Leitz Ortholux Focus Mechanism (post-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 coarse focus buffer, i.e., the mechanism for countering the weight of the stage. Pre-1953 the microscopes use a torsion spring with an adjustment nut covered by a cap, post-1953 there are two internal compression springs without any external adjustment facility.

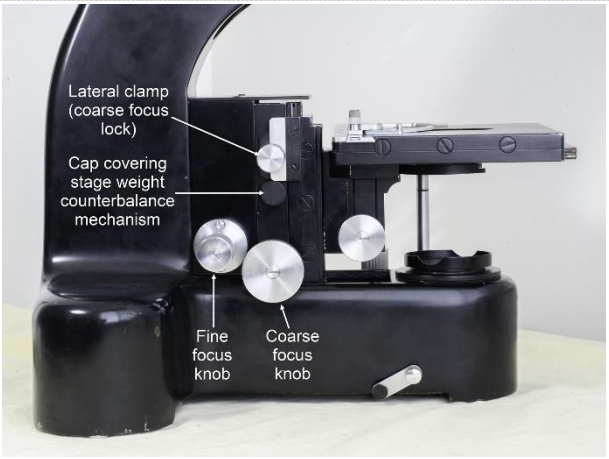

Figure 1: Leitz Ortholux pre-1953, view of the microscope’s left side.

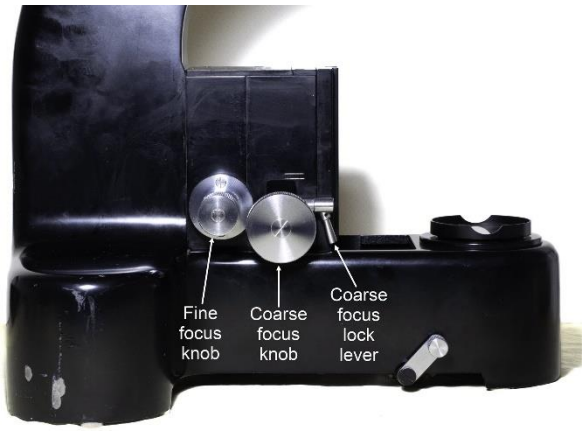

Figure 2: Leitz Ortholux post-1953, view of the microscope’s left side.

These maintenance notes cover only the post-1953 Ortholux focus mechanism.

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 two functional units, the fine focus block, and the coarse focus block (Figure 3.) This division is somewhat arbitrary because some parts of the mechanism fulfil both some fine and some coarse focus functions.

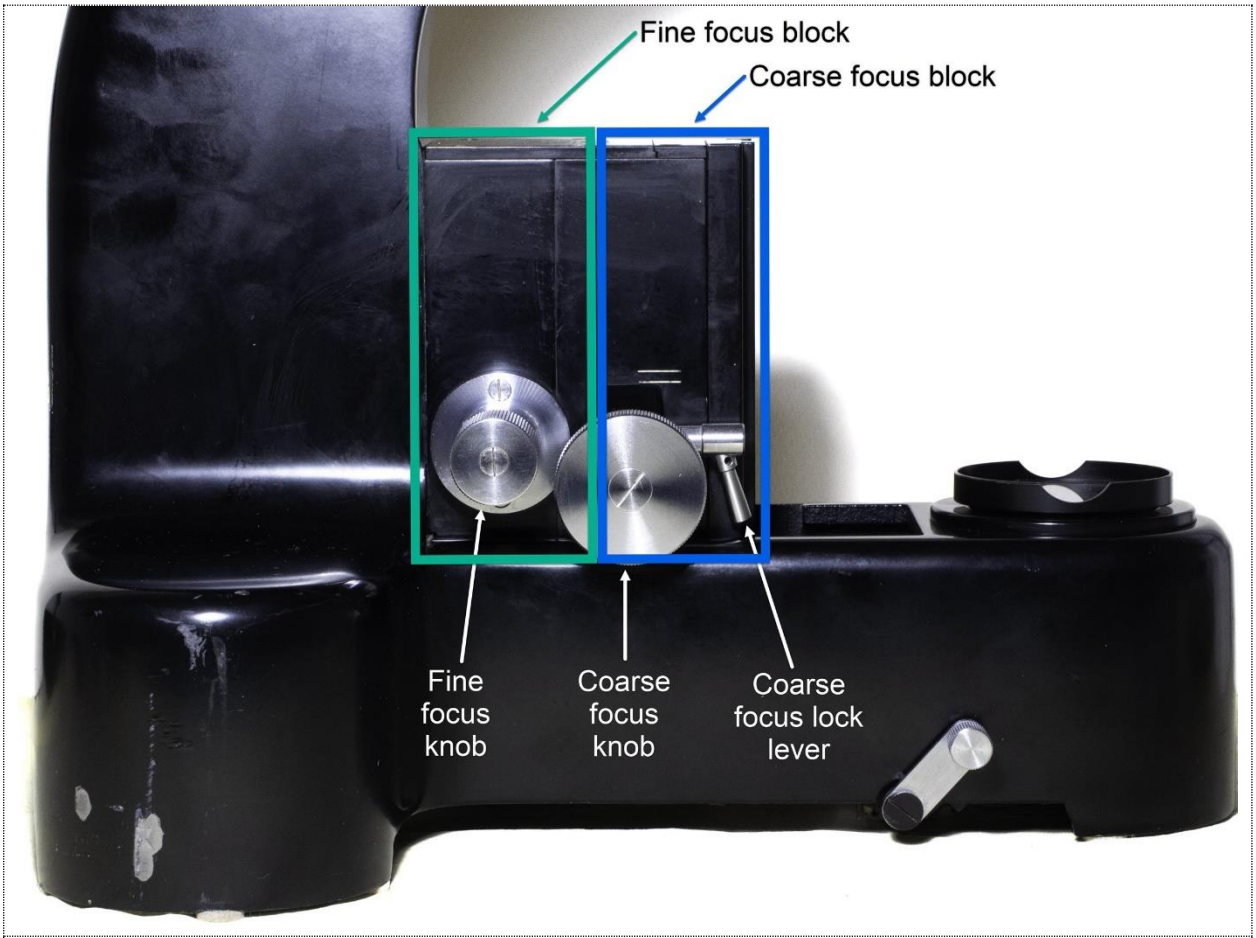

Figure 3: Leitz Ortholux microscope from 1958/59 (view from the left side.) The stage has been removed.

The fine focus block is attached by four sturdy screws to the microscope stand. The fine focus has a range of approx. 2.5 mm covered by 25 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 disc cam which creates the up-and-down movement) and a slide between two linear ball bearings transferring the fine focus movement to the next unit, the coarse focus block.

The coarse focus block has a rack and pinion mechanism and a slide with two linear ball bearings that relays the coarse focus movement to the stage. Also, the coarse focus block has a built-in coarse focus buffer to compensate for the weight of the stage and it has a lock lever for the coarse focus.

Figure 4 shows the focus mechanism obliquely from above.

