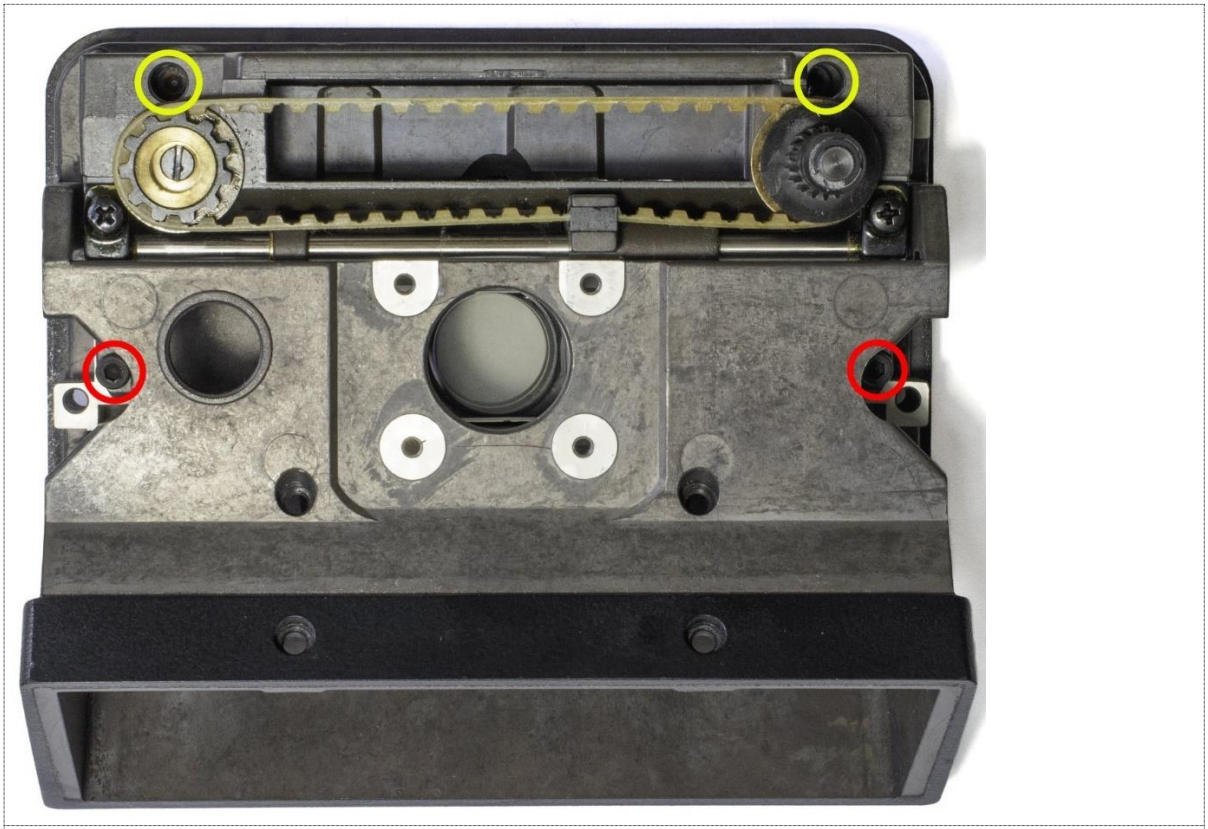

Figure 12: The base of the head with parts of the beam splitter module viewed from above. The beam splitter module is attached to the head base with four screws, two M3x8 (yellow circles) and two M3x12 (red circles.)

Unscrew all four screws and carefully pull out the beam splitter module (Figure 13) from the head base while taking care not to bruise the prisms. Put the module on the table on a clean piece of microfibre cloth.

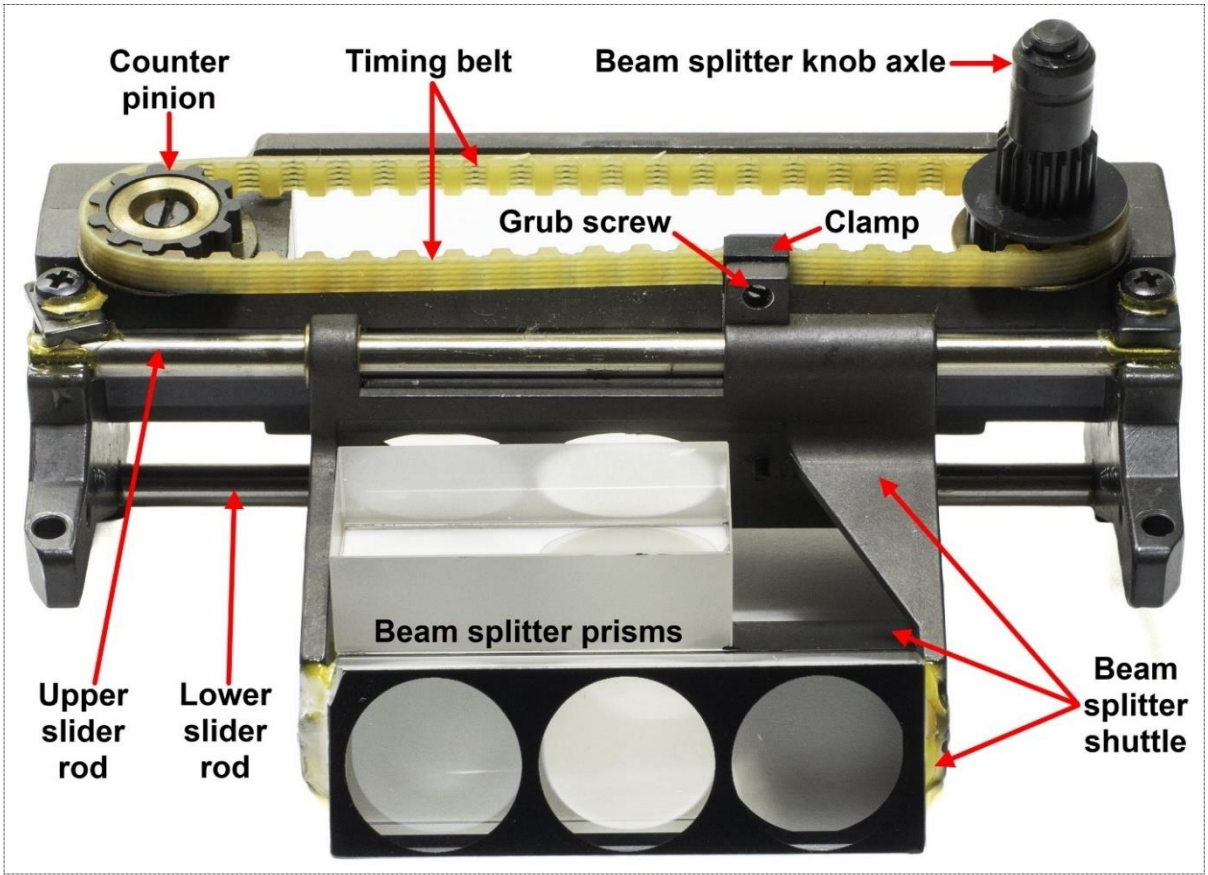

Figure 13: The removed beam splitter module.

