Leitz Ortholux Focus Mechanism (pre-1953) Maintenance Notes

The “black era” Leitz Ortholux microscopes were manufactured from approx. 1937 to 1974. Although all Ortholux microscopes (except the later Ortholux II) look similar from the outside, Leitz’ ongoing product development/improvement efforts led to several design differences through the years. Of particular interest for these maintenance notes is that the focus mechanism underwent a significant change in 1953. When viewed from the outside there are two differences (Figure 1 and Figure 2):

1. The focus lock. Pre-1953 the coarse focus can be locked by a lateral clamp, while post-1953 has a locking lever directly on the course focus control.
2. The mechanism for counterbalancing the weight of the stage. Pre-1953 the microscope uses a torsion spring with an adjustment nut covered by a cap, post-1953 there are two internal compression springs without any external adjustment facility.

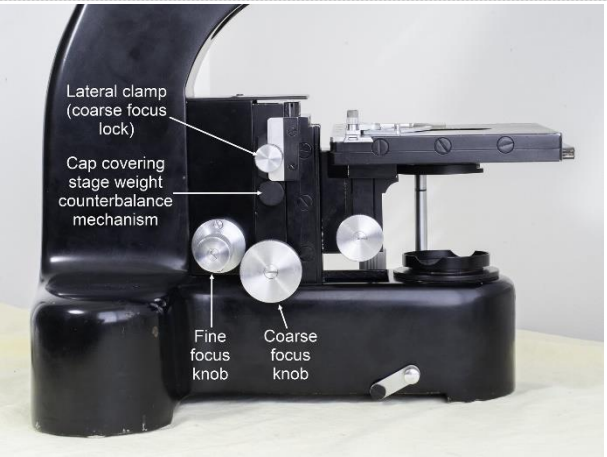

Figure 1: Leitz Ortholux pre-1953; view of the microscope’s left side.

Figure 2: Leitz Ortholux post-1953; view of the microscope’s left side.

These maintenance notes cover only the pre-1953 Ortholux focus mechanism. More specifically, the notes describe the disassembly, cleaning, greasing and reassembly of the focus mechanism of a 1947 Ortholux microscope.

Grease

I don’t have any special insights about lubrication but have with the layman’s naive confidence chosen to use Mobilgrease 28 throughout for the focusing mechanism. Please feel free to choose differently.

Control knobs

Control knobs for coarse and fine focus, stage movement, condenser height, etc., are in the Leitz black era microscopes usually made of nickel or chromium plated brass. After many years of service, the knurled circumferences of these knobs have often caught and accumulated dirt, sweat and fat from the user’s fingers. After the knobs have been removed, they can be cleaned by soaking in warm water with

dishwashing detergent and brushing along the grooves with a hard toothbrush. It the knobs are still attached to the microscopes cleaning becomes more difficult but can be accomplished by wrapping the knob circumferences in cloth strips wetted with water and detergent, and subsequent brushing in the direction away from the microscope. Never use a steel brush to clean these knobs - the plating is sensitive to scratches.

Focus Mechanism Introduction

The Leitz Ortholux focus mechanism can be divided into three functional units, the fine focus block, the coarse focus block, and the stage (Figure 3.)

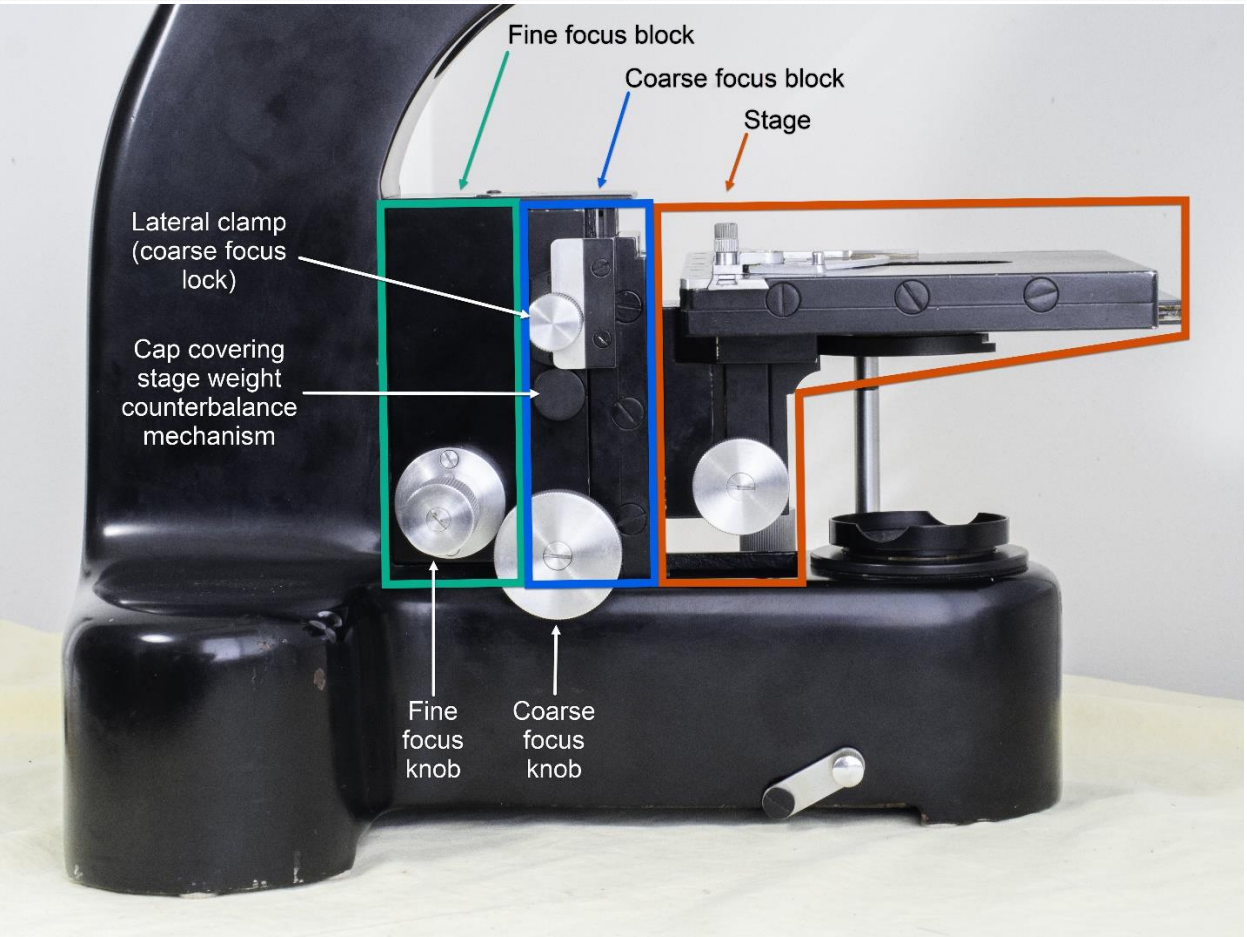

Figure 3: Leitz Ortholux microscope from 1947 (left side view).

The fine focus block is attached by four screws to the microscope stand. The fine focus has a range of approximately 2.8 mm covered by 27 revolutions of the fine focus control. The fine focus block contains the controls (the fine focus knobs), the mechanism for the fine focus (a worm gear connected to a cam wheel that determines the up-and-down movement) and a slide with four linear ball bearings relaying the fine focus movement to the next unit, the coarse focus block.

The coarse focus block (Figure 3 and Figure 4) contains the controls (knobs), the coarse focus mechanisms (a rack and pinion drive and a torsion spring to counterbalance the weight of the stage) and another slide with two linear ball bearings that relay the coarse focus movement to the stage. The

coarse focus block also has an adjustable counterbalance mechanism for the weight of the stage and an external lateral clamp for locking of the coarse focus.

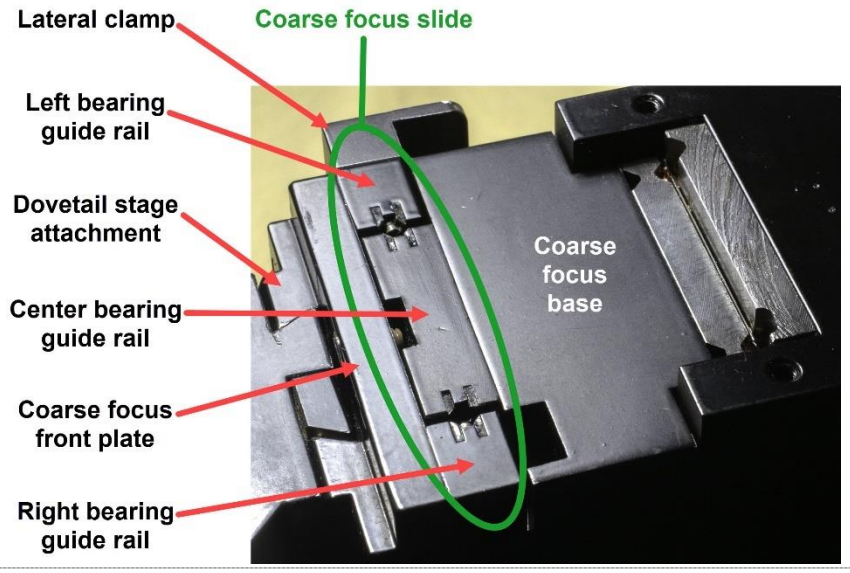

Figure 4: Coarse focus block viewed from above. The ends of the linear bearings are visible between the bearing guides.