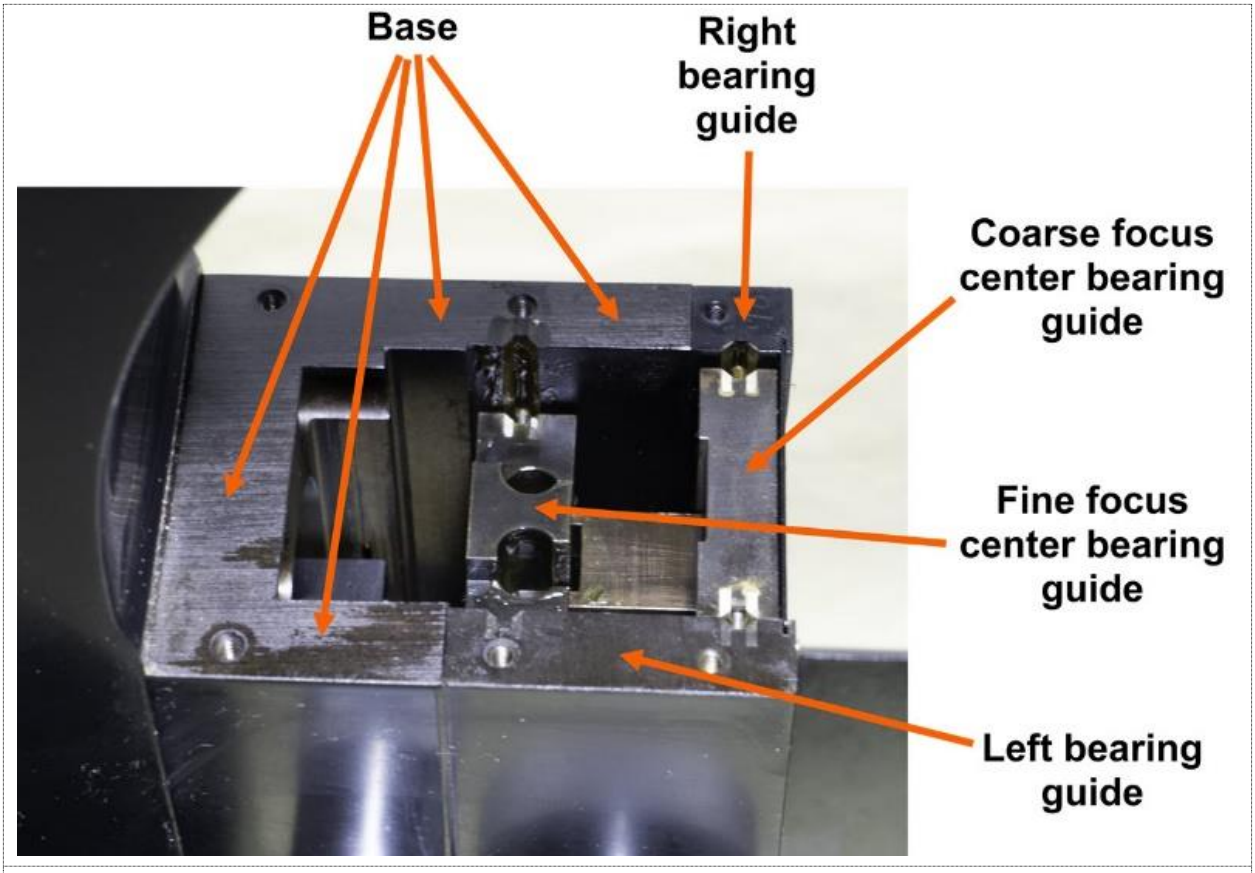

Figure 4: The focus mechanism seen obliquely from above.

The fine focus center bearing guide is moving up-and-down between two linear ball bearings and is driven by the fine focus control.

The coarse focus center bearing guide is connected to and moving with the fine focus center bearing guide. It is also situated between two linear ball bearings and is further driven by the coarse focus control.

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 two top covers (Figure 5, one of which is the "Leitz" name plate with the microscope's serial number) sitting above the focus assembly and one bottom cover (Figure 6) which can be accessed from the underside of the microscope. Note that the bottom cover holds a spring, the fine focus buffer. 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.

If you sit in front of the microscope, you will now face the front plate of the coarse focus block (Figure 7.)

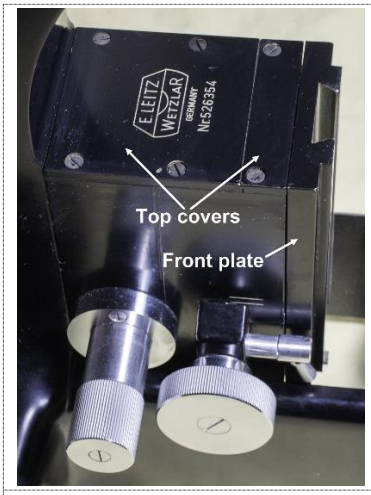

Figure 5: The two top covers.

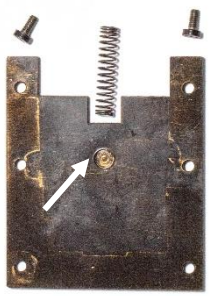

Figure 6: The bottom cover with the fine focus buffer (the spring) which fits into the depression (at the white arrow.)

Figure 7: The front plate of the coarse focus block.

Disassemble the coarse focus slide

Remove the coarse focus block's front plate which is held by four screws (Figure 7.) Take care not to lose any of the washer-like shims that may sit between the front plate and the coarse focus center bearing guide (Figure 8) and make a note of where they were sitting so they can be properly put back at re-assembly. The purpose of the shims is to fine align the stage to be exactly perpendicular to the optical axis of the microscope. Remove the black shield above the coarse focus center bearing guide (Figure 8 and Figure 9) by pulling it upwards.

With the front plate out of the way, unscrew and remove the coarse focus lock lever (Figure 3.)

We are now ready to disassemble the coarse focus slide. The following items will be removed: The right bearing guide, the coarse focus center bearing guide, and the two linear ball bearings (each with a bearing race and eight 3.5 mm bearing balls) that sit on each side of the coarse focus center bearing guide. The left bearing guide can't be removed (yet) because it is blocked by other components, but we can still easily disassemble the slide after only removing the right bearing guide. The right bearing guide is attached to the coarse focus block by the four larger black screws seen in Figure 8. The two smaller screws in the right guide (Figure 8) don't attach to anything in the conventional way, they are only used to adjust the tension across the two linear ball bearings. The screws have an excentric pin at the tip (Figure 11) which fits snugly into a small groove (Figure 14) in the focus block. By turning the screws, the excentric pins force the right bearing guide to move slightly sideways so a suitable tension can be applied over the bearings of the coarse focus slide.

Go ahead and remove the four larger and the two smaller screws from the right bearing guide and remove the guide (Figure 10) from the coarse focus block. Also remove the coarse focus center bearing guide. Collect the brass retainers and steel balls from both ball bearings (Figure 13). Each bearing has 8 balls in a 4+4 arrangement, the ball diameter is 3.5 mm.

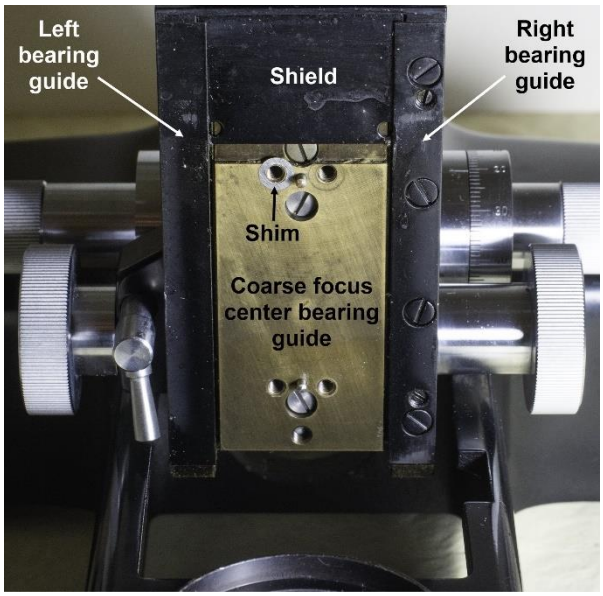

Figure 8: The coarse focus center bearing guide (after the front plate has been removed.)