7. Clean and grease the beam splitter module.

The main cause of beam splitter sluggishness is aged grease in the counter pinion (Figure 13), or more precisely, hardened grease between its brass bushing and the black plastic pinion wheel (Figure 16.)

Be careful not to touch or contaminate the prism surfaces in the beam splitter module; it may even be a good idea to wear disposable nitrile gloves while working with the module. Also be careful not to allow any force to be applied to the prisms – this can happen if you, for example, push on with a screwdriver to loosen some screws in the module while the prisms rest on the table and inadvertently take the load.

In the beam splitter module (Figure 13) the beam splitter shuttle holds the prisms that are designed to provide the beam splitting. The shuttle is attached with a clamp to a timing belt and can be moved sideways running on the upper slider rod. By turning the beam splitter knob the user moves the shuttle into one of its three beam splitting positions. The end points for the shuttle are where it meets the sides of the beam splitter module, while the midpoint is determined by a detent stop on the underside of the lower sliding rod (Figure 14.)

Aged grease may be found on and below the beam splitter axle, below the counter pinion and the on the detent stop on the lower sliding rod. The upper sliding rod appears ungreased.

Release the small grub screw and the black plastic clamp (Figure 15) that hold the timing belt attached to the beam splitter shuttle. The grub screw apparently has some threadlocker applied but with a well-fitting screwdriver the screw can still be forced to release. Alternatively, treat the screw head with acetone on a cotton swab for a few minutes to soften the threadlocker before releasing the screw. Pull up the clamp to release the timing belt.

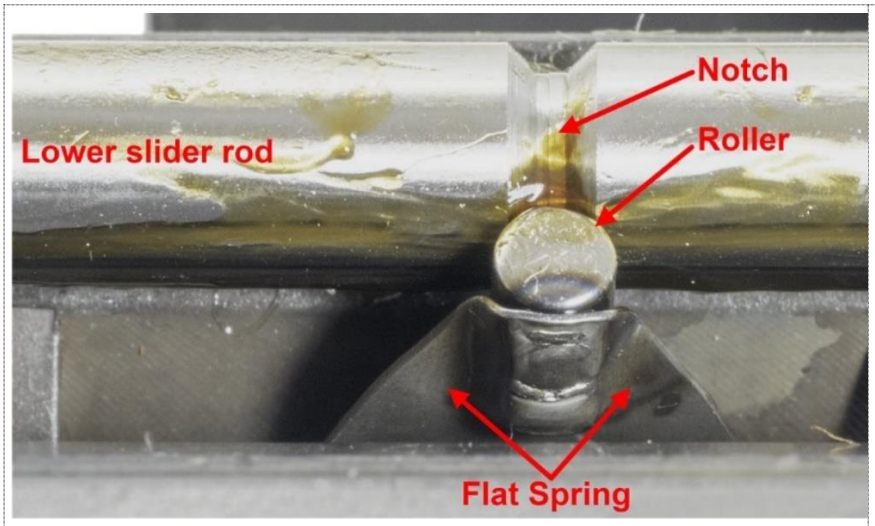

Figure 14: The beam splitter shuttle's detent stop on the lower slider rod viewed from the underside of the beam splitter module. It is covered with aged grease.

Figure 15: Closeup of the grub screw and the plastic clamp.

Unscrew the M3x6 screw that attaches the counter pinion to the beam splitter module and remove the counter pinion. Hardened grease will probably make it stick to the module.

Remove the timing belt. If it appears intact and still usable, clean it from old grease residues with white spirit. If it is cracked or broken, replaced it with a new belt. The timing belt is a standard component available from several manufacturers with the designation 4T5/245, which means 4 mm width, 5 mm T-type pitch and 245 mm length. It will have 49 teeth.

Carefully separate the black plastic pinion from the brass bushing and the brass washer below (Figure 16) – the parts may be almost glued together due to the old, degraded grease. The parts are as follows, starting from below referring to Figure 16: Brass washer (o.d. 19.5 mm, i.d. 8.2 mm, thickness 0.5 mm), black plastic pinion, brass bushing, and black M3x6 screw. Thoroughly clean all greased surfaces including the adjacent surface on the beam splitter module with white spirit; some of the hardened grease may need to be scraped off with a plastic or wooden stick. If the washer is tarnished, polish it with a suitable metal polish (e.g., Autosol or Peek.)

Pry off the E-clip from the top of the beam splitter axle. It may be difficult to get it off; one way to manage is to partly release the clip by pushing a wide flat screwdriver against its open arms, then it protrudes on the backside and can be pried off with a small screwdriver. Pull off the axle from the shaft and remove the brass washer (identical to the washer above) below (Figure 17.) Thoroughly clean all greased surfaces including the shaft and the adjacent surface on the beam splitter module

with white spirit. If the washer is tarnished, tidy it up with a suitable metal polish (e.g., Autosol or Peek.)

Clean off as much as possible of the old grease on and around the detent stop on the lower slider rod (Figure 13 and Figure 14) using cotton swabs wetted with white spirit. Move the shuttle as required to gain better access for the cleaning. Apply a very small blob of fresh grease (for example, Super Lube Multi-Purpose Synthetic Grease with Syncolon, NLGI grade 2) to the detent stop notch just where it meets the roller (Figure 14.)

Figure 16: The counter pinion disassembled.

Figure 17: The beam splitter knob axle disassembled.

Attach the timing belt to the beam splitter shuttle with the plastic clamp and the grub screw (Figure 15.) The clamp should be placed so it locks one of the timing belt ridges into a corresponding notch in the shuttle arm. Tighten the grub screw well. I didn't apply any fresh threadlocker on the screw, but feel free to decide differently.

Lightly grease (same grease as above) the bottom of the removed beam splitter axle and attach one of the brass washers to it. Lightly grease the other (free) side of the washer and the entire axle shaft. Attach the axle with the washer over the shaft (Figure 13 and Figure 17.) Attach the E-clip to the notch in the top of the shaft. Wrap the timing belt over the axle's pinion, it will only be loosely wrapped for now.

Grease the outer periphery of the brass bushing and push it into the black plastic pinion. Make sure that the bushing is properly fitted into the pinion as indicated in Figure 16. Lightly grease both sides of the other brass washer and attach it to the underside of the combined bushing/pivot. Attach the washer/bushing/pivot combination to the beam splitter module with the M3x6 screw, but don't yet tighten the screw. The hole in the bushing allows for some play which is very helpful for the reassembly of the timing belt. Wrap the timing belt over the pinion. Check that the belt is properly attached over both pinions and stretch the belt by pushing the counter pinion outwards quite hard with your fingers. The belt requires a good stretch to avoid play in the beam splitter settings, but don't overdo the stretching. Once the belt tension appears satisfactory, tighten the M3x6 screw thoroughly.

Check that the beam splitter shuttle moves properly by turning the beam splitter knob axle back and forth.

8. Reattach the beam splitter module from the head's base.

Check that all prism surfaces in the beam splitter module are clean, if necessary, clean them.

Use a camera blower to blow off any dust inside of the head base.