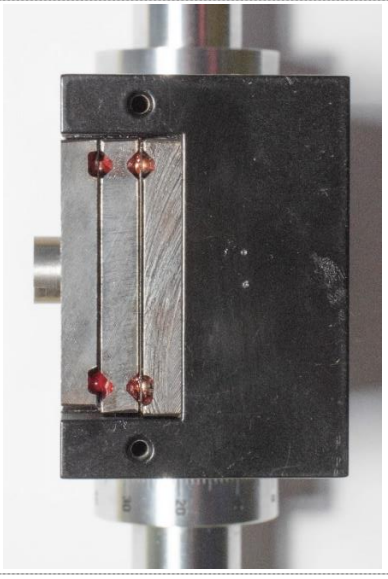

Figure 5: Fine focus block viewed from above.

The stage is attached the stage holder which is attached to the coarse focus block by a dovetail mount, and then the condenser is attached to the stage holder with another dovetail mount. Above the left coarse focus knob is a lateral clamp which can be used to temporarily lock the coarse focus. On both sides above the coarse focus knobs are caps covering the control for tension adjustment of the torsion spring that counterbalances the weight of the stage.

Microscopes have various types of bearings depending on the function requirements. A common characteristic of microscope ball bearings is that they are not subject to hard wear under heavy loads, instead their purpose is to allow for smooth and precise movements with no or minimal play. On the Ortholux microscope both the coarse and fine focus slides move on linear ball bearings (Figure 7). The slide of the coarse focus block runs on two linear ball bearings, while the slide of the fine focus block moves on four linear ball bearings. Both fine focus knobs rotate against thrust ball bearings (Figure 6). Additionally, there are a couple of plain bearings in less critical functions. Figure 6 and Figure 7 explain the ball bearing parts. Should you lose any of the bearing balls during the work, new balls of many different sizes can be purchased from Amazon and other vendors.

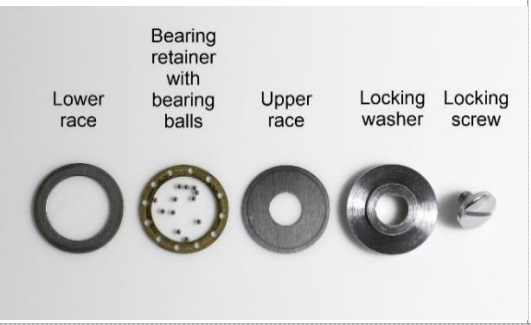

Figure 6: The parts of a thrust ball bearing.

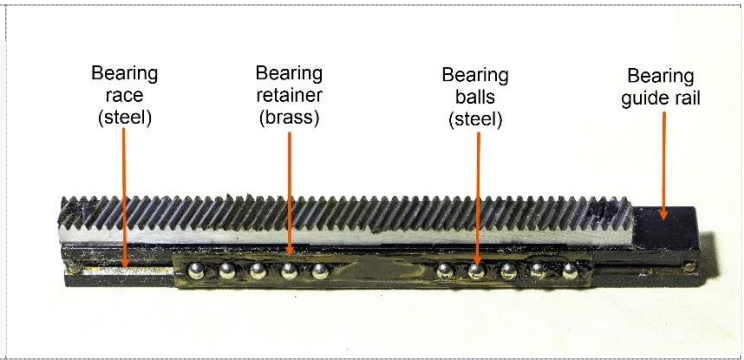

Figure 7: The parts of a linear ball bearing (only one of the races is shown).

Prepare the microscope for the work

Remove the following parts from the microscope stand: Lamp, objectives, nosepiece, head with eyepieces, condenser, and the entire stage.

Remove the lateral clamp from the left side of the coarse focus block. It consists of two parts (Figure 8) attached with 2 + 2 screws on the left side of the coarse focus block.

The “Leitz” name plate with the microscope’s serial number sitting above the focus assembly may also be removed to provide more space, although it is not really in the way.

If you sit in front of the microscope, you are now facing the front plate of the coarse focus block (Figure 9).

Figure 8: The lateral clamp (at the top) and the clamp disc (at the bottom) removed from the left side of the coarse focus block.

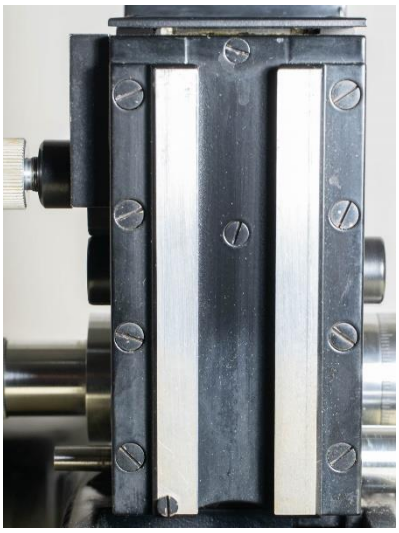

Figure 9: The front plate of the coarse focus block. (The left coarse focus knob has been removed in this image.)

Figure 10: The front plate after being removed from the coarse focus slide. Note on the left side the three large heads of the partially loosened lateral tension screws that determine the tightness applied across the bearings.

Disassemble, clean, and re-grease the coarse focus block

The coarse focus slide and the coarse focus block

Disassemble the coarse focus slide by removing the left bearing guide rail (Figure 12) which is attached behind the front plate. Loosen (only by 1-2 mm, don’t’ remove them) the three lateral tension screws with the large heads on the left side of the front plate and remove the four black screws facing you along the left side (Figure 10, Figure 11 and Figure 12; the figures show that both the left and the right guide rails have been removed; this is actually not necessary – it is sufficient to only remove the left guide rail.) The three lateral tension screws with the large heads determine the lateral pressure (“squeeze”) applied over the bearings. The four facing screws join and lock the left guide rail to the front plate. The coarse focus slide with its two bearings will now be accessible – be careful not to lose any of the bearing balls.

Figure 11: The front plate – oblique view of the back side and the left side.

Figure 12: The left and the right bearing guide rails showing the linear bearing races, the bearing retainers, and the balls. The rack attached to the right rail is part of the coarse focus rack and pinion mechanism.

Figure 13: The two linear bearing retainers, before and after polishing.

Proceed with a thorough cleaning of all moving parts of the entire coarse focus slide. Put the two bearing retainers and the bearing balls (there are 20 balls each 3.1 mm diameter) into a vial with a suitable petroleum-based solvent (e.g., “white spirit”.) Scrub with the solvent and a cloth or cotton swabs until all old grease has been removed. Wipe the bearing balls dry with a lint-free microfiber cloth (don’t use paper towels – they leave a lot of tiny paper fibers on the surface of the balls.)

Clean all four bearing races from old grease using solvent and cotton swabs. Note that the races can be cleaned with the right bearing guide rail still attached to the front plate (although the images show that the right guide rail has been removed.) Similarly, the races of the center bearing guide can be cleaned while still attached to the coarse focus base (Figure 14 and Figure 15.)

The bearing retainers are made of brass and may have ugly looking gray or black tarnished surfaces due to oxidation to copper(II)oxide. As long as the retainers are cleaned from old grease the tarnish should not impair their function, but it is conceivable that it may catalyze and accelerate the aging of any applied grease. If you wish to be thorough, it is not difficult to remove the tarnish by rubbing with a piece of cloth wetted with metal polish (e.g., Autosol Metal Polish), or by sandpapering using a very fine sandpaper. Be sure to wash the retainers thoroughly with warm water and dishwashing detergent to remove any traces of abrasive. Let the retainers dry completely before reassembly.

Remove the four long screws that attach the coarse focus base to the fine focus block (Figure 16.) With this we have reached the end of the coarse focus block. Having the coarse focus base separated from the microscope makes it much easier to work with the coarse focus control (knobs) and the coarse focus counterbalance mechanism.

Remove the center bearing guide from the coarse focus base (Figure 17 and Figure 18) – it is attached with two short screws.

Remove the fine focus buffer (Figure 19) from the microscope stage right below the coarse focus base. It is accessible from the underside of the microscope. (The purpose of the fine focus buffer is to relieve

some of the strain on the fine focus mechanism by providing some upwards directed force to counter the weight of the coarse focus block and the stage.)

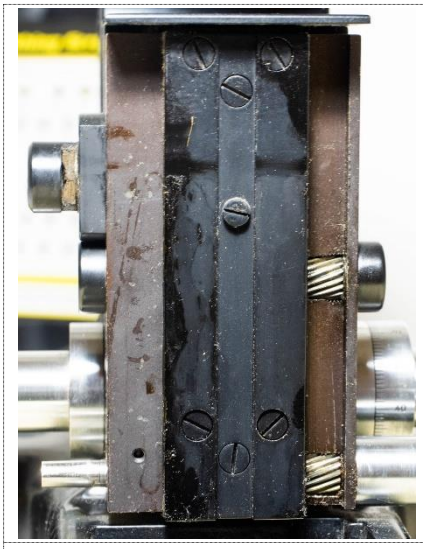

Figure 14: View of the coarse focus base after the front plate and the two bearing guide rails have been removed. The black part in the middle (with 7 screws) is the center bearing guide – its bearing races are not visible here because they face to the sides. The upper pinion (on the right side) belongs to the coarse focus counterbalance mechanism. The lower pinion is part of the coarse focus rack and pinion mechanism and is directly attached to the coarse focus knobs.