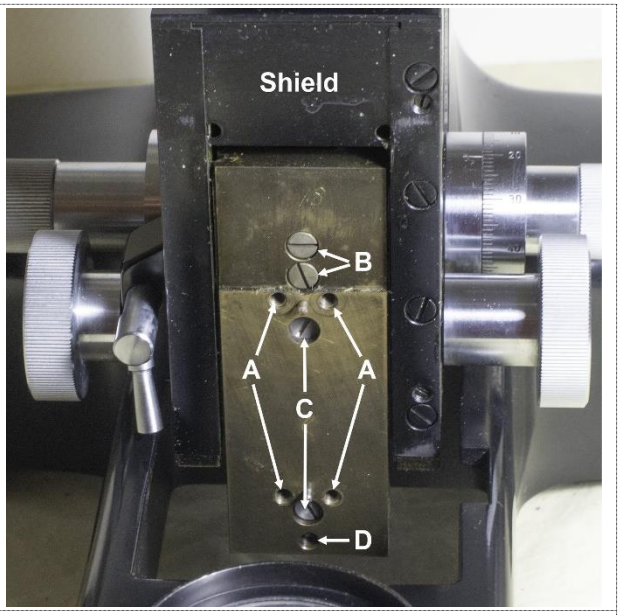

Figure 9: The coarse focus center bearing guide (with the coarse focus turned down as low as possible.)
A = Four screw holes for the screws that attach the front plate to the coarse focus center bearing guide.
B = Two screws that hold the coarse focus buffer receiver.
C = Two screws that hold the coarse focus rack.
D = Screw hole for the coarse focus slide stop (attached on the backside.)

Figure 10: The right bearing guide (with 4 + 2 screws) after removal.

Figure 11: One of the two screws used for applying tension across the ball bearings. Notice the excentric pin. The screw head is on the left side of this enlarged image.

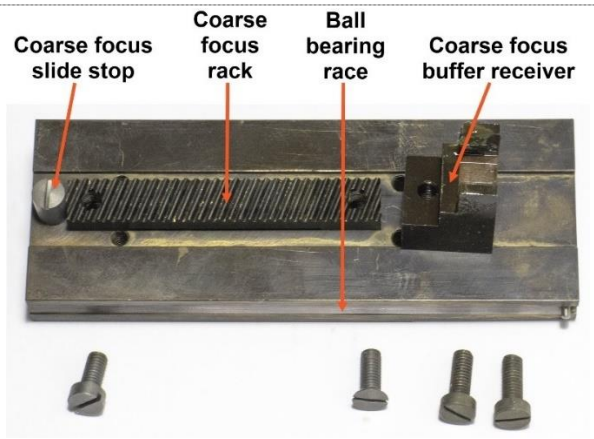

Figure 12: The back side of the removed coarse focus center bearing guide. The coarse focus rack and the buffer receiver have in this image been removed (and loosely put back on the guide just to illustrate where they were attached.)

Figure 13:One of the two coarse focus linear ball bearing retainers including the bearing balls. Everything is covered with old grease and dirt.

Normally the coarse focus rack can be left attached on the back side of the coarse focus center bearing guide (Figure 12). If however the coarse focus rack needs to be replaced (perhaps due to broken teeth) this is a good time to remove it from the guide and replace it with a suitable spare rack.

Remove the buffer receiver from the back side of the coarse focus center bearing guide (Figure 12).

Remove both coarse focus buffer springs from the channels in the fine focus center bearing guide (Figure 14 and Figure 15.) The buffer springs provide an upwards directed force on the coarse focus control to compensate for the weight of the coarse focus control slide and the stage including the condenser. It relieves some of the mechanical strain put on the focus mechanism and it also makes it more pleasant to work with a focus control that turns with similar ease in both directions. The knobs inserted into the upper end of the springs (Figure 15) push upwards against the coarse focus buffer receiver (Figure 12) that is attached on the backside of the coarse focus center bearing guide.

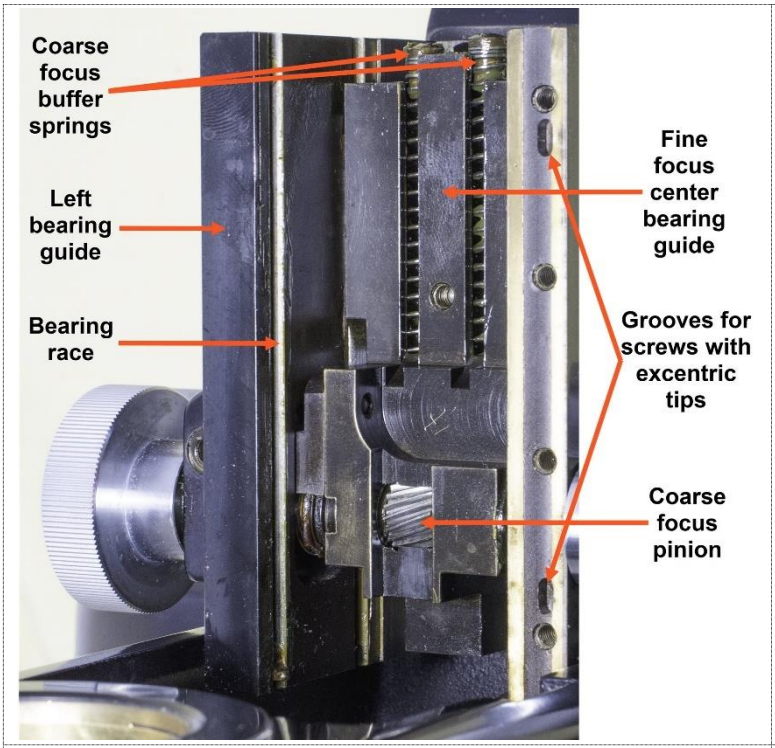

Figure 14: The focus mechanism after the coarse focus slide has been removed.

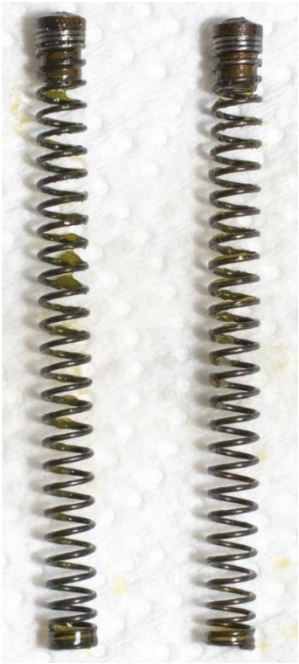

Figure 15: The coarse focus buffer springs.

Remove the focus mechanism from the microscope stand

Now the entire focus mechanism (or what is left of it…) will be removed from the microscope stand. Because of the heavy weight of the focus mechanism including the stage and the condenser, the mechanism is tightly secured to the stand by four sturdy M5x15 screws (the locations of the screws are indicated in Figure 16 and Figure 18.) Not only are these screws tight, but they are also somewhat difficult to reach. For successful removal, use a good quality screwdriver with a well-fitting tip and an enough long shaft. Also pre-treat the screws with penetrating oil (for example, WD-40.) Use some support to put the microscope on the table with the backside facing upwards and the bottom facing towards you (Figure 17). In this way the penetrating oil can be applied to the screws from the backside – just add one drop per screw and let it work. Repeat as necessary. To get better access before removing the screws remove the filter holder in the microscope foot just below the condenser.

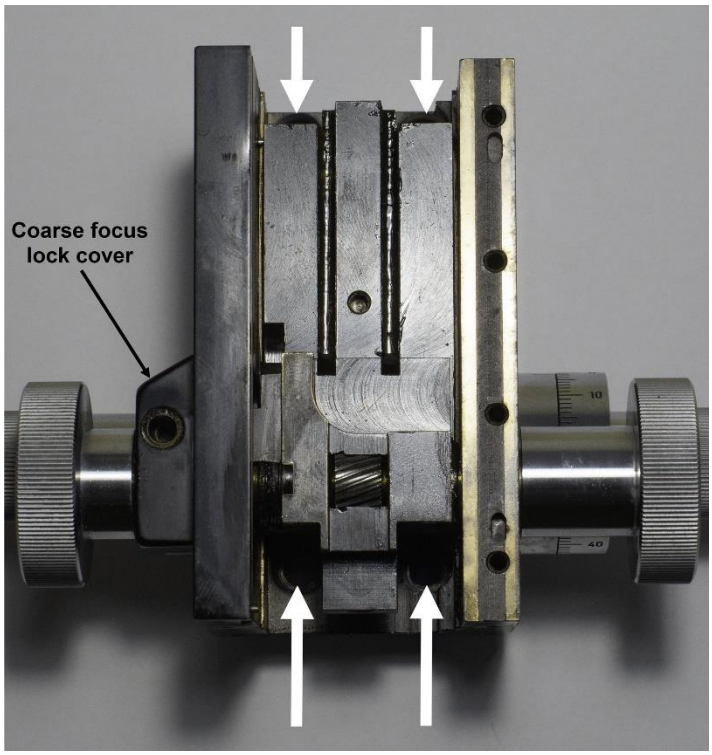

Figure 16: The focus mechanism after removal from the microscope stand. The arrows point to the four screws holes for the M5x15 screws that attach the base of the focus mechanism to the stand.