Check that both sides of the head mount window in the bottom of the head base are clean; if necessary, clean them.

Taking care not to dirt any of the optical surfaces and not to nick the prisms, carefully put back the beam splitting module into the head base. Attach the module with the four M3 screws with Allen heads as indicated in Figure 12.

9. Disassemble and clean the head front's bearings and slides.

The head front contains the mechanism that automatically compensates the mechanical tube length when the interpupillary distance is changed. When the eyepiece slides are moved horizontally on their greased dovetail rails two levers transfer the slides' lateral movement into a corresponding horizontal back-and-forth movement of the horizontal slide (Figure 18) that is attached to the head base (Figure 10.) This maintains the mechanical tube length, because with the horizontal slide firmly attached to the head base, the entire head front is made to move inward by the same amount as the interpupillary distance change is increased, and vice versa.

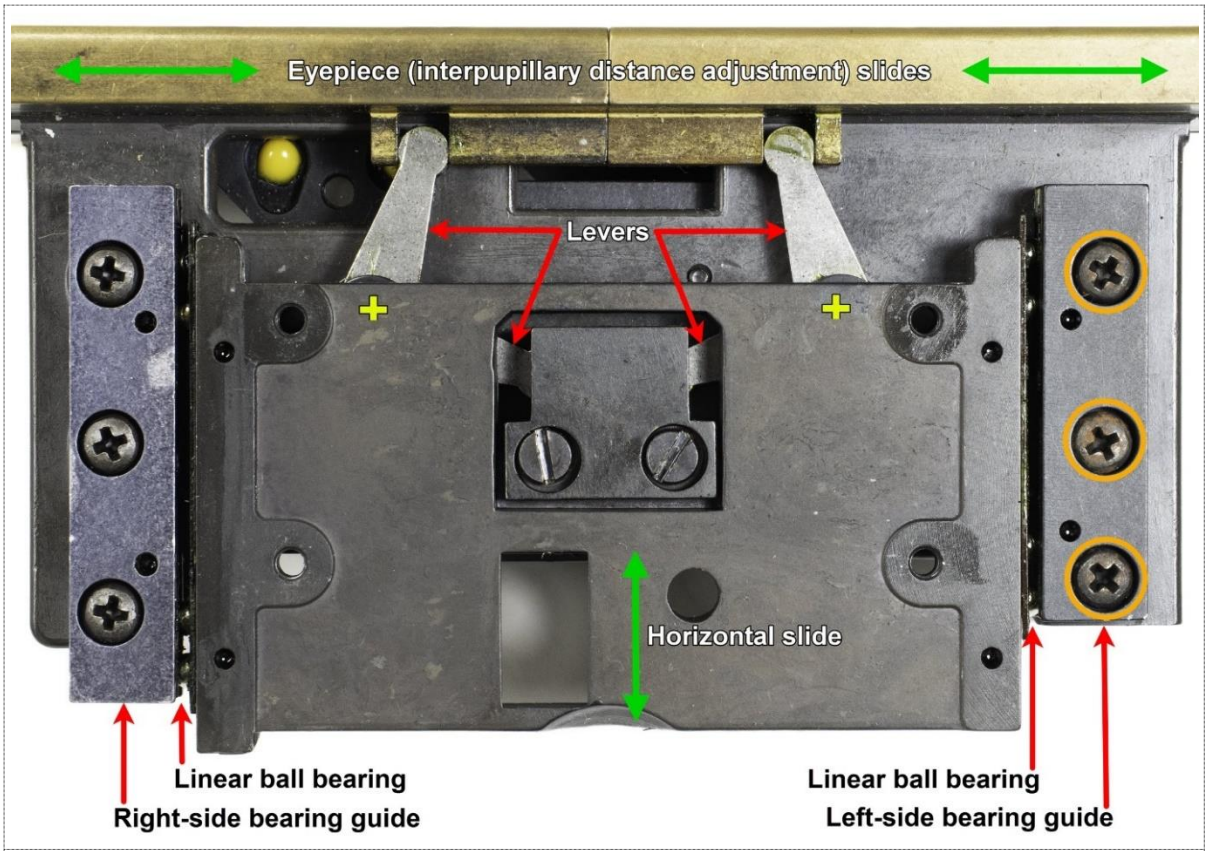

Figure 18: The removed beam splitter module viewed from above.

The double-sided green arrows indicate the movements of the slides. The yellow crosses indicate the location of the two levers' pivot points.

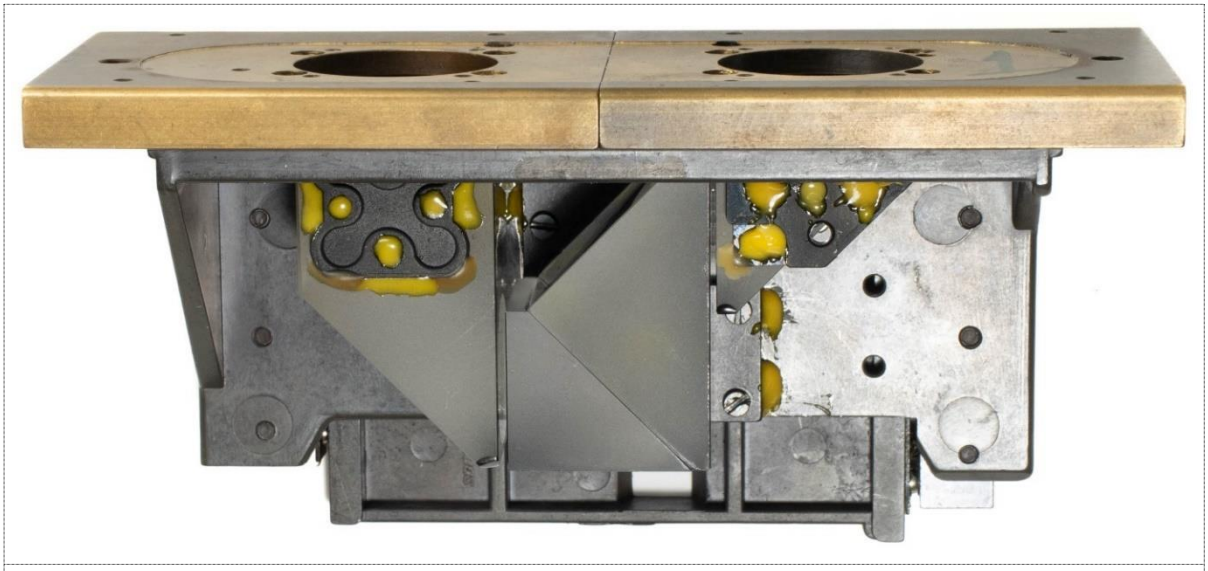

Figure 19: The removed beam splitter module viewed from below.

The dominating cause of the eyepiece slides' sluggishness is aged grease in their sliding surfaces (Figure 20.) The grease in the ball bearings is also similarly aged, but ball bearings are typically much less susceptible to stiff grease than friction slides.