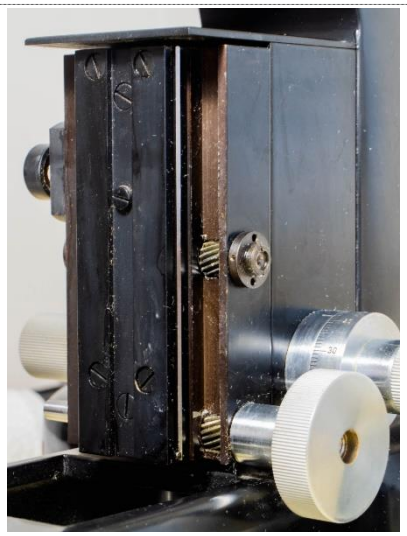

Figure 15: Another view of the coarse focus base, but turned to better show its right side. One can see the center bearing guide (with the 7 screws) with the right bearing race facing to the side. The cap covering the counterbalance mechanism has been removed.

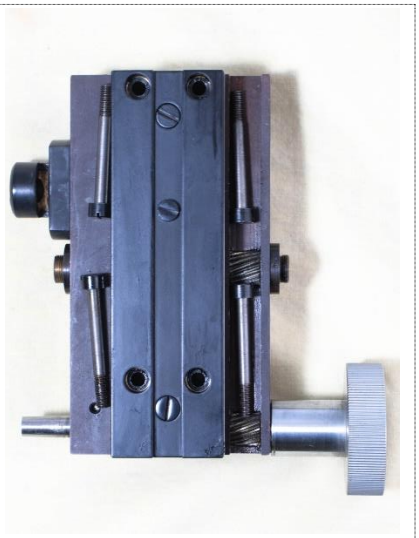

Figure 16: The coarse focus base (with the center bearing guide still attached) after removal from the fine focus block of the microscope. The attaching four long screws are included in the image. Note the empty screw holes for these screws.

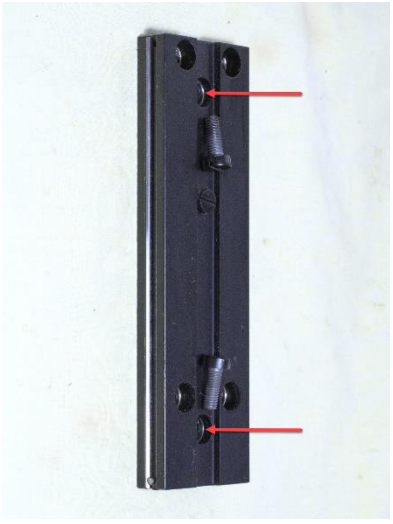

Figure 17: The center bearing guide after removal from the coarse focus base. The two attaching short screws are included in the image. The left bearing race is also visible here.

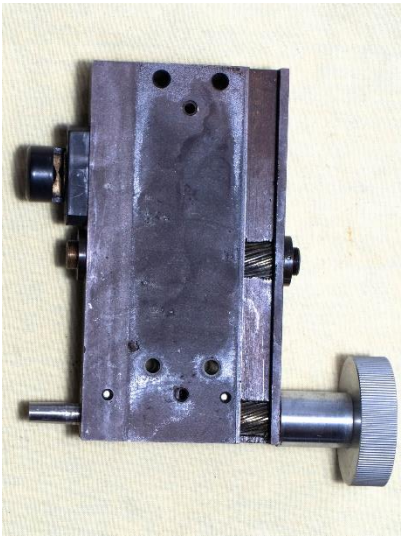

Figure 18: The coarse focus base after removal of the center bearing guide.

Figure 19: The fine focus buffer (picked apart) after removal from the microscope stand just below the coarse focus base.

The coarse focus counterbalance mechanism

The coarse focus counterbalance mechanism (Figure 18, in the middle of the coarse focus base) contains an adjustable torsion spring that compensates for the weight of the stage and condenser. It balances the coarse focus so the stage will move both up and down with the same smooth feeling and the same resistance.

To access the mechanism, remove the cover caps from each side of the coarse focus block. There you will find black spanner nuts that anchor the counterbalance mechanism. Before the spanner nut on the right side can be taken out two very small black locking screws (1.3 mm, you will need a 1.0-1.2 mm screwdriver) need to be loosened or removed (Figure 20.)

Removal of the spanner nuts requires a pin-face spanner (Figure 21) that fits the holes on the face of the spanner nuts (the holes are approx. 1.6-1.7 mm in diameter). It may be tempting to bypass the pin-face spanner and instead use some improvised tool, but this comes with a risk that the spanner nut holes get damaged. If the spanner nuts are difficult to unscrew, it helps to pre-treat them with penetrating oil (e.g., WD-40) for a few hours or days, and to heat them with an electric heat gun just before removal. Once accessed, clean all parts of the mechanism (Figure 22) with solvent. The axle has a cog wheel (pinion) which affects the same rack as the pinion of the coarse focus control. The axle sits inside of a torsion spring with axial legs at both ends. One of the legs fits into a hole in the cog wheel and the other leg fits into a hole in the plain bearing on the left side. Both sides of the axle are held by plain bearings, and the plain bearings are kept in place by the spanner nuts. The bearing on the left side can be rotated in ¼ turn increments to apply a suitable tension to the spring (but more about that later).

Figure 20: The spanner nut on the right side with the two tiny locking screws loosened.

Figure 21: Pin-face spanner – a special and useful tool for microscope service.

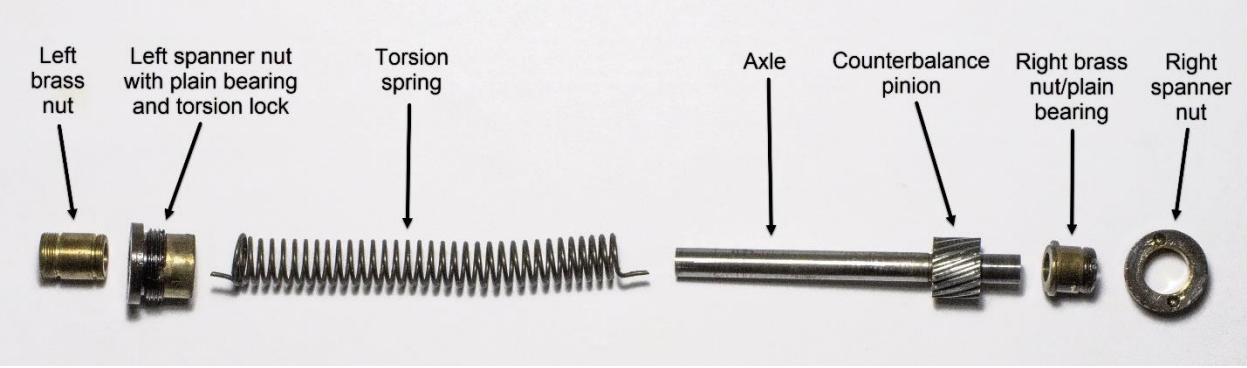

Figure 22: The coarse focus counterbalance mechanism taken apart. When assembled the axle is on the inside of the spring.

Figure 23: Close-up of the details on the left side of the coarse focus counterbalance mechanism. Note the tiny hole in the bearing where the left leg of the torsion spring will be inserted.

Figure 24: Close-up of the details on the right side of the coarse focus counterbalance mechanism. Note the tiny hole in the pinion where the right leg of the torsion spring will be inserted.

Figure 25: Close-up of the left spanner nut/bearing/torsion lock assembly. The two bulges on top of the bearing (to the left) will lock into square indentations on the backside of the spanner nut.

Figure 26: Same parts as in Figure 25 but here turned upside-down. Shows the four square indentations on the spanner backside (the part in the middle) which will lock to the bulges on the bearing.

Figure 27: A side view of the left spanner nut/bearing/torsion lock assembly. The short thread of the brass nut (the part in the middle) is screwed into the bearing/torsion lock.

Grease the torsion spring and all bearing surfaces. Reassemble the counterbalance mechanism taking care that the spring legs are properly inserted into the holes of the cog wheel and the left bearing (Figure 23 ,Figure 24 ,Figure 25 ,Figure 26 ,Figure 27). Attach and tighten the spanner nuts. Tighten (but not too much) the small locking screws on the periphery of the right spanner nut (Figure 20.)

The left brass nut that is screwed into the left bearing/torsion lock can be rotated to apply a suitable tension to the torsion spring, and then locked. The tension of the torsion spring will be adjusted later after the coarse focus block has been re-assembled.

The coarse focus control

The axle of the coarse focus control mechanism complete with the coarse focus knobs is accessible from the backside of the coarse focus base (Figure 18 and Figure 28.) Remove the long locking screws from the center of both coarse focus knobs. Holding the knobs in each hand, turn them in the opposite directions until one of them releases from the focus control axle. The remaining knob will be removed later. Note that the left and right knobs are different and should not be confused.