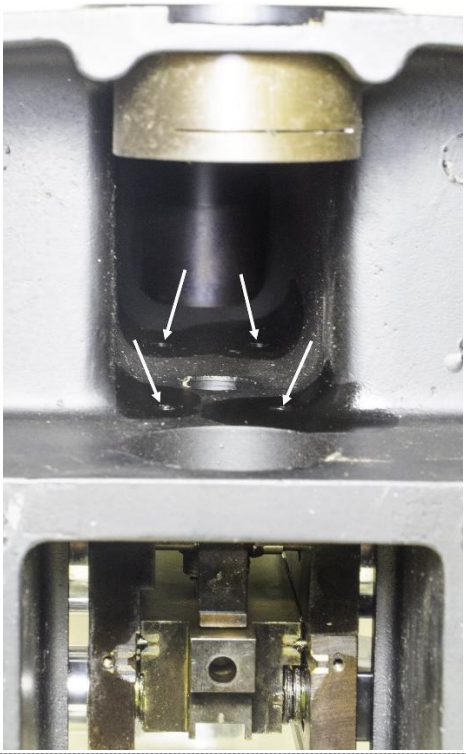

Figure 17: View from below into the arm of the microscope stand. The arrows point to the four screw holes where the penetrating oil should be applied. The focus mechanism is just below in the image.

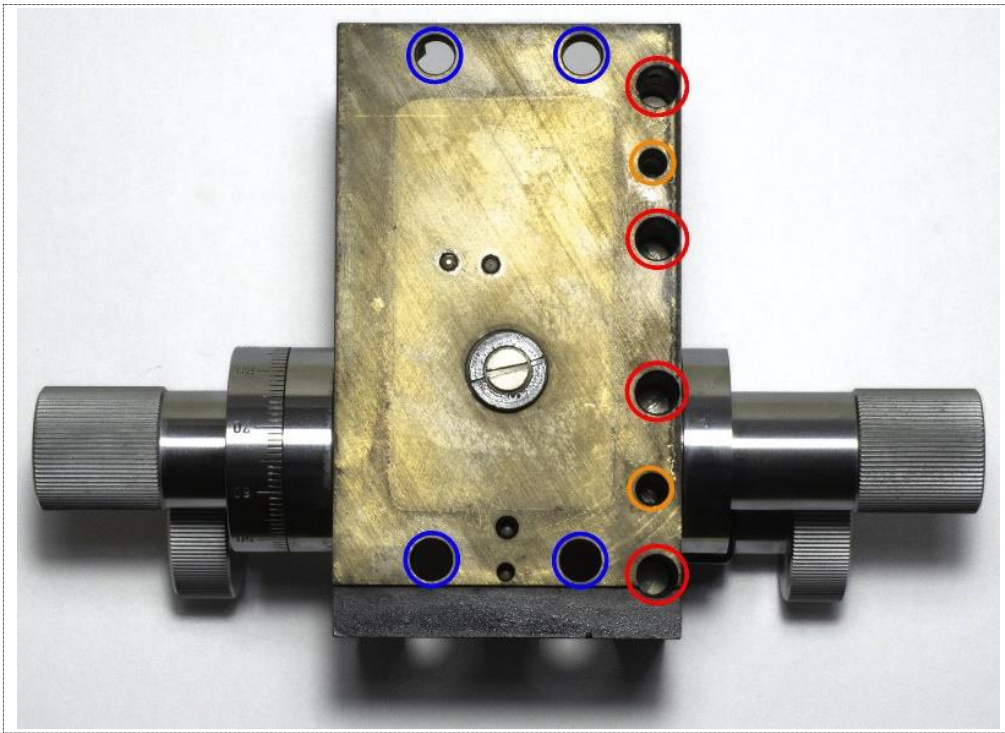

Figure 18: The back side of the focus assembly after it has been removed from the stand.
Blue circles: Screw holes for the four robust M5x15 screws that attach the focus assembly to the microscope stand.
Red circles: 4 screws attaching the left bearing guide.
Orange circles: 2 screws (same as in Figure 11) for adjusting the tension over the fine focus slide.

Clean the disassembled parts from old grease

With most of the coarse focus block disassembled, now is a good time to clean all available parts from old grease and dirt. Use a suitable petroleum-based solvent (e.g., “white spirit”) and clean the parts by soaking and/or scrubbing them with a piece of cloth or cotton swabs wetted with the solvent. Clean all parts and all accessible surfaces that appear to be greased or oily. After cleaning, the bearing balls should be wiped 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.)

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 coarse focus control knobs

Removing the coarse focus knobs (Figure 19) from the coarse focus axle is the second difficult part (the first was the removal of the focus mechanism from the microscope stand.) During manufacturing the coarse focus control axle ends were apparently greased to facilitate attaching the knobs, but now many years later the knobs tend to get stuck on the aged grease. Leitz technicians most probably had a gentle method and perhaps some clever tools for removing these knobs. But not having any knowledge about Leitz’ methods I choose to resort to a some-what brutal hack, the “hammer and steel rod” method described below. Although the coarse focus axle appears to be quite robust, it is still important to use good judgement and be careful not to overdo the heating and hammering moments involved.

Figure 19: The removed coarse focus knobs.

Begin by removing the screws in the center of the coarse focus knobs. They are not really screws, but rather nuts (they have the threads on the inside and attach to the external threads on the axle tips.)

Place the focus mechanism on a suitable support with one of the knobs facing upwards. Put a few drops of penetrating oil (for example, WD-40) into the hole in the middle of the knob and let it work for one or a few days. (It is somewhat doubtful whether the penetrating oil really will penetrate very far through the old, hardened grease, but anything that could facilitate the knob removal should be tried.)

What follows here is difficult to accomplish with only two hands, but easily accomplished with the help of another person. Heat the inner narrower part of the knob (that’s where the axle is attached) with an electric heat gun. Continue to heat the knob until it is just too warm to touch (approx. 50-60°C, or 120-140°F), but at the same time be careful not to overheat it - the heat guns are quite powerful and there are a couple of possibly heat sensitive plastic washers below the knobs. Then grab the focus mechanism

by the warm knob (use gloves) with the knob facing upwards and with the heavy focus mechanism hanging below. Hold the focus mechanism hanging just above a thick, folded towel to catch and protect it when it releases from the knob. Put a short (5-10 cm) steel rod with a suitable diameter (e.g., the blunt end of an old, decommissioned drill bit) into the knob's screw-opening with one end of the rod touching the tip of the coarse focus axle. Tap the other end of the rod with a light hammer with a plastic head. Tap gently and many times; it may take a lot of taps, but eventually the axle together with the focus mechanism will release from the knob in your hand and fall down on the towel below.

Repeat the procedure to remove the other knob.

On the coarse focus axle between each of the coarse focus knobs and the fine focus bearing guide is a transparent plastic washer (1.0 mm thick, 6.1 mm inner diameter, 14.0 mm outer diameter, Figure 25) embedded in grease – be sure not to lose it.

Clean the insides of the knobs and the ends of the coarse focus control axle with a suitable solvent. If desired, the knurls (grooves) on the outside of the knobs can be cleaned from brownish deposits (from finger fat, etc.) by soaking in warm water with dishwashing detergent and brushing along the grooves with a hard toothbrush.