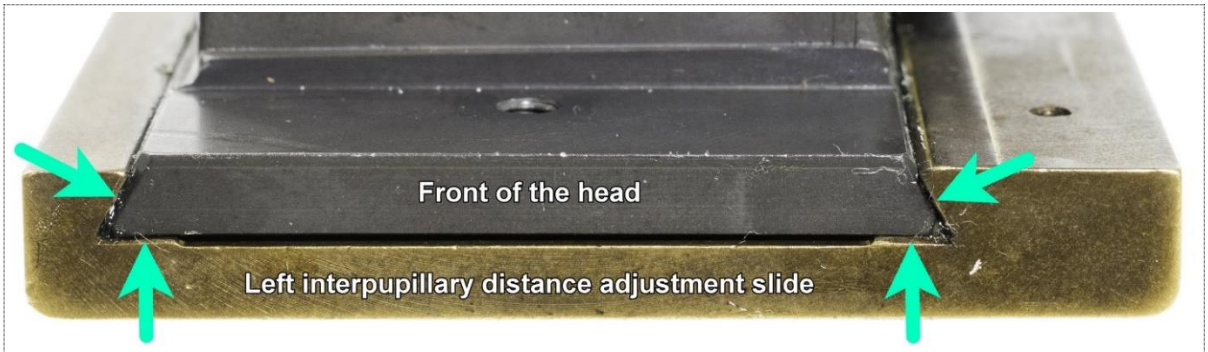

Figure 20: The end of the left eyepiece (interpupillary distance adjustment) slide.
The green arrows point to the slide's sliding surfaces.

To properly clean and regrease the eyepiece slides they need to be removed from the head front, which requires that the eyepiece prisms (Figure 11) first must be removed. This is unfortunate, because proper prism alignment (collimation) is essential for a well functioning microscope head, and anyone who removes the prisms need to be able to put them back again without jeopardizing their alignment. The screw head holes (four for each prism) in the eyepiece slides are slightly wider than the screw heads (Figure 21) which provides an opportunity for an expert to fine tune the prism alignment but also leaves it open for misalignment by an amateur like myself.

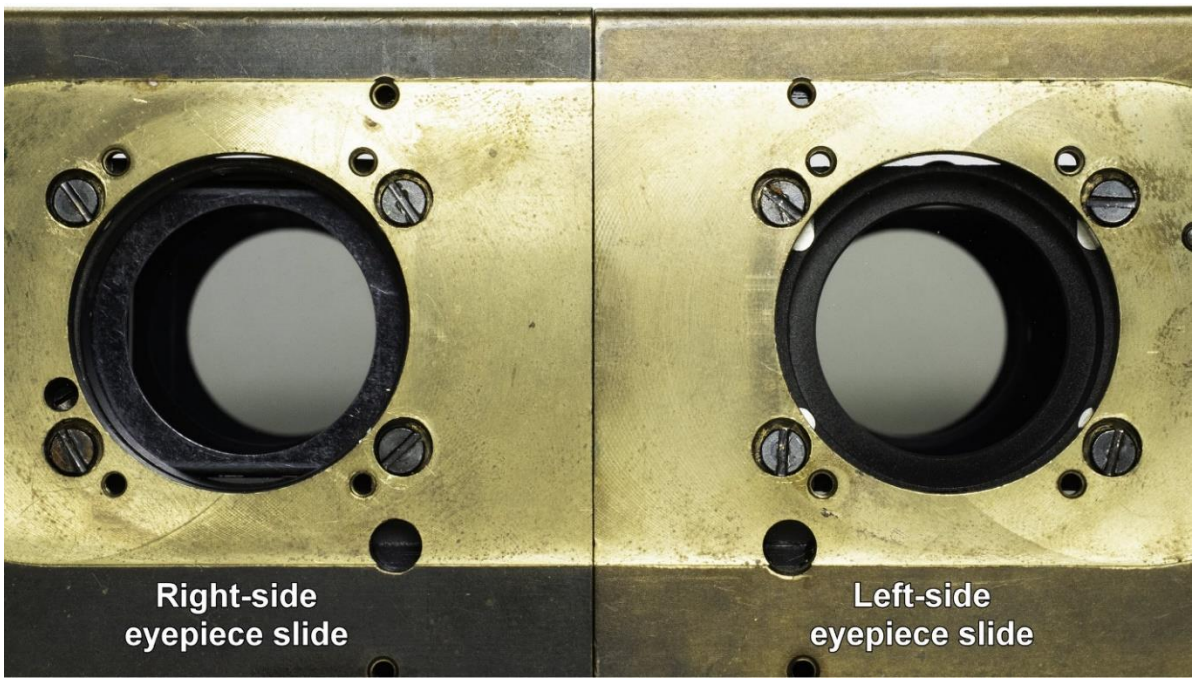

Figure 21: The eyepiece slides showing the 4 + 4 screws that attach the prisms to the backside of the slides. The head is here turned upside down to have the eyepiece prisms accessible from above. Notice how the screw heads are positioned in the screw holes.

To fix sluggish eyepiece slides without removing the prisms I could imagine two approaches:

1) Treating the slides with penetrating oil. One often hears success stories where some sluggish or frozen parts have been released with penetrating oil. I doubt however that it is a reliable solution for the eyepiece slides. Penetrating oil consists mainly of oil dissolved in some white spirit type of solvent. The solvent part will dissolve the old, stiff grease and make everything to move smoothly initially, but sooner or later the solvent evaporates, and the item gets sluggish again. Another issue is that it appears very difficult and perhaps impossible to try to treat the eyepiece slides with penetrating oil without having any of it contaminating the prism surfaces.
2) Cleaning and regreasing only the short lengths of the slides that become accessible with the slides in their regular outer and inner interpupillary distance positions, followed by moving the slides back and forth several times to distribute the grease. I tried this, and unsurprisingly it didn't work. The was no perceptible improvement.

Conclusion: Removing the prisms can't be avoided, and instead to our best ability we must focus on reattaching the prisms in a way that preserves their original alignment.

Therefore, before starting the work, document your head's initial eyepiece prism positions in the eyepiece slides by taking a photo of them as in Figure 21. Illuminate the eyepiece slides straight on to make the screw heads and the screw head holes to stand out. The photo will show the eyepiece prisms' original alignment in the up-down and sideways directions, and even more importantly, their rotational alignment. Looking at Figure 21 (for convenience, the head is put upside-down in the image) one can see that at manufacturing the prisms were not aligned with the screw heads exactly centered, they were left somewhat lopsided, presumably due to precise factory alignment. Later, when we replace our eyepiece prisms, we will aim to align them as similarly to this as possible.

Be sure to keep the head front's prisms safe and protected from dust and dirt all the time.

Push the eyepiece slides together as far as it goes. Note that once the horizontal slide has been removed the eyepiece slides are free to move sideways allowing the eyepiece prisms to collide with the sides of the head front or with the beam splitting prism in the middle. This should be avoided, as it may make the prisms misaligned in their holders or even damage them.