The axle assembly can now be removed from the coarse focus base by taking out two screws and releasing the covering clamp (Figure 29.) The diameter of the axle is 6.0 mm but tapers off to 5.5 mm at the ends where the knobs attach. The axle ends also have internal threads for the knob locking screws.

The knobs' center holes where the locking screws go are threaded on the inside. It seems that the idea was to use a suitable screw as a jack to remove the knobs from the axle. When I tried it out, an M4 screw appeared to fit into the knob threads, but there still was some play which made me unsure about the thread compatibility. I also felt unsure whether a regular screw could be used, or if a modified screw was required (like a screw with a somewhat thinner tip without threads.) So, to be safe, I took a different approach to remove the remaining knob from the axle. I put a few drops of penetrating oil (WD-40) into the knob's screw hole and let it sit. After a couple of days, I used a heat gun to heat the part of the knob where the axle was sitting, and then, holding to the knob, I put a steel rod into the screw hole and knocked lightly on the end of the rod with a small hammer. The knob released quite easily from the axle. The rod should have a diameter of 3.7-3.9 mm (4.0 mm would be too wide) and be at least 4 cm long. Suitable rods are available from Amazon, but I sacrificed a 5/32" drill bit where the blunt end fortunately had a diameter of 3.9 mm.

Figure 28: The coarse focus base. The left focus knob has been removed (on the right side in this image because the coarse focus base is here viewed from its backside).

Figure 29: The coarse focus base with the covering clamp and the coarse focus mechanism removed.

The figures above don't show all parts belonging to the axle, so here follows a list of the parts, ordered from the left knob to the right knob (the list is mirrored if compared with Figure 28 and Figure 29):

Locking screw for the left knob
Left knob (with an indent on the surface that faces the coarse focus base)
Transparent plastic washer
Two black metal washers (spring washers)
White plastic washer
Coarse focus axle (with the pinion close to its right side)
White plastic washer
Right knob (with a flat surface that faces the coarse focus base)
Locking screw for the right knob

Clean all parts with solvent. After drying, grease all sliding surfaces of the axle, the coarse focus base and the covering clamp. Attach the clamp with the two corresponding screws. Check that the axle rotates freely. Now grease all sliding surfaces and washers pertaining to both knobs. Assemble the right knob first using the following sequence, starting from the focus block: White plastic washer, the right knob (with a flat surface facing the focus block), locking screw. Tighten the locking screw. Then assemble the left-knob using the following sequence, starting from the focus block: White plastic washer, the two

black metal washers, the transparent plastic washer, the left knob (with an indented surface facing the focus block), locking screw. Tighten the locking screw.

Check that the axle with the knobs rotate freely. Check the axial play of the axle by pushing it back-and forth sideways. If there is significant play a suitable extra washer could be inserted together with any of the other knob washers.

Disassemble and clean the fine focus block

The fine focus slide

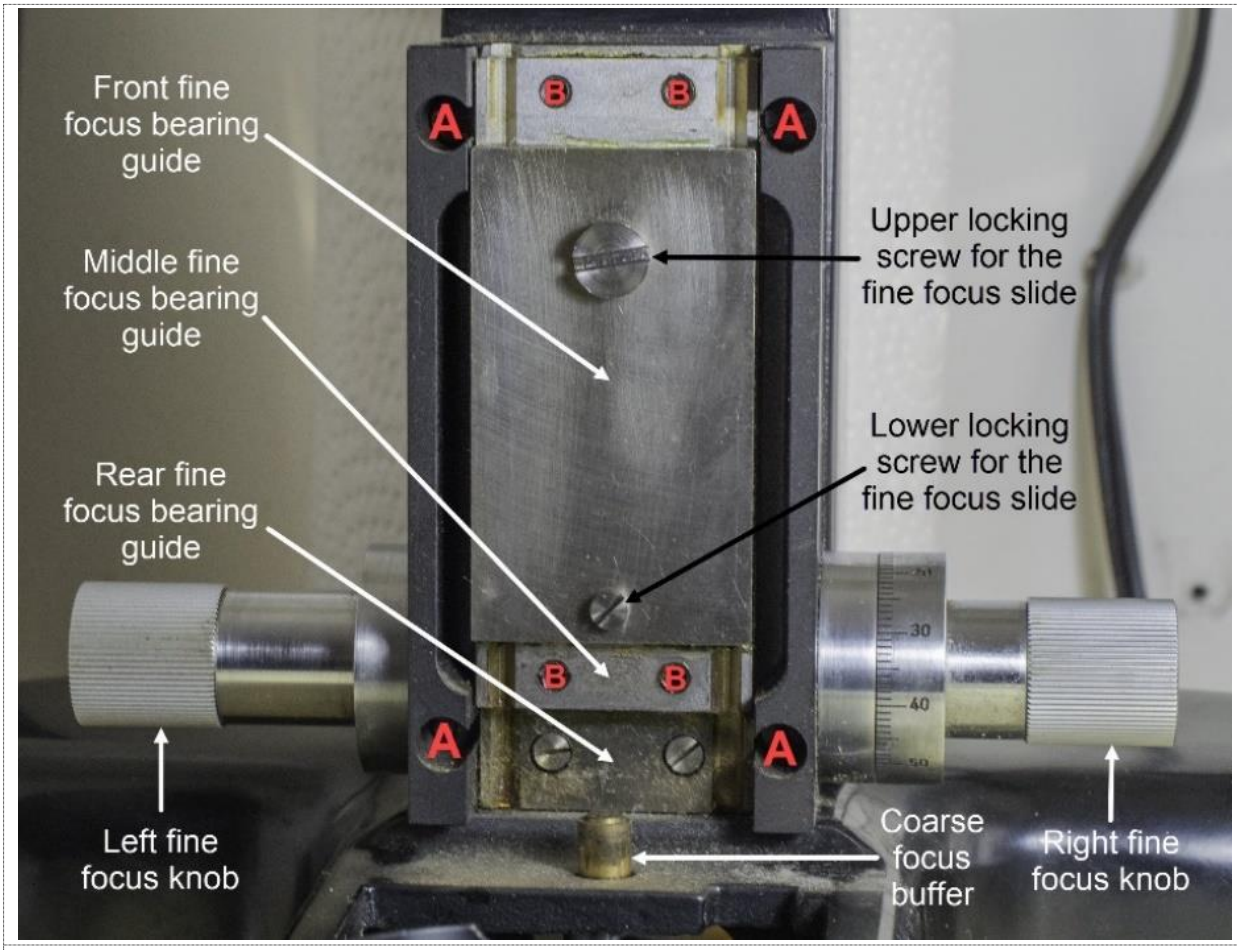

Figure 30: The fine focus block while still attached to the microscope stand (frontal view).

With the coarse focus block now out of the way we are facing the fine focus block (Figure 30.) The rear fine focus bearing guide and the front fine focus bearing guide are joined together and firmly attached to the fine focus block with the upper and lower locking screws. Between these guides the middle fine focus bearing guide is sandwiched supported by four linear ball bearings. The coarse focus block is firmly attached to the middle bearing guide by four screws going into the threaded screw holes tagged "B" in Figure 30. The middle bearing guide is the moving part of the fine focus slide; its vertical position is determined by the fine focus control and thus relayed to the entire coarse focus block including the stage.

Remove the four robust screws located below the tag "A" in Figure 30 and remove the fine focus block from the microscope stand.

Open up the fine focus slide by removing the two locking screws (upper and lower) for the fine focus slide (Figure 30.) Remove the front bearing guide taking care not to lose any of the now liberated bearing balls (Figure 31). You can now access the outer fine focus bearing. Collect the bearing balls (16 pcs with 3.2 mm diameter) and the brass bearing retainer and put them into a vial with a suitable petroleum-based solvent (e.g., "white spirit".) Also pick up and put aside the two standoffs which were accompanying the two locking screws. Note that the lower (small) standoff has a circular groove on one end – that end should face down towards the cam wheel axle.