Remove the coarse focus lock cover (Figure 16, Figure 20 and Figure 21) – it is attached with only one small screw that normally is hidden under the left control knob.

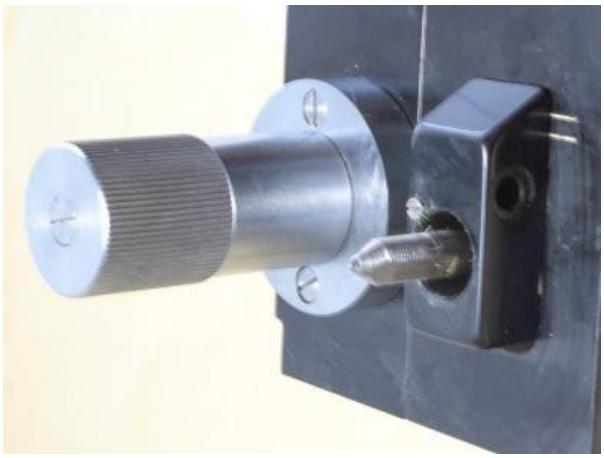

Figure 20: The coarse focus lock cover (to the right in the image) with the coarse focus axle sticking out (the knob has been removed.)

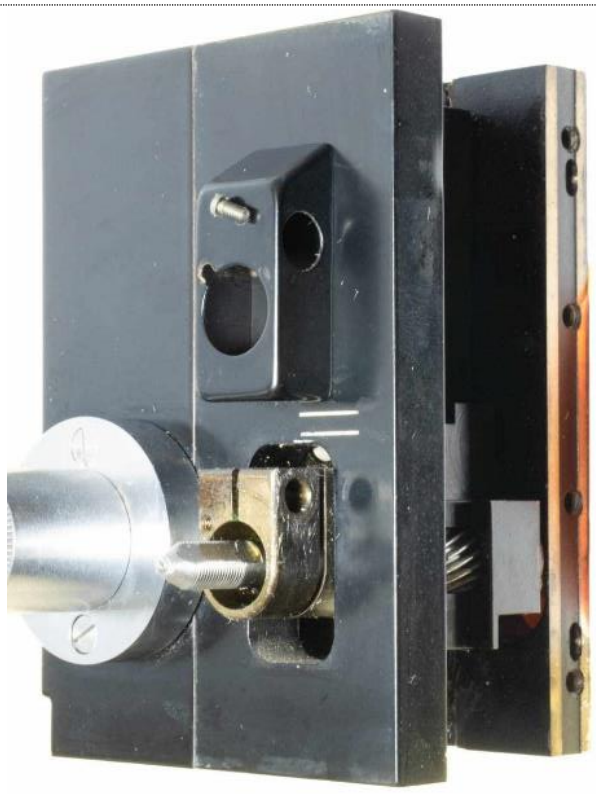

Figure 21: The coarse focus lock cover after removal showing the focus lock clamp. (The cover is shown loosely placed above the clamp.)

The coarse focus lock mechanism is now visible (Figure 21) – it is just a clamp around the inner part of the left coarse focus knob (brass colored in Figure 19.) It is tightened by turning the lock lever (*Figure 3*) thus preventing the coarse focus control from moving.

Remove the fine focus center bearing guide

We still need to disassemble the coarse focus axle which sits in the fine focus center bearing guide (Figure 14.) And to remove that guide, we first need to remove the left bearing guide from the base of the fine focus block (Figure 4 and Figure 22.)

Begin by removing the four screws (with red circles in Figure 18) from the backside of the base. Now it should be possible to remove the left bearing guide from the base, perhaps with the help of some wiggling. The two tension adjustment screws (with orange circles in Figure 18, also see Figure 11) don't need to be removed, but it may help to ease the tension over the fine focus center bearing guide by trying to rotate them slightly. The fine focus axle guide below the left fine focus knob (Figure 22 and Figure 28) is also somewhat in the way as it sticks out 3-4 mm over the left bearing guide.

Together with the left bearing guide also remove the now freed fine focus center bearing guide and collect the retainers and balls from both linear ball bearings. These ball bearings are identical to those in the coarse focus slide. Clean all bearing balls, retainers, and races with solvent, similarly as was previously done with the coarse focus slide (section Clean the disassembled parts from old grease.)

The back side of the fine focus center bearing guide has a radial ball bearing (Figure 23) which acts as the coarse focus block's receiving point of the fine focus setting as determined by the fine focus control. This ball bearing doesn't need to be removed and it also appears that it doesn't need any grease other than along the outer edge.

Figure 24 shows a view of the fine focus mechanism in the base of the fine focus block after the fine focus center bearing guide has been removed.

Figure 22: The base of the fine focus block and the left bearing guide.

Figure 23: The back side of the fine focus center bearing guide.

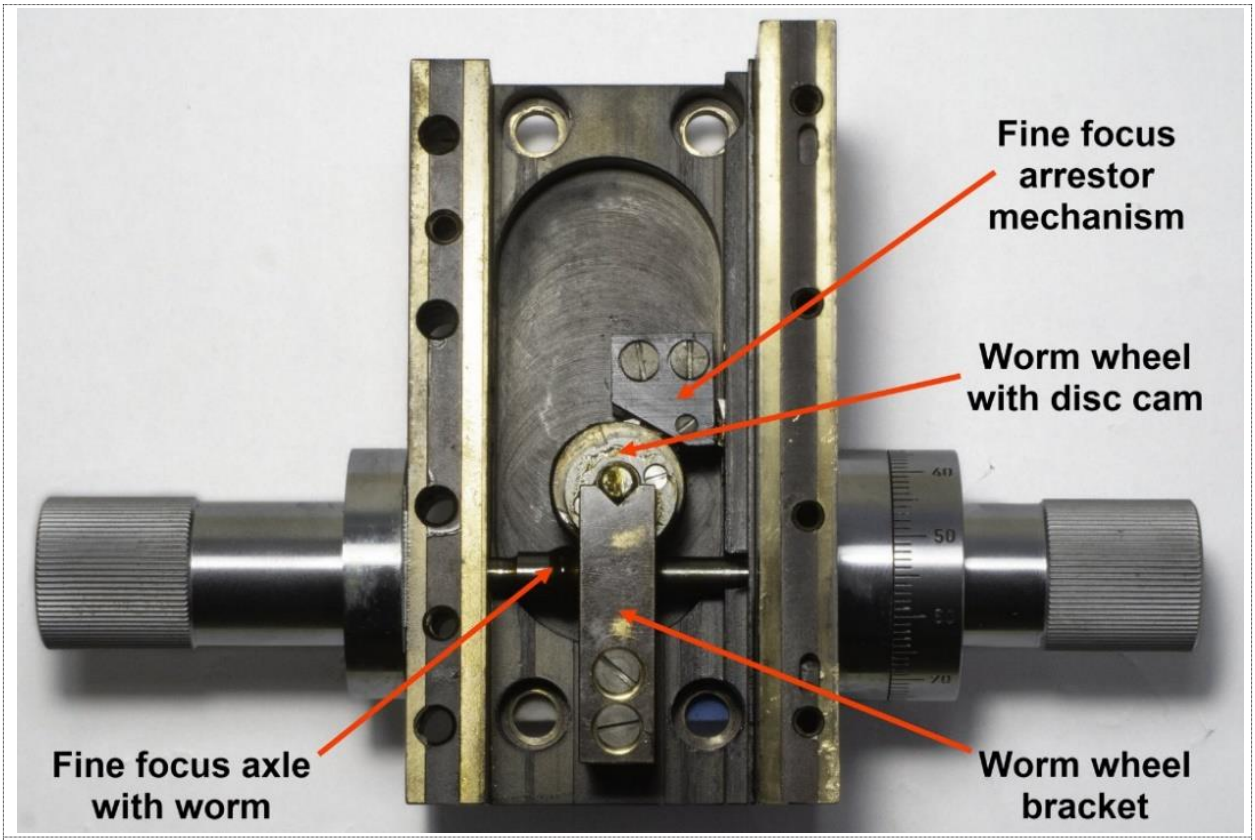

Figure 24: The fine focus mechanism after the fine focus center bearing guide has been removed.