We will start by removing the horizontal slide with its levers and bearings (Figure 18.) Loosen the three M3x10 Philips screws (indicated with orange circles in Figure 18) from the left-side bearing guide, i.e., the shorter of the guides. Don't remove the taller right-side bearing guide; by leaving it where it is, it will help with the alignment of the horizontal slide during the reassembly. Remove the now released horizontal slide (Figure 23) from the right-side guide and retrieve all loose bearing parts (besides the left bearing guide, also the 4 + 4 steel bearing balls (3.5 mm diameter) and both bearing retainers) from both bearings (Figure 22.) The receiving groove for the levers (Figure 23) is attached to the slide with two screws – there is however no need to remove it.

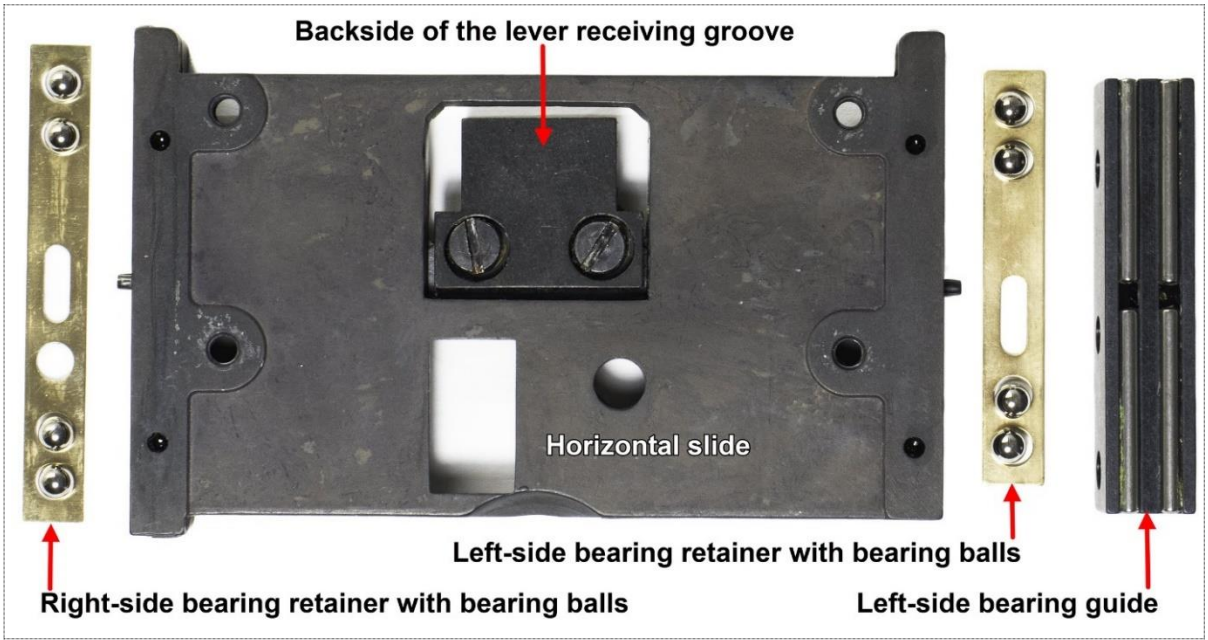

Figure 22: The bearing parts after removal from the horizontal slide. View from above.

The right-side bearing guide (the longer one) is not included here because it was left attached on the backside of the head front.

The parts in the image are, from the left to the right:

- *Right-side bearing retainer, brass. It is the taller one of the two retainers. Although it has a fifth (empty) hole, it is symmetric. Four 3.5 mm steel bearing balls are placed in the holes as indicated in the image.*
- *Horizontal slide. Both sides of the slide have races for the two bearings.*
- *Left-side bearing retainer, brass. It is the shorter one of the two retainers. It is not symmetric, so it is important that it is reattached turned in the correct way. Four 3.5 mm steel bearing balls are placed in the holes as indicated in the image.*
- *Left-side bearing guide. It's turned with the bearing race facing up – the four race rods (a.k.a. "needles" or "wires") are permanently attached in grooves in the guide.*

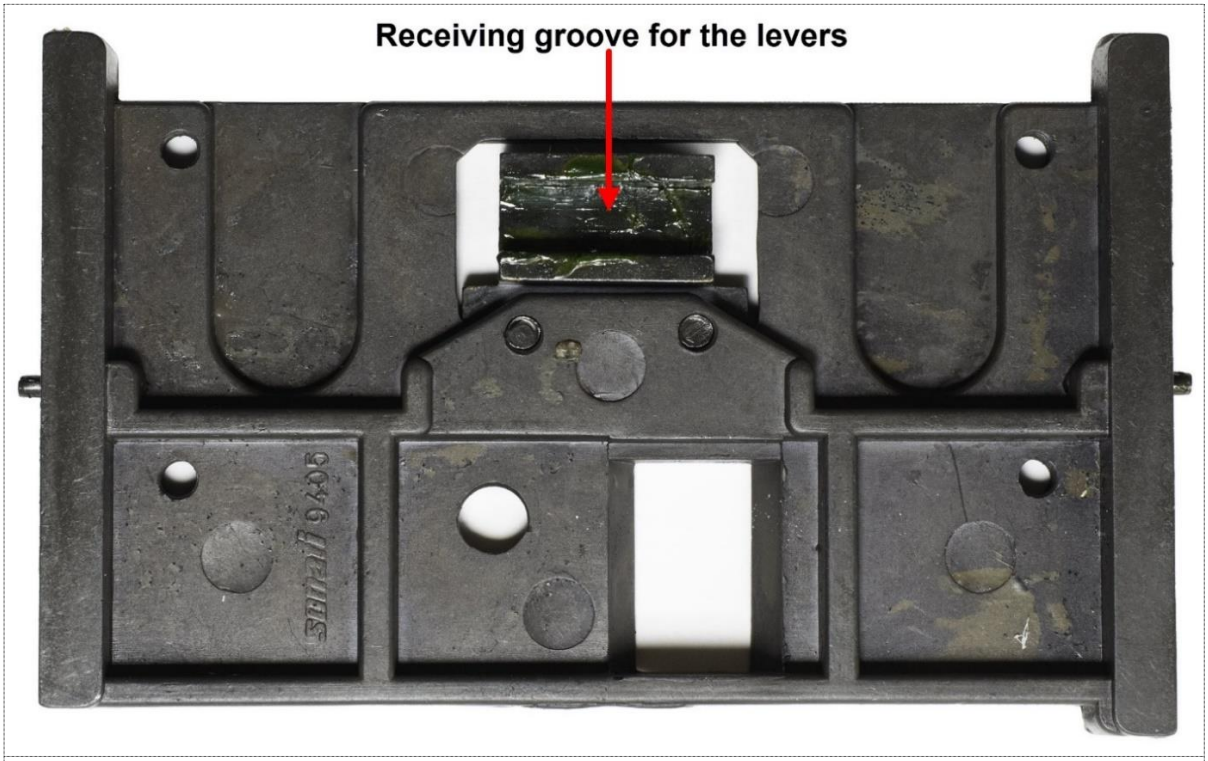

Figure 23: The underside of the horizontal slide. The receiving groove is where the levers push the slide. The purpose of the small pins on the sides of the slide is to keep the bearing retainers constrained within the bearings.