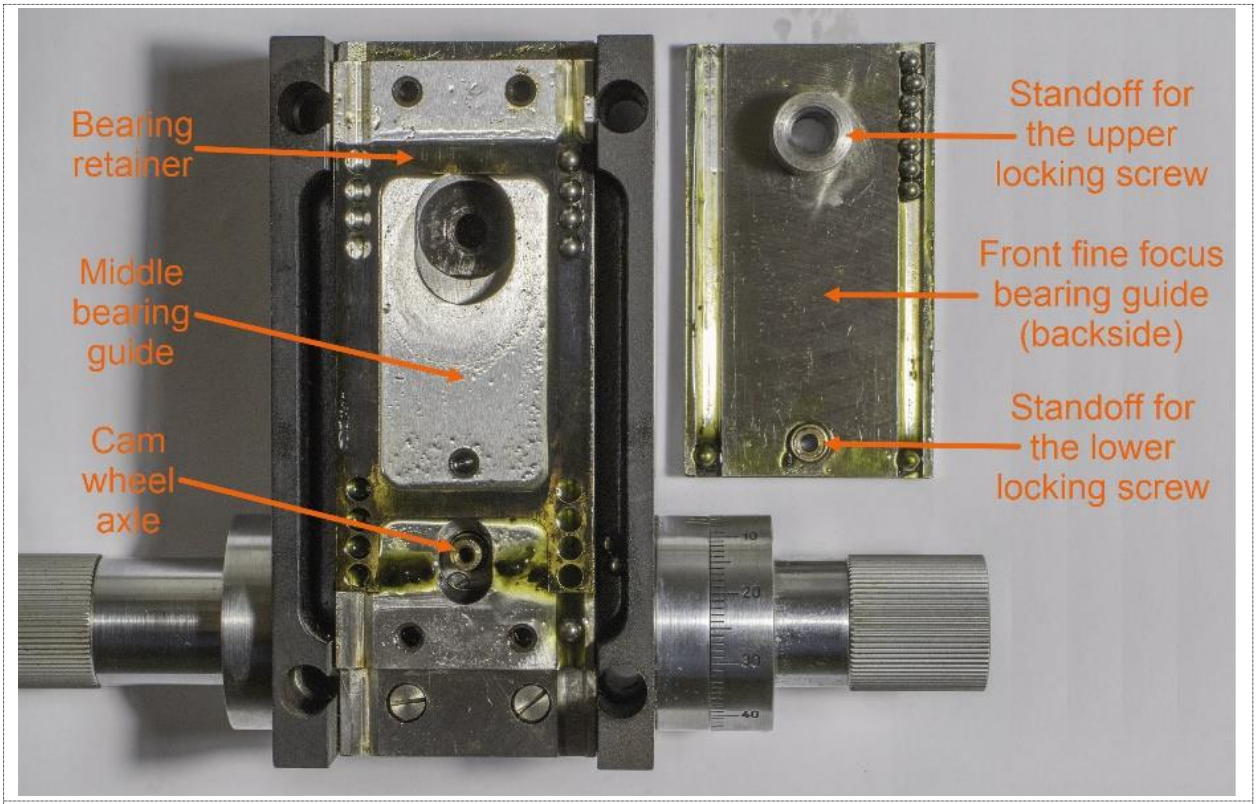

Figure 31: The fine focus block after removal from the microscope stand. The front bearing guide has also been removed and placed with its backside facing up. The revealed outer fine focus bearing is covered with accumulated dirt and old partly hardened grease.

Next remove the middle bearing guide, again taking care not to lose any bearing balls (Figure 32). This is the inner fine focus bearing. As before, collect the bearing balls (16 pcs with 3.3 mm diameter) and the brass bearing retainer and put them into another vial with a suitable petroleum-based solvent (e.g., "white spirit".) Be sure to keep the parts of the outer and inner bearings separate, as both the balls and the retainers are different.

Remove the follower wheel from the back side of the middle bearing guide (Figure 32.) It is attached by a special screw which also serves as a plain bearing allowing the wheel to rotate freely. The excentric cam wheel of the fine focus control pushes up against the follower wheel thus transferring the fine focus movement to the middle guide. The combined weight of the connected coarse focus block, the stage and the condenser ensure that the follower wheel always is snugly pressed down against the cam wheel.

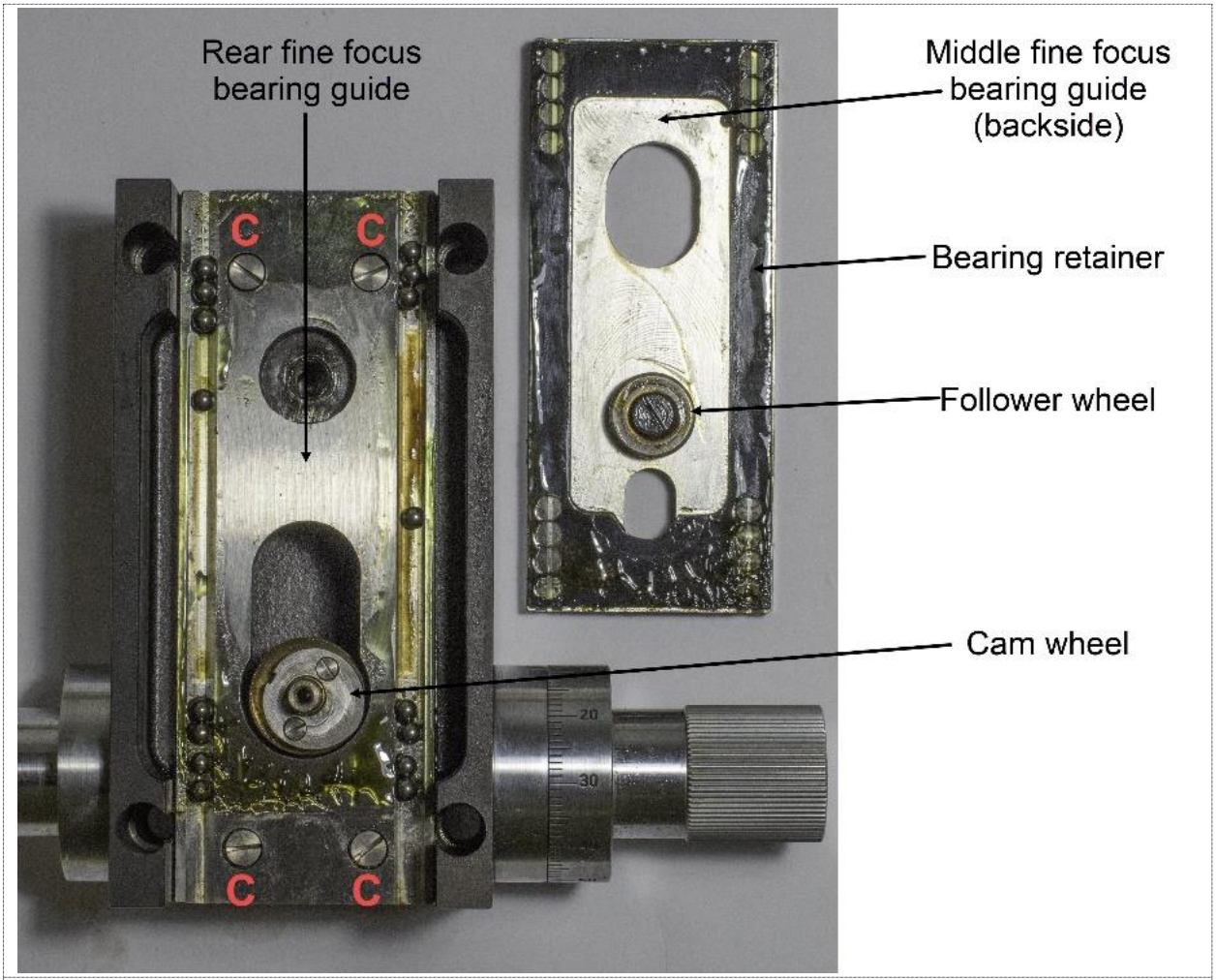

Figure 32: The fine focus block after the middle bearing guide has been removed and placed with the backside facing up. The revealed inner fine focus bearing is also covered with accumulated dirt and old hardened grease.

Remove the rear fine focus bearing guide from the fine focus base by taking out the four screws indicated by the tag "C" in Figure 32. This leaves the fine focus base (Figure 33) accessible for cleaning.

Remove old grease and clean all remaining slide parts with pieces of cloth and/or cotton swabs wetted with a suitable petroleum-based solvent (e.g., "white spirit".) Here is a summary of the parts of the fine focus slide that should be cleaned:

- The front bearing guide,
- the middle bearing guide,
- the rear bearing guide,
- two standoffs,
- the outer fine focus bearing retainer and balls,
- the inner fine focus bearing retainer and balls,
- the follower wheel, and
- the front surface of the fine focus base.

After cleaning, dry the parts. Wipe the bearing balls dry with a lint-free microfiber cloth (don't use paper towels – they leave a lot of tiny paper fibers on the surface of the balls.)

If the cleaned brass bearing retainers are tarnished, you can either leave them as they are, or polish them to remove the tarnish, refer to section Disassemble, clean, and re-grease the coarse focus block.

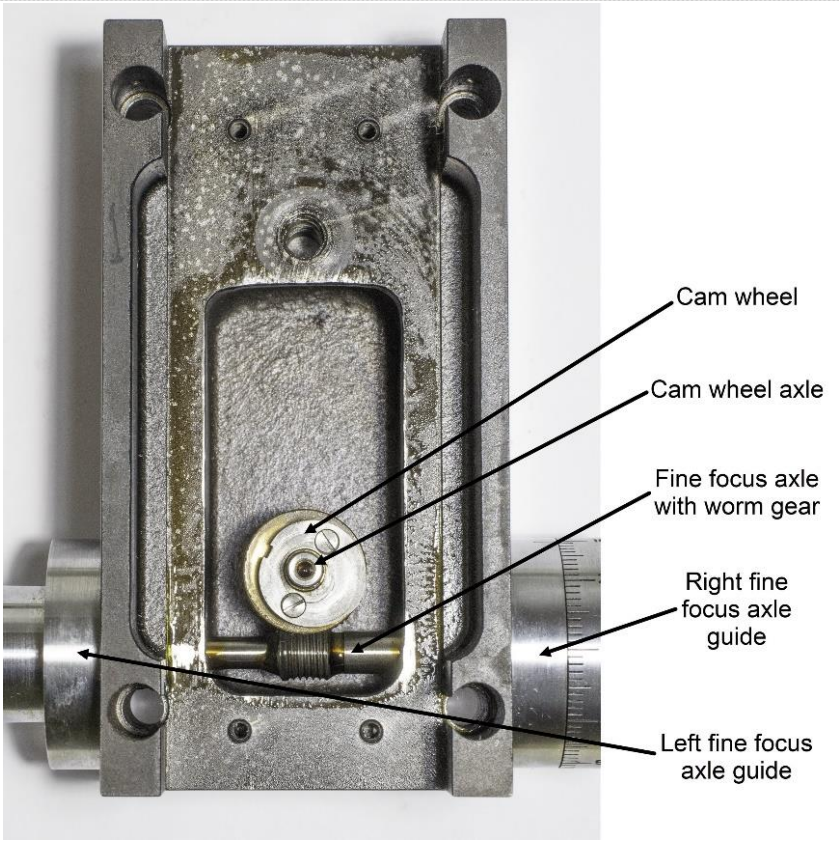

Figure 33: The fine focus base after the rear bearing guide has been removed.