Disassemble and clean the coarse focus axle

The single plastic washer under the right knob was mentioned above, now we need to turn our attention to the left side of the coarse focus axle (Figure 25).

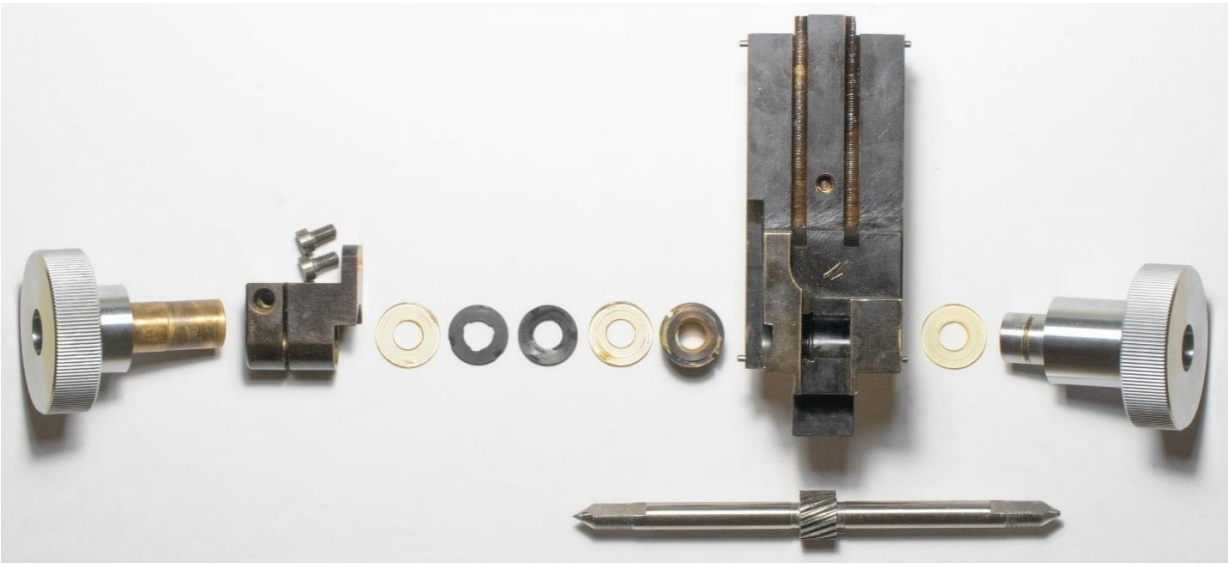

Figure 25: The fine focus center bearing guide with removed and disassembled coarse focus axle and knobs. The parts are in the same order as they appear on the axle, from the left to the right side:

- *Left coarse focus knob (the nut in the center of the knob is not shown)*
- *Focus lock clamp (Figure 21), including the two screws that attach it to the left side of the fine focus center bearing guide*
- *Transparent plastic washer*
- *Tooth lock washer, black steel, three teeth on the outside, three indents on the inside*
- *Tooth lock washer, black steel, three teeth on the outside, three teeth on the inside*
- *Transparent plastic washer*
- *Locking nut*
- *Fine focus center bearing guide, and below it the coarse focus axle*
- *Transparent plastic washer*
- *Right coarse focus knob (the nut in the center of the knob is not shown)*

Remove the two screws that hold the focus lock clamp attached to the fine focus center bearing guide and pull of the clamp. Retrieve the four washers below but notice how the two black tooth lock washers are assembled – with the convex sides facing each other and with the outer teeth gripping into the plastic washers on both sides. It appears that the adjacent plastic washers easily are slightly deformed due to these nabs. All three plastic washers have the same measures: 1.0 mm thick, 6.1 mm inner diameter, 14.0 mm outer diameter.

Figure 26: Pin-face spanner – a special tool for microscope service

The next item to remove is the locking nut that keeps the coarse focus axle in its correct lateral position. It has two small holes on the surface and requires a special tool, a pin-face spanner, for removal (Figure 26). The nut appears to be quite tight, so to save the spanner pins from breaking due to excessive torque it may be a good idea to treat the nut threads with some penetrating oil and then to heat it with a heat gun to approx. 50-60°C (120-140°F) before attempting to loosen it.

Once the nut is removed the coarse focus axle can be pulled out from the left side. The axle is left-right symmetric, so there is no need to keep track of which side is the left vs. the right.

The sliding surfaces of the axle (inside the locking nut, inside the plain axle bearing on the right side of the fine focus center bearing guide, and on adjacent surfaces of the axle), plus all washers need to be cleaned from old grease. Use solvent and procedures described previously.

Remove and clean the fine focus knobs and axle

The fine focus knobs are attached to the ends of the fine focus axle and secured by a long screw through the knob center. The axle ends are slightly tapered (Figure 31) to define how far down on the axle the knobs should sit. The axle ends are also hollow and have threads on the inside to hold the long screws. The screw drives (e.g., the slots in the screw heads) are very narrow why I had to custom grind the tip of a regular 6 mm screwdriver to make it fit.

The ”hammer and steel rod” hack used previously (section Remove the coarse focus control knobs) to remove the coarse focus controls is not suitable for the fine focus knobs because the fine focus mechanism’s worm gear is very vulnerable to damage from blows to the fine focus axle.

The insides of the knobs have threads that on first sight doesn’t appear to have any function. It has however been suggested that Leitz technicians used to have a special tool, some kind of screw, which would use the threads and act as a jack to gently pry off the knobs from the axle. We will borrow this idea to put together a simple tool for removal of the fine focus knobs. The following parts are needed (Figure 27):

- An M5x20 screw with an Allen or hex head
- An Allen or hex key which fits the M5x20 screw
- A steel rod, diameter 3.7-3.8 mm, length 16-17 mm

Figure 27: The tool used to remove the fine focus knobs.

The steel rod is required because the threads on the inside of the knobs don’t go all the way down to the axle tip. The rod can be made by cutting a suitable nail or a thread free section of a long screw with a suitable diameter. Both the diameter and the length of the rod are critical. If the rod is too thick it may get stuck in the threads inside the knob and damage them, if it is too thin it may damage the hollow end of the fine focus axle. If the rod is too short the M5x20 screw will bottom out in the threads before the axle has been released from the knob, if it is too long there will be less threads in the knob available to distribute the force required to pry out the axle.

Start by removing the screws in the center of the fine focus knobs. Then turn the fine focus knobs to a setting close to the midpoint of the fine focus range. This is to safeguard the worm and the teeth of the worm gear from damage during the knob removal – we don’t want to accidentally force the worm wheel to move beyond the range allowed by its fine focus arrestor mechanism. Therefore, turn the fine focus control in any direction until it stops, then turn it back full 12 turns to reach the midpoint.

Put a few drops of penetrating oil (for example, WD-40) into the empty screw hole in the middle of the left knob and let the oil work for one or a few days.

Pour out any excess of penetrating oil from the inside of the knob. Put grease on the threads on the inside of the knob, a toothpick may help to distribute the grease over all threads. Also cover all threads of the M5x20 screw with grease. The grease is important to prevent the screw from seizing under the load. Heat the outside of the inner narrower part of the knob (that's where the axle is attached) with an electric heat gun. Continue to heat the knob until it is too warm to the touch (approx. 50-60°C, or 120-140°F). Put the steel rod into the screw hole and attach and screw down the M5x20 screw until it reaches the steel rod. Hold the warm knob firmly with one hand (use gloves) and use the Allen (or hex) key to slowly tighten the M5x20 screw until the axle releases from the knob. There is a small axial ball bearing between the knob and the fine focus axle guide (Figure 32), be sure to retrieve all of its parts. The bearing consists of two bearing races made of steel (each 0.6 mm thick, inner diameter 4.6 mm, outer diameter 9.0 mm), a bearing retainer made of brass (0.5 mm thick, inner diameter 4.6 mm, outer diameter 9.0 mm, with 12 holes for the bearing balls), and 12 very small (1 mm) bearing balls.