Pry off the E-clips from the pivot screws of both levers (Figure 24) and remove the transparent plastic washers (o.d. 8.0 mm, i.d. 5.1 mm, thickness 0.5 mm) that sit over the levers. Carefully lift off the levers from the pivot screws - this may be somewhat difficult as the levers are constrained by the pivot screws and the notches in the eyepiece slides. The levers are symmetrical so there is no need to remember exactly how they were attached. Remove the transparent plastic washers below the levers. Don't remove the pivot screws from the horizontal slide.

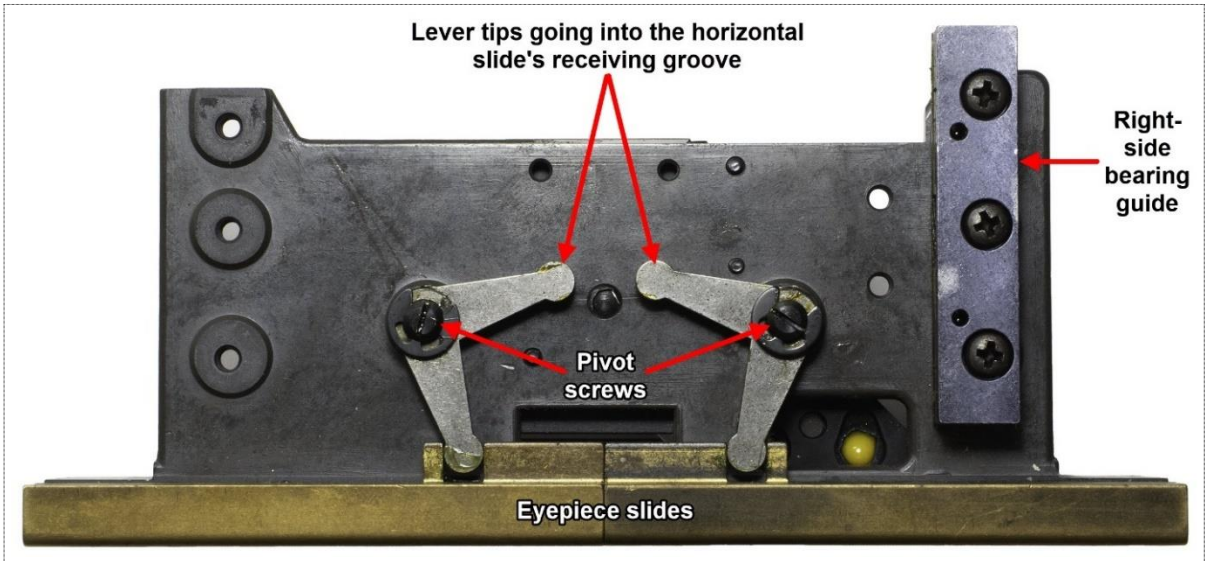

Figure 24: The head front viewed from above after the left-side bearing guide and the horizontal slide have been removed.

Use white spirit and pieces of cloth or cotton swabs to thoroughly clean off any old grease from all parts, including the horizontal slide with its still attached right-side bearing guide, receiving groove, and pivot screws. Not all of the old grease will dissolve in the solvent, so you will also need to scrape it off. Wooden, pointed toothpicks are very useful for this. The brass bearing retainers tend to be very tarnished by reaction with the old grease but can be tidied up by rubbing with a suitable metal polish (like Autosol or Peek.) Allow the cleaned parts to dry in the air.

Now over to the eyepiece slides. Wear disposable nitrile rubber gloves (at least on the one hand by which you will hold the prisms) in preparation for handling the eyepiece prisms. With the gloved hand hold on to one of the eyepiece prisms (including the sheet metal structure that is glued to it with the yellow cement that can be seen in Figure 25) while unscrewing the four M2x6 screws that attach it to the eyepiece slide (Figure 21.) Carefully remove the prism and put it in a clean and safe space for temporary storage. Repeat with the other prism.

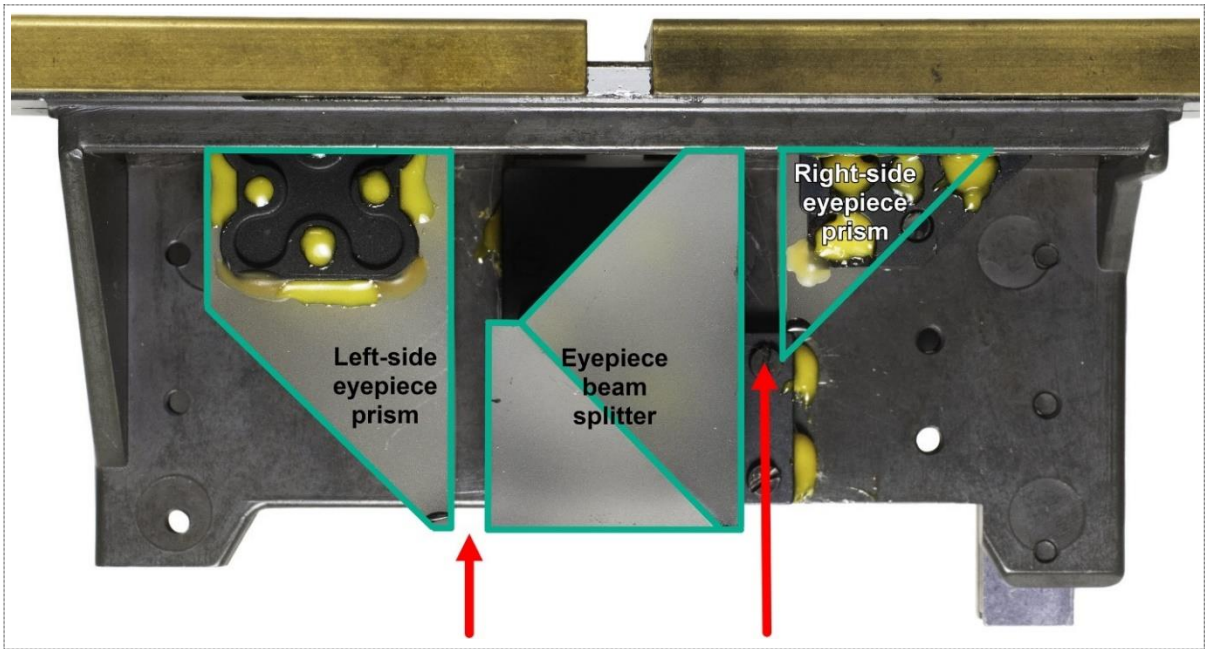

Figure 25: The head front viewed from below. The prisms are outlined with green lines. The red arrows point to the voids between the prisms where the adjacent surfaces are supposed to be exactly parallel.

Remove the M2x3 stop screw from the inside of the left eye-piece shield (Figure 27) and pull off both eyepiece slides sideways from the head front. Retrieve the leaf springs from the head front's lower slide (Figure 26 and Figure 28.) Use white spirit to thoroughly clean off all old grease from the leaf springs and all sliding surfaces including the grooves where the leaf springs were sitting. Make sure to also remove any solid grease residues that didn't dissolve and may stick and hide in the corners of the slides.

Figure 26: Closeup of one of the leaf springs in the head front's lower slide.