The fine focus knobs

First the fine focus knobs need to be removed from the fine focus axle. This will be done with the axle still sitting in the fine focus base. Between the knobs and the fine focus axle guides (Figure 33, Figure 34 and Figure 35) are small thrust ball bearings that ensure that the fine focus control turns smoothly. Be careful not to lose any of the bearing balls when the knobs are removed. It is recommended to work with the base in a bin so any runaway bearing balls don't get lost. The left and right fine focus knobs are different and should not be confused. Take notes of how the knobs, the bearings and the axle are assembled.

Turn the fine focus knobs until the bulge of the cam wheel (Figure 33) points to the right. Remove the long locking screws from the centers of both fine focus knobs. Holding the knobs in each hand, turn them carefully in opposite directions until one of them releases from the fine focus axle. Collect the bearing parts and put them for cleaning in a small vial with a suitable petroleum-based solvent (e.g., "white spirit".)

Figure 34: The removed left fine focus knob. The thrust ball bearing is still sitting in the right axle guide. The washer in the image is the outer bearing race facing the knob. The fine focus axle is sticking out from the center of the axle guide – the end is slightly tapered to fit into the knob.

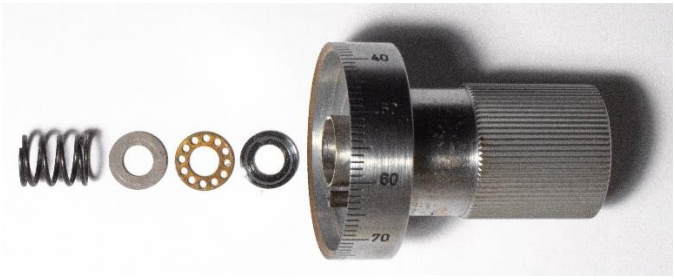

Figure 35: The removed right fine focus knob. On the inside of the knob is a groove (barely visible in the image) for the thrust ball bearing. The bearing parts are shown in the order as they were assembled, except that the bearing balls are not included in the image.

Use penetrating oil, a heat gun, a steel rod and a light hammer (preferable with a plastic head) to remove the remaining knob in a similar way as was done with the coarse focus knobs. A serious warning, however: Be gentle and mindful with the hammer! The fine focus axle's worm interlocks with a worm wheel made of brass that sits below the cam wheel (Figure 39, Figure 40 and Figure 41.) The worm wheel teeth are sensitive to damage from the hammer impulses that propagate through the fine focus axle and the worm. The impact at the moment when the axle releases from the knob is particularly dangerous. Take any necessary precautions and plan your approach before executing. It is much better to use many light knocks rather than a few hard. An intact worm wheel is critical for a precise fine focus control and can't be replaced with any standard component. After successful removal, collect the bearing parts and put them for cleaning in another small vial with solvent.

The fine focus axle is now resting in the axle guides (Figure 36.) It's fixed radially by the guides' plain bearings, but because it has been liberated from the knobs it can move 1-2 cm axially.

The axle guides are then removed by taking out the screws on the face of the guides (Figure 36 and Figure 38). On the backside each axle guide has two pins to keep the guides properly aligned in the fine focus base – don't lose these.

Without the support of the axle guides the axle can now be pulled out of the fine focus base. With the axle loose, keep an eye on the cam wheel and the other parts that sit on the cam wheel axle (Figure 40, Figure 41 and Figure 42.) These parts are under pressure from a spring and once the fine focus axle is gone, they will slip off its axle. It's a good idea to take note of how the various parts are assembled on the cam wheel axle.

Figure 36: The fine focus axle and the left and right axle guides removed from the fine focus base.

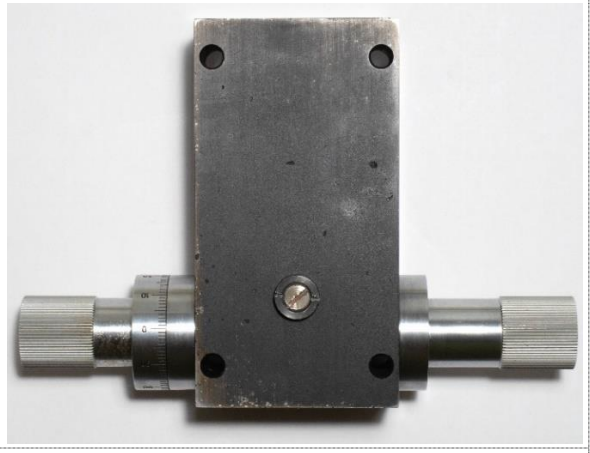

Figure 37:The fine focus base viewed from its backside.

Left side - with axle guide still attached

Left side - after the left axle guide has been removed

Right side - with axle guide still attached

Right side - after the right axle guide has been removed

Figure 38: Views from the sides of the fine focus base.

Finally, clean the following parts with pieces of cloth and/or cotton swabs wetted with a suitable petroleum-based solvent (e.g., “white spirit”):

- Two sets of ball bearing parts, one for each knob
- The fine focus axle, including the worm
- The plain bearing surfaces in both fine focus axle guides

After cleaning, dry the parts. Wipe the bearing balls dry with a lint-free microfiber cloth.

The fine focus mechanism

A worm gear together with a cam wheel (Figure 39) convert the turning of the fine focus control into the desired very small vertical movement of the microscope stage. One turn of the fine focus control moves the stage 0.1 mm. As the cam wheel rotates its excentric edge determines the height of the fine focus by pushing up against the follower wheel on the backside of the middle bearing guide (Figure 32) which in turn is firmly attached to the coarse focus block. The follower wheel is pressed down tightly on the cam wheel with the entire weight of the coarse focus block and the stage. Here an ordered list follows of how all parts pertaining to the cam wheel axle are assembled (starting from the backside of the fine focus base):

- Cam axle attachment (Figure 37) at the backside of the fine focus base. The end has a screw head with a locking nut; most probably this is to enable axial adjustment of the cam wheel axle. It's probably best to leave it untouched, unless there is a good reason to adjust it.
- Spring (Figure 40 and Figure 42). The spring pushes the worm wheel up against the worm (on the fine focus axle) to eliminate play in the worm gear.
- Washer, or to be more precise, shoulder washer (Figure 42). Distributes the spring tension to the worm wheel. Also its shoulder provides space for the fine focus arrestor wing to fit in just below the worm wheel.
- Worm wheel (Figure 39 and Figure 40). The receiving part of the worm gear. It is integrated with the cam wheel.
- Cam wheel (Figure 39, Figure 40 and Figure 41).
- Standoff for the lower locking screw (Figure 31). (It was removed earlier when the front fine focus bearing guide was removed.)
- Lower locking screw for the fine focus slide (Figure 30). (It was removed earlier when the front fine focus bearing guide was removed.)

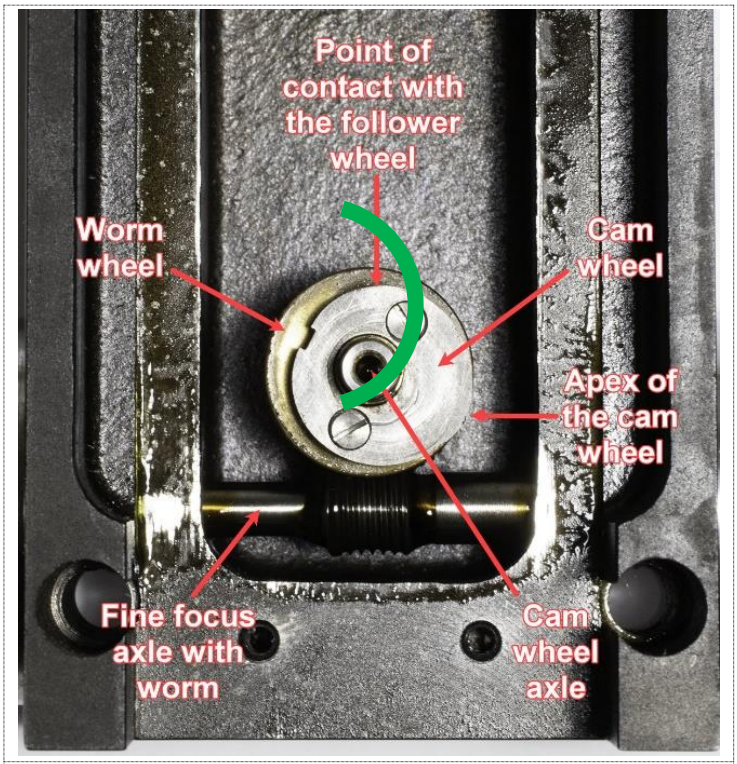

Figure 39: The cam wheel and the fine focus axle.
The green arc indicates the cam wheel's rotational range, i.e., the range within which the tip of the cam wheel is allowed to rotate.