Repeat the procedure to remove the right knob. It has a similar ball bearing as the left knob, but with an additional spring (Figure 32) between the bearing and the fine focus axle guide.

Remove the left and right fine focus axle guides which are under the knobs (Figure 28.) Each guide is attached by two screws and two small pins that ensure proper alignment. The pins stick snugly to the fine focus block (Figure 30) and the insides of the guide axle holes fit tightly to the fine focus axle acting as plain bearings. Therefore, some gentle tapping with a small plastic hammer may be needed to release and remove the axle guides.

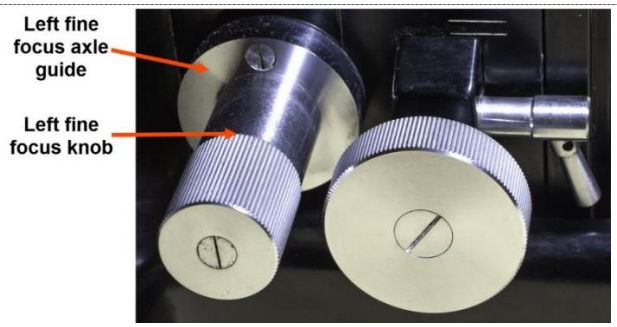

Figure 28: The left fine focus knob and axle guide.

Figure 29: The left and the right axle guides which sit between the fine focus knobs and the fine focus block. The upper image shows their outer surfaces, the lower image shows their inner surfaces.

Figure 30: The right side if the fine focus base showing where the right axle guide was attached.

The axle guides are not identical; for example, the outer side of the right axle guide has a narrow circular slit that fits to the spring, while the inner side of the left axle guide has a cut-out that matches its overlap on the left fine focus bearing guide (Figure 29.)

Once the axle guides are removed the fine focus axle can easily be pulled out (Figure 31).

Figure 31: The fine focus axle. The axle ends are tapered where they are attached to the fine focus knobs and have threads on the inside. Note the pin to the right of the worm – it is part of the fine focus arrestor mechanism.

Finally remove old grease and clean all parts (Figure 32) with a suitable solvent. Optionally, the grooves on the periphery of the fine focus knobs may be cleaned by soaking in warm water with dishwashing detergent and brushing along the grooves with a hard toothbrush.

Figure 32: The disassembled fine focus axle with guides, bearings, and knobs. The parts are in the same order as they appear on the axle, from the left to the right side:

- *Left fine focus knob (the long screw in the center of the knob is not shown)*
- *Left axial ball bearing with two races and one retainer (the balls are not shown)*
- *Left fine focus axle guide*
- *Fine focus axle (note that it is not right-left symmetric)*
- *Right fine focus axle guide*
- *Spring between the right guide and the right axial ball bearing*
- *Right axial ball bearing with two races and one retainer (the balls are not shown)*
- *Right fine focus knob (the long screw in the center of the knob is not shown)*

Disassemble and clean the fine focus mechanism

Once the knobs and the fine focus axle have been removed the fine focus mechanism is easy to access (Figure 33).

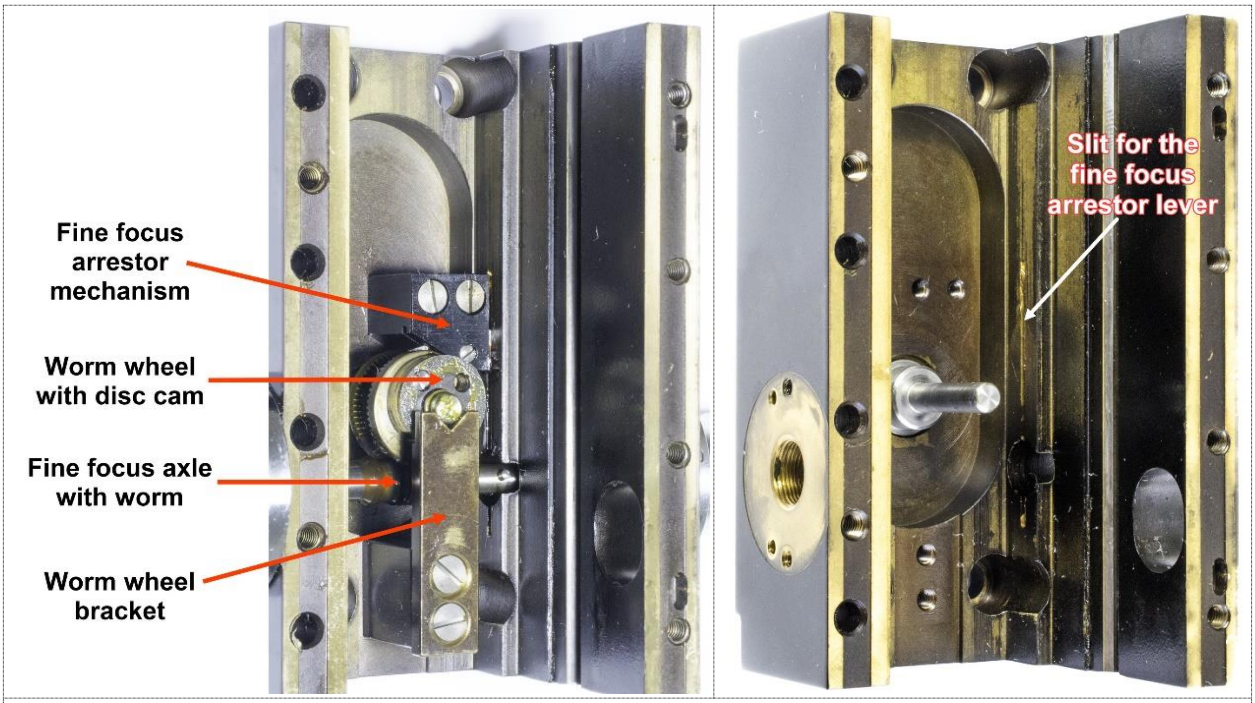

Figure 33: The fine focus base. The left image shows it complete, including the fine focus mechanism; the right image shows it with everything removed except for the worm wheel axle.

The worm gear with the disc cam is the heart of the fine focus mechanism. The worm wheel sits on the worm wheel axle that sticks up perpendicularly from the base. Just below the worm wheel is first a shoulder washer (with the shoulder facing upwards) and then further down a spring (Figure 35). When the fine focus control is turned 25 full turns, the worm gear slows down the turning rate so the worm wheel only makes just below half a turn. The disc cam attached to the top of the worm wheel converts this half turn to an approx. 3 mm vertical movement that is relayed to the coarse focus block through the radial bearing on the back side of the fine focus center bearing guide (Figure 23.) The worm wheel bracket is a simple arm on a rectangular spacer (Figure 33 and Figure 35) that holds the worm wheel in place (although this seems redundant because the worm on the fine focus axle already does that.) There is also a fine focus arrestor (Figure 33 and Figure 34) that prevents the fine focus controls to be turned beyond the designated 25 turn range. It has an L shaped lever where the short end is pushed by a small spring into a groove in the side of the worm wheel (Figure 36). The groove is arranged in such a way that any time the worm wheel reaches the ends of the focus range, the lever arm also reaches the end of the groove and is forced out of it thereby moving the other end of the lever in the way of the pin on the fine focus axle (Figure 31) which blocks any further rotation of the axle.