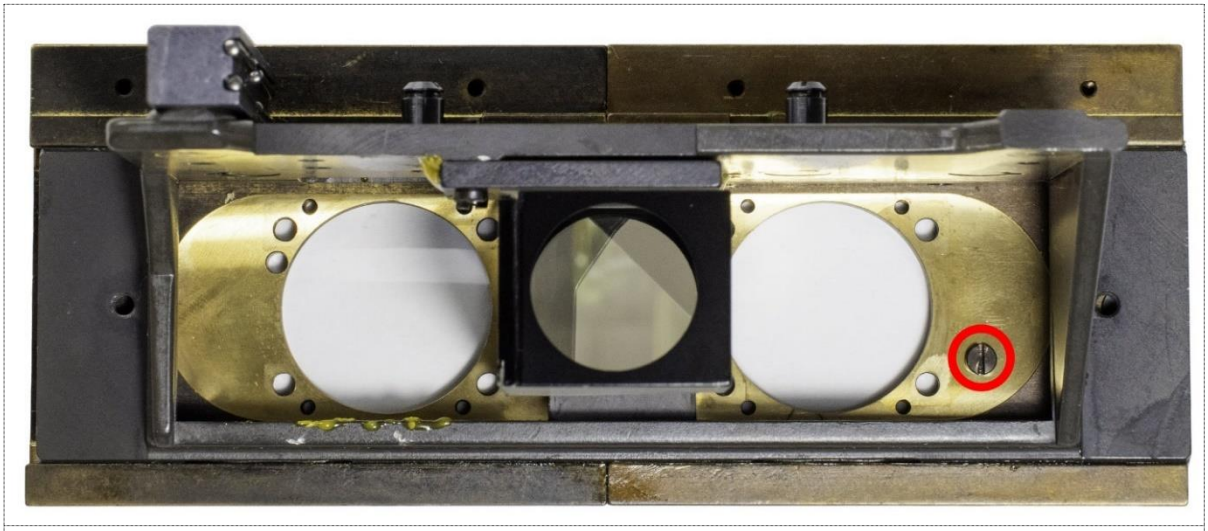

Figure 27: The head front viewed from the backside after the eyepiece prisms have been removed. Only the eyepiece beam splitter prisms (in the center of the image) are left attached.

The red circle indicates the stop screw that sets the limit for how far outwards the eyepiece slides can move.

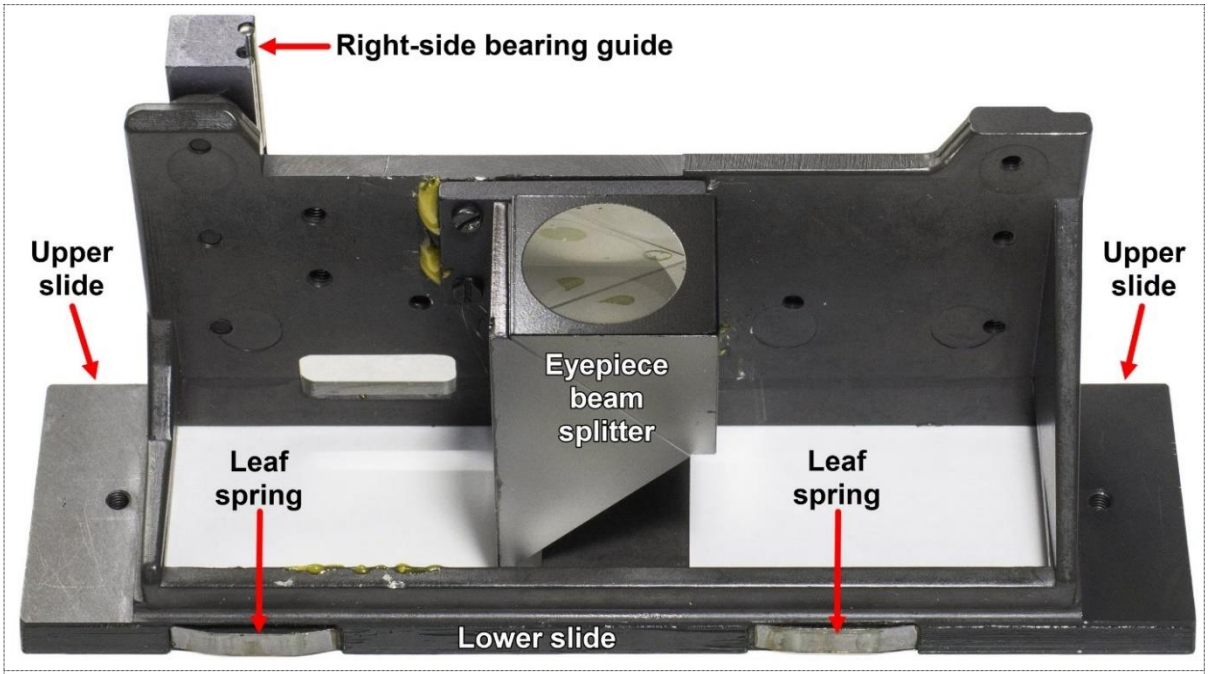

Figure 28: The head front viewed obliquely from the backside after the eyepiece slides have been removed.

10. Grease and reassemble the eyepiece slides and the eyepiece prisms to the head front.

Grease the sliding surfaces of the eyepiece slides and the head front. Also grease the leaf springs and reattach them to their grooves in the head front's lower slide (Figure 28.) Use any good quality grease with a suitable viscosity (for example, Super Lube Multi-Purpose Synthetic Grease with Syncolon, NLGI grade 2.) Attach the eyepiece slides and move them back and forth a couple of times to distribute the grease. Push the slides together so they are centered on the head front. Thoroughly wipe off any excess grease. Reattach the M2x3 stop screw to the inside of the left eyepiece shield. Move the eyepiece slides somewhat apart from each other.

Inspect the optical surfaces of the eyepiece prisms for dust or dirt, and, if applicable, clean them with your preferred lens cleaning protocol.

Using a gloved hand attach the eyepiece prisms to the backsides of the eyepiece slides with the M2x6 screws. Don't confuse the right prism with the left prism (Figure 25.) With the help of the photo (similar to Figure 21) that you took before the prisms were removed do your best to position the screws in the shields' screw holes to appear as similarly as possible to how they originally were. Tighten the screws moderately.

11. Grease and reassemble the horizontal slide with its ball bearings to the head front.

Put the head front on the table with the bearing side up (as in Figure 24) using some support to avoid that it rests on the prisms.

Lightly grease one side of the transparent plastic washers and attach them over the pivot screws with the greased sides facing down.

Lightly grease the hole in the middle of the levers, a few mm of the nearest surfaces around the holes where the plastic washers will sit (on both siders of the levers) and on the sides of one of the rounded lever tips (Figure 29.)