The fine focus range (approx. 3 mm) is determined by the difference between the highest and lowest points of the excentric cam wheel. These points are reached within ½ turn (180°) of the cam wheel. To ensure a linear fine focus movement the usable cam wheel turning range must be somewhat smaller, in this case approx. 160°.

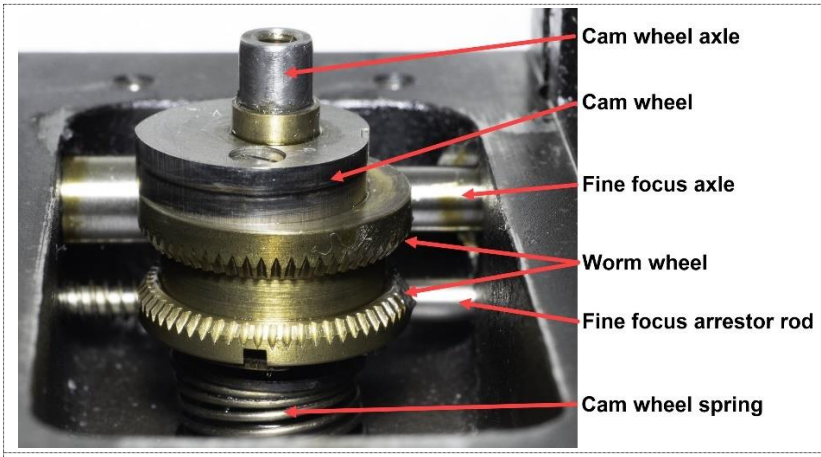

Figure 40: The cam wheel assembly.

Figure 41: The cam wheel and the fine focus axle.

Figure 42: The cam wheel assembly after the cam wheel has been removed.

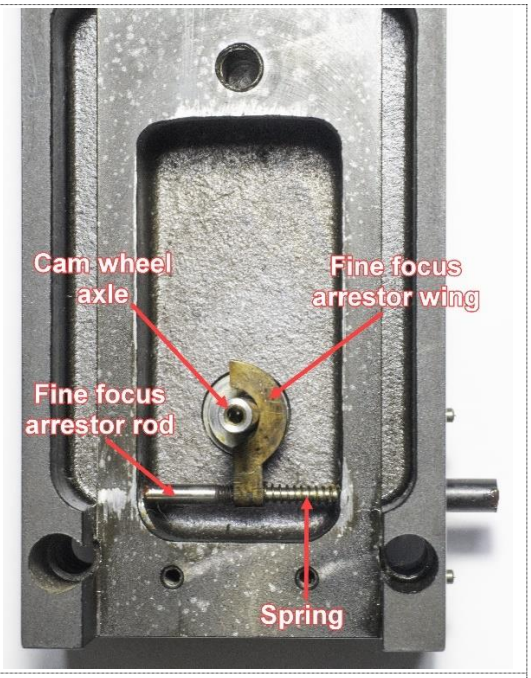

Figure 43: The fine focus arrestor assembly.

Figure 42 and Figure 43 show the mechanism used to stop the turning of the fine focus knobs just before the highest and the lowest points of the cam wheel have been reached. The underside of the worm wheel has two protruding screw heads separated by approx. 160°. They are positioned to push against a fine focus arrestor wing (Figure 42 and Figure 43) just before any of the end points of the cam wheel are reached. The wing is attached to a fine focus arrestor rod which is under tension by a spring. When the wing is pushed, it moves the rod to the right and out of the opening in the fine focus base's right side (through the black cylinder that sticks out of the side of the base in Figure 43.) When the rod sticks out it gets in the way of a screw on the inside of the right fine focus knob (barely visible in Figure 35) making it impossible to turn the knob further in the same direction. Only when the knob is turned the other way, the rod retracts freeing the knob again. Continuing turning the knob, it will eventually reach the other end of the fine focus range where the other protruding screw now pushes out the arrestor rod, etc.

The fine focus arrestor rod with the wing can be left in the fine focus base, there is normally no need to remove these parts.

Clean the following parts with pieces of cloth and/or cotton swabs wetted with a suitable petroleum-based solvent (e.g., “paint thinner”):

- The cam wheel
- The worm wheel
- The spring and the washer (from the cam wheel axle)
- The cam wheel axle
- The fine focus arrestor wing

After cleaning, dry the parts from remaining solvent.

Re-grease and assemble the fine focus block.

Push the fine focus arrestor rod into its arresting position (push the rod against the spring as far as it goes) and sparsely apply some grease on the now exposed sliding surfaces. Move the rod back and forth a couple of times to distribute the grease.

Grease the plain bearing surfaces on the inside of the two fine focus axle guides (Figure 36.) These are the sliding surfaces that hold the fine focus axle in its radial position.

Attach the left side fine focus axle guide to the fine focus block with the two belonging screws.

Grease the cam axle and then put the following onto it (in this order):

- The large cam axle spring
- the cam axle washer, lightly greased (with the wide collar facing downwards as in Figure 42)
- the cam wheel (apply generously of grease on the cogs of the attached worm wheel)

Put the fine focus axle into position through the fine focus block’s right side. While pushing in the fine focus axle, adjust the height of the cam wheel to make sure that the worm of the fine focus axle is correctly positioned between the adjacent teeth of the worm wheel. Check that the fine focus axle rotates freely and slowly moves the cam wheel. From now on, keep the fine focus axle in this symmetrical mid position and avoid letting it slip sideways. Use a plastic or wood stick to push the wing of the fine focus arrestor rod slightly away from the cam axle, align the wing with the narrow part (the shoulder) of the cam axle washer and release it. The wing should now be in a position between the washer and the worm wheel where it can be actuated by the two screws on the underside of the worm wheel when the fine focus reaches its outer ranges. Rotate the fine focus axle until the apex of the cam wheel points to the right. The fine focus arrestor rod should not engage in this position.

Attach the right fine focus axle guide to the fine focus block with the two screws. Grease the small spring (Figure 35) which keeps the knob’s ball bearing in place and put it into the circular groove in the axle guide.

Assemble the right knob’s ball bearing (Figure 35): Put the right fine focus knob on the table with the bearing side up. Generously grease the shiny side of one bearing race and put it down into the knob’s bearing groove with the greased shiny side facing upwards. Add the brass bearing retainer. Use two

pointed toothpicks to rotate the retainer a few mm to allow some grease to reach into the holes for the balls. Use tweezers (and perhaps a magnifier) to pick the 1.0 mm bearing balls one by one (there should be 12 balls) and place them into the retainer holes. Use a toothpick to push them fully down into the holes. Check that all bearing balls are present and properly seated. Grease the upper bearing race's shiny side and carefully put it on top of the retainer with the balls making sure that its greased shiny side faces downwards. Be careful so the bearing balls don't dislodge. The grease will help to hold the bearing parts in place. Don't yet attach the knob to the fine focus axle.

Assemble the left knob's ball bearing (Figure 34): During this assembly take care not to let the fine focus axle slip too much from its proper position centered in the fine focus base. Put the fine focus base on a suitable support (to allow space for the right end of the axle) with its left side facing upwards. Grease the bottom of the bearing groove in the axle guide (there is no separate lower race) and add the brass bearing retainer. Proceed as above by adding the balls and the upper bearing race. The grease should hold the bearing parts together.

Put the fine focus base on its back on the table. Take the two knobs in each hand and slip them simultaneously onto the fine focus axle. Be careful not to disturb the ball bearings, and also to keep the fine focus axle centered. Push the knobs on the axle all the way as far as it goes and keep them tightly pressed together with one hand – if you let go even for a fraction of a second, the spring in the right knob will separate the knobs and you risk that the bearing balls will dislodge, which means that you will need to reassemble the bearings from scratch again. While keeping the knobs pressed together, attach and tighten (not too hard) the two long knob screws in the center of the knobs. Once the screws on both knobs are tightened you can loosen your grip. Check that the fine focus knobs rotate freely, that the cam wheel works as supposed, and that the fine focus arrestor rod engages and stops the knob rotation when the fine focus extremes are reached.

Possible fine focus arrestor alignment problem: At the highest and at the lowest fine focus settings the fine focus arrestor rod engages in such a way that the fine focus control is blocked from being turned beyond the high or low focus extreme. On turning the focus control back again the arrestor rod disengages and allows the focus control to continue to rotate the other way until it reaches the other end of the fine focus range. If the fine focus arrestor is misaligned with the fine focus mechanism it can happen that the arrestor rod disengages too late, which means that the focus control unfortunately becomes locked in to only be able to move back and forth for slightly less than one turn. There is probably some Leitz secret how to pre-emptively align the arrestor mechanism with the way the right knob is attached to the axle, but I haven't been able to figure it out. Below is instead a post-mortem hack described suggesting how the right focus knob can be re-aligned if it sometime gets stuck due this arrestor misalignment. The hack requires that the right focus knob is not stuck on the fine focus axle. The idea is to slightly loosen the right knob from the axle and then hold the right knob still while slightly rotating the left knob (which should remain firmly attached to the fine focus axle.) One slight rotation of the fine focus axle sliding within the right knob will help to align the knob with the focus arrestor mechanism. An advantage with this hack is that it can be applied even after the entire microscope focus mechanism has been reassembled.