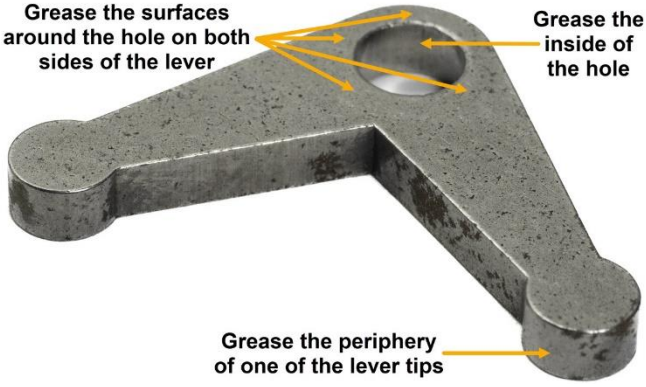

Figure 29: One of the levers showing where it should be greased.

Attach the levers over the pivot screws with the greased tips in the grooves on the backsides of the eyepiece slides (Figure 24.) The fit is tight, so you may need to move the slides slightly and carefully back and forth to get the levers all the way down over the pivot screws.

Lightly grease one side of the transparent plastic washers and attach them over the pivot screws on the levers with the greased sides facing up.

Attach the E-clips in the pivot screws' grooves.

Now you need to decide whether you wish to grease the horizontal slide's linear ball bearings, or not. I don't think it is a critical decision, but it may be easier to assemble the horizontal slide and the ball bearings if they are greased. I choose anyway to keep the ball bearings ungreased.

Carefully move the eyepiece shields together so they are centered on the head front as in Figure 24. The levers should now be symmetric, which makes it easier to attach the horizontal slide.

Grease the inside of the receiving groove in the horizontal slide (Figure 23) – it should be greased even if you decided to keep the bearings ungreased.

Prop up the head front and fix it in a vertical position with its attached right-side bearing guide at the bottom. Tilt it slightly backward to prevent that the horizontal slide and the bearing components fall off. An adjustable vise with rubber protection over the jaws is ideal (as in Figure 30), but a stable

setup can be arranged in other ways. Three important aspects: The setup must be stable, the bearings should be positioned horizontally, and the prisms must be protected from fingerprints, grease, or any other contamination.

If you decided to grease your ball bearings, apply some grease now on all four bearing races.

Place the longer of the two bearing retainers (Figure 22) over the upward facing bearing race on the right-side ball bearing guide (Figure 30.) Use forceps to put four bearing balls into the four outermost retainer holes (as in Figure 22.)

Attach the horizontal slide over the bearing. Make sure to have it correctly turned as indicated in Figure 30, and let the small pin on its lower race go into the long hole in the middle of the retainer. Hold the horizontal slide steadily attached over the assembled bearing and push it inward against the head front to get the two free lever tips to snap into the receiving groove (Figure 23) on the backside of the slide. Fitting it may require some slight movements of the horizontal slide and of the two eyepiece slides. Peek between the horizontal slide and the head front to verify that the lever tips really are seated in the groove.

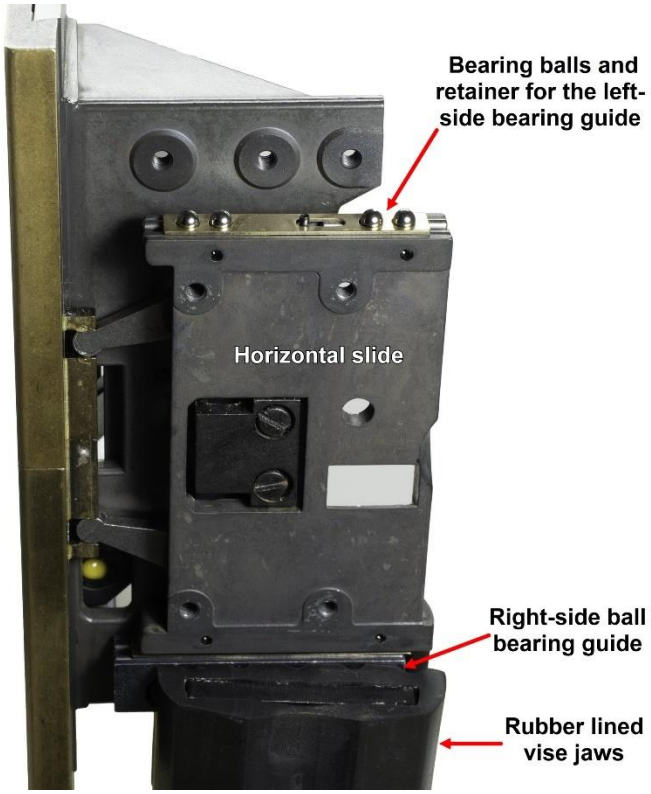

Figure 30: The head front held in a vise during reassembly of the horizontal slide with its ball bearings.

Place the short retainer on the upward facing race of the horizontal slide. This retainer is not symmetric, so make sure to turn it correctly as indicated in Figure 22 and Figure 30. The retainers long hole should go over the small pin in the middle of the race. Use forceps to put the remaining four bearing balls into the retainer holes.

Attach the left-side bearing guide over the bearing, but make sure to have it turned correctly. Attach and screw down the three M3x10 Philips screws as far as they go, but don't tighten them yet; release them just enough so the guide can be moved sideways as allowed by the play in the screw holes. Press the guide very firmly with your fingers against the horizontal slide and the right-side bearing guide below and successively tighten the screws to lock in the left-side guide. Leave the screws well tightened.

Check that the interpupillary distance adjustment works satisfactorily by moving the eyepiece slides; check that both eyepiece slides move in sync together with the horizontal slide, as expected.

Attach the front shell to the head front using its two metal washers and two M3x4.5 Philips screws (Figure 11.)

12. Reassemble the head (except the eyepiece tubes.)

Push the eyepiece slides together so they meet in the middle.

Push the head front (with the diopter adjustment mechanism) into the head base (with eyepiece/phototube beam splitter) and attach it with the four M3x6 screws (Figure 10.) Tighten the screws.

Attach the plastic head cover over the head base. Use the two M2.5x6 Philips screws on each side of the cover and the two Philips screws in the bottom of the head base.

Attach the phototube using its four M3x8 Philips screws. Attach it with the clamping knob in the same direction as in Figure 1. The screws are unfortunately very close to the inner wall of the phototube, so having a screwdriver with a very narrow shank will help a lot. Keep the microscope head with its side on the table and the phototube facing sideways – if you drop a screw, it will not fall down into the head.

With your fingers turn the beam splitter knob axle (Figure 13) fully clockwise. Attach the beam splitter knob with the "↑" symbol facing towards the front. Push it all the way down over the axle.

Attach both eyepiece tubes, each with four M2x5 Philips screws as in Figure 6. Screw down the screws all the way but don't yet tighten them.

13. Perform an eyepiece collimation.

Perform an eyepiece collimation as per the current version of the maintenance notes Eyepiece Collimation of Leitz 160 mm Microscopes. The collimation is an adjustment of the head's eyepiece tubes to ensure that their optical paths overlap. Good collimation is important to avoid microscope user fatigue and even double vision.

After adjusted eyepiece collimation, conclude the work by attaching the eyepiece shields (Figure 1) over the eyepiece tubes using four M2x8 Philips screws for each shield. Attach first the left shield (the one with the interpupillary distance scale) and then the right shield.