Alignment hack if the fine focus control is stuck at the low extreme: Turn the fine focus control to raise the stage until it stops at the position where it is stuck (this will be after slightly less than one turn from the low extreme). Loosen only the screw that holds the right fine focus knob (half a turn should be OK). The knob will still remain attached to the fine focus axle but it will also be loose enough so it can slide

around on the axle end. Hold the right knob tight so it doesn't rotate, and now turn the left knob approx. 30° in the direction that would raise the stage (don't turn too far – then the focus may instead get stuck at the upper extreme.) The left knob will bring the fine focus axle to slide 30° against the inside of the right knob and thereby move the arrestor rod out of the way. Tighten the screw on the right knob. After this realignment the focus control should be free to move over the entire fine focus range.

Alignment hack if the fine focus control is stuck at the high extreme: Turn the fine focus control to lower the stage until it stops at the position where it is stuck (this will be after slightly less than one turn from the high extreme). Loosen only the screw that holds the right fine focus knob (half a turn should be OK). The knob will still remain attached to the fine focus axle but it will also be loose enough so it can slide around on the axle end. Hold the right knob tight so it doesn't rotate, and now turn the left knob approx. 30° in the direction that would lower the stage (don't turn too far – then the focus may instead get stuck at the lower extreme.) The left knob will bring the fine focus axle to slide 30° against the inside of the right knob and thereby move the arrestor rod out of the way. Tighten the screw on the right knob. After this realignmen the focus control should be free to move over the entire fine focus range.

Once the fine focus control works reliably attach the rear fine focus bearing guide using the four screws (Figure 32). Before tightening the screws make sure that the fine focus cam wheel can turn without touching the rim of the opening in the rear guide. Grease all sliding surfaces of the follower wheel (its periphery and the inside plain bearing) and attach it to the middle fine focus bearing guide using the special screw. Check that the wheel rotates freely. Apply grease to the races of the rear guide, to the races of the middle guide (on the same side where the follower wheel is) and to both surfaces of the tall bearing retainer. Put down the retainer close to the upper end of the rear guide and align it with the races. Place all 16 of the 3.3 mm bearing balls into the retainer holes and push the balls down with a toothpick. Carefully add the middle guide with the follower wheel facing down. Don't detach the guide again as this will dislocate the bearing balls. Next, apply grease to the races of the middle guide's upside, to the races of the front guide and to both surfaces of the (smaller) bearing retainer. Put down the retainer on the middle guide aligning it with the races (Figure 31). Place all 16 of the 3.2 mm bearing balls in the retainer holes and push the balls down with a toothpick. Put the large and the small locking screw standoffs into the openings in the middle guide. Note that the small standoff has a groove on one side – this side should face down. Carefully add the front guide with the races facing down. Finally secure the fine focus slide with the two locking screws (one large and the other small, Figure 30.) The tightness of these screws determines how smoothly the middle guide will move up and down when the fine focus control is turned. Too much tightening will make the fine focus too sluggish, and with too little tightening the fine focus may become wiggly, or the screws may even eventually come loose. Note that the smaller of the locking screws (the lower screw) is attached into the cam wheel axle. The axle also has what looks like an adjustment screw (with a lock nut) on the back side of the fine focus base (Figure 37). Presumably it can be used to adjust the tension/pressure applied over the fine focus slide, but I have not attempted to try out if/how it may work. It seems strange that this adjustment only would affect the lower part of the slide, while there is no corresponding adjustment option for the upper part. Another way to change the tightness of the slide could be to use slightly larger or smaller bearing balls.

Finally, attach the fine focus block to the microscope stand using the four large screws ("A" in Figure 30). Now we will continue to prepare and attach the coarse focus block.

Re-grease and assemble the coarse focus block.

The coarse focus base should now include the coarse focus axle with knobs and the coarse focus counterbalance mechanism, all greased and ready for work.

Reattach the lateral clamp socket including the screw (the upper part in Figure 8) to the left side of the coarse focus base using the two corresponding screws. The clamp gap should face forwards.

Use the two corresponding short screws to attach the center bearing guide (Figure 17) to the coarse focus base (Figure 14, Figure 15 and Figure 16.)

Use the four corresponding long screws to attach the coarse focus base to the fine focus block (which already should be attached to the microscope stand) (Figure 15 and Figure 16.)

Put a little grease on and into the cylinder of the fine focus buffer (Figure 19) and attach the buffer from the underside of the stand below the coarse focus base.

Assemble the coarse focus block slide

Put the microscope on its back with the coarse focus base facing upwards. In this way the linear ball bearings of the coarse focus slide will be in a horizontal position which makes the entire slide easier to assemble. As a safety precaution consider performing this part of the work with the microscope in a bin, as this will make any accidentally dropped bearing balls easy to recover.

When we disassembled the coarse focus slide, we left only the right bearing guide rail (the one with the coarse focus rack) attached on the back side of the front plate. (If you removed the right bearing guide rail you should now attach it to the back side of the front plate. On the back side of the front plate are two small guide pins [barely visible on the left side of Figure 11] that will ensure proper positioning of the right guide rail before it is secured with the four corresponding screws.)

On the left side of the front plate (Figure 10, where the left bearing guide rail will be attached) loosen the three lateral tension screws with the large heads. Don't remove them, only release them approx. 1-2 mm.

Apply grease on the coarse focus rack attached to the backside of the right bearing guide rail (Figure 12.)

Apply grease on all involved bearing races:

- Both bearing races situated on each side of the center bearing guide that you already have attached to the coarse focus base (Figure 15),
- the right bearing guide rail (which is attached to the front plate), and
- the left bearing guide rail.

Apply grease to both sides of the two brass bearing retainers (Figure 13). Make sure that the retainer holes get some grease – this will help to hold the balls in place during assembly. Press the retainers into the grease approximately in the middle of the center bearing guide races facing to the right and to the left, respectively. Using forceps to place all 20 bearing balls (3.1 mm diameter) into the retainer holes. This is somewhat tricky as the retainer holes are facing sideways, but the grease will keep the balls in place. Use a pointed toothpick to push each of the balls to the bottom of the holes – this ensures that the balls stick and don't fall out too easily, and also aligns the retainers properly with the race grooves.

Carefully push the race of the right guide rail (which is attached to the front plate) against the right race of the center bearing guide (where the retainers and balls are.) This step is somewhat critical because it is important that the races meet with proper alignment and that the none of the bearing balls are dislodged. Keep holding the races lightly pressed together with your right hand so the races can't separate again. If they separate, some of the balls will most probably dislodge and force you to check and reposition the retainers and balls.

Still holding the bearing on the right side tightly closed, slightly raise the left side of the front plate a few mm to allow space for attaching the left guide rail. Slip in the left guide rail against the left race of the center bearing guide (where the retainers and balls are). Once attached, don't allow the bearing to separate. Now, holding both bearings closed, lower the raised left side of the front plate so it rests on the left guide rail. Use the four corresponding screws to attach the left guide rail to the front plate. Don't fully tighten the screws, leave them ever so slightly loose. Do the same with the three lateral tension screws. Now you may loosen your grip of the bearings as they will be kept in place by the screws. Successively tighten the three lateral tension screws until the slide is tight without shearing. The lateral tension screws determine the tightness over the bearings; the focus should move smoothly but must be completely free from play. Once the tightness feels satisfactory, fully tighten the four screws to finally secure the right guide rail to the front plate.

Take the microscope out of the bin and put it in the normal upright position.

Attach the clamp disc (the lower part in Figure 8) to the left side of the front plate making sure it fits into the groove of the lateral clamp.

Adjust the coarse focus counterbalance mechanism

Attach the stage (complete with the condenser holder) to the coarse focus block's dovetail and secure it with its tightening screw. Put a condenser into the condenser holder.

Unscrew and remove the cover cap from the left side of the coarse focus block (Figure 3.) Find a screwdriver with a wide and narrow tip that fits across both drives of the left brass nut (Figure 22.) The nut is under slight pressure by the torsion spring which keeps the nut locked in its outer position. Release the nut from its locked position by pressing it down with the screwdriver and then increase the torque of the mechanism's torsion spring by turning the nut counterclockwise. Move the stage up and down with the coarse focus control while successively turning the nut until the focus knob turning resistance feels the same for both the upward and the downward movement. Note that to turn the nut, you will need to keep it pressed down. If you just suddenly remove the screwdriver from the nut, the torsion spring will immediately snap back to its untwisted state. When you are satisfied with the torsion spring torque, slowly and partly release the nut, turning the screwdriver slightly back and forth to allow the nut to snap into one of its locked positions (the "snaps" happen at every 90° rotation of the nut.) Once the nut has locked, you can remove the screwdriver from the nut's drive. The torsion spring will now retain the desired torque and nicely balance the up and down turning of the coarse focus control. Finish by attaching the cover cap.