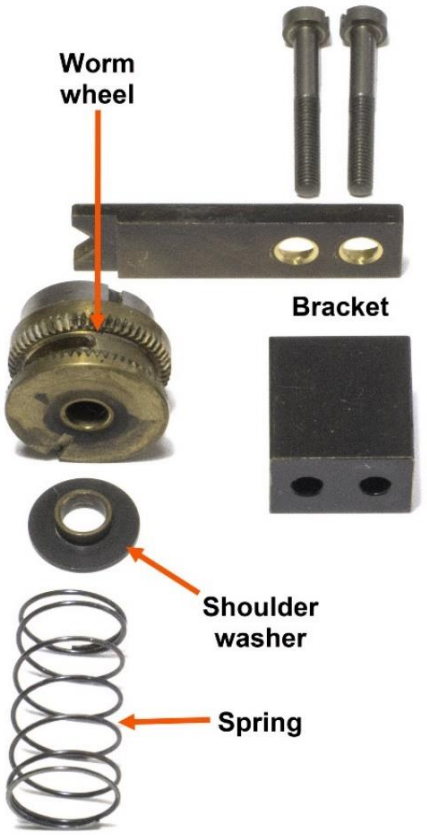

Figure 35: The part of the fine focus mechanism which is attached on the worm wheel axle.

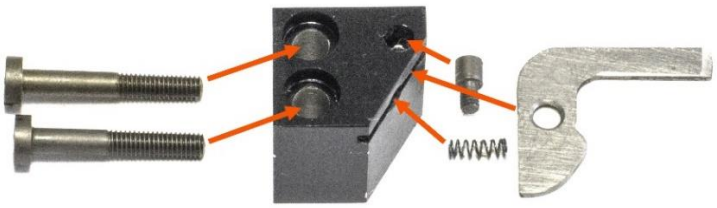

Figure 34: The fine focus arrestor (disassembled.) The arrows indicate where the different parts are attached.

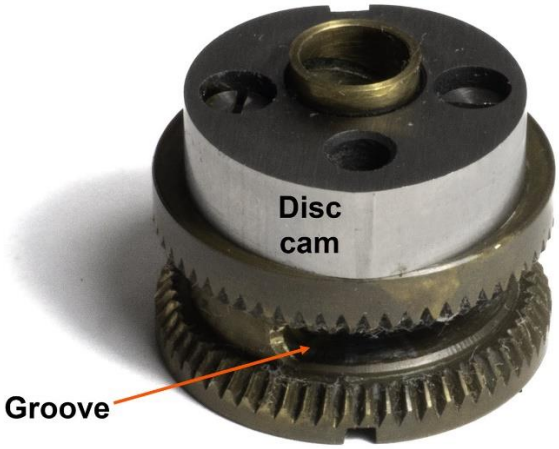

Figure 36: The worm wheel.

Remove first the fine focus arrestor and then the worm wheel bracket. Use solvent to clean all parts from old grease.

This concludes the picking apart and the cleaning of the focus mechanism. We are ready to proceed with greasing and reassembling.

Grease and reassemble the fine focus mechanism

Grease all surfaces, outsides and insides, of the components on the worm wheel axle (Figure 35) – the spring, the shoulder washer, the worm wheel and don't forget the worm wheel axle. Leave the bracket to the side for now. Make the grease layer extra thick on the worm wheel teeth. Assemble the parts on the worm wheel axle. The shoulder washer should sit with the shoulder up, or in other words, with the flat side down. Turn the worm wheel so the tip of the cam points to the right.

Apply grease on all sliding surfaces of the fine focus axle (Figure 31) and the center holes of both axle guides (Figure 29). Attach the right axle guide with its screws to the base. Put the fine focus axle from the left side into its position with the right end through the right axle guide and with the worm between the teeth of the worm wheel. Make sure that the focus axle's arrestor pin (Figure 31) is on the right side of the worm. Attach the left axle guide with its screws to the base with the fine focus axle sticking through it. Hold the axle centered with your fingers (it can still move sideways because the knobs have not yet been attached) and check that it rotates freely. Rotate the axle to make the tip of the cam to point to the right side again.

Grease the small spring (Figure 32) and put it into the circular groove in the right axle guide.

Assembling the right knob's ball bearing (Figure 32): Put the right fine focus knob on the table with the bearing side up. Grease both sides of one of the bearing races (it looks like a washer) and put it down into the knob's bearing groove with the shiny side facing upwards. Grease the bearing retainer allowing some grease to reach into the holes for the balls. Put the retainer on top of the race. 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 another bearing race and carefully put it on top of the retainer with the balls and with its shiny side facing 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.

Assembling the left knob's ball bearing (Figure 32): 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 both sides of one bearing race and put it with the shiny side up into the bearing groove of the left axle guide. Proceed as above by adding the bearing retainer, the bearing 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 ends. Be careful not to disturb the ball bearings, and also to keep the fine focus axle centered. Push the knobs all the way as far as they go, and then keep them pressed together with one hand – otherwise the small spring under the right bearing will push them apart which may jeopardize the bearings. Still keeping the knobs pressed together, attach the two long knob screws into the center of the knobs and tighten them. Once the screws on both knobs are tightened you can loosen your grip over the knobs. Check that the fine focus knobs still rotate freely.

Grease all sliding surfaces of the fine focus arrestor components (Figure 34), i.e., the entire lever, the small spring, the slit where the lever is attached, and the slit in the right side of the base (Figure 33) where the long lever arm rests when it's not blocking the fine focus. Assemble the parts and attach them to the base. Make sure that the short arm sits properly in the groove of the worm wheel. Before the two screws that attach the fine focus arrestor to the base are tightened, we need to do some

alignment. If the focus arrestor is too close to the worm wheel the arrestor mechanism may be too slow to release when the fine focus knobs are turned the other direction again. This would abruptly stop the fine focus after only one turn in that direction, a very irritating malfunction. To prevent that from happening, attach the two screws to just before they tighten. Push the arrestor mechanism upwards as far as it goes (i.e., away from the worm wheel - the screws allow for approx. 1 mm of play) and now tighten the screws. Turn the fine focus control repeatedly to both end points of the fine focus range to check that the focus arrestor works properly.

Attach the bracket (Figure 35) on top of the worm wheel.

Put a thin layer of grease on the periphery of the cam on top of the worm wheel.

We will now turn our attention to the fine focus center bearing guide with its coarse focus axle.

Grease and reassemble the fine focus slide

Grease the plain bearing (i.e., the hole for the coarse focus axle) on the right side of the fine focus center bearing guide (Figure 25). Grease the axle surface that slides against the plain bearing and attach it through the bearing into the fine focus center bearing guide. The axle is symmetric, so there is no need to worry which side is left and which is right.

Grease the inside of the locking nut (Figure 25, the nut functions as the left plain bearing for the coarse focus axle.) Tighten if with the pin-face spanner (Figure 26.)

Grease and attach one transparent washer over the right side of the coarse focus axle on the side of the center baring guide. The grease will prevent it from falling off.

Grease and attach the four washers according to Figure 25 over the left side of the coarse focus axle on the side of the center baring guide. Also attach the focus lock clamp. Don’t yet attach the knobs.

Grease generously the four bearing races involved in the fine focus slide: The races on each side of the fine focus center bearing guide, the corresponding race on the right side of the base of the fine focus block, and the inner race of the left bearing guide. Refer to Figure 4.

Use a suitable support to put the fine focus base on its right side so the greased race faces up. Grease one of the linear bearing retainers (Figure 13) on both sides allowing some grease to reach into the holes for the balls. Put the retainer on the race of the fine focus base approximately 15 mm from the top.

Grease a second linear bearing retainer on both sides allowing some grease to reach into the holes for the balls. Put the retainer on the lower race of the left bearing guide approximately 15 mm from the top.

Use tweezers to pick the 3.5 mm bearing balls and place them into the retainer holes of both bearings. Use a toothpick to push them fully down into the holes and align them in the race. Check that all bearing balls are present and properly seated.

Put the fine focus base on its back on the table.

Now the task is to join and fix the two bearings of the fine focus slide. “Joining” a bearing is the procedure of aligning and putting together the two greased bearing races so the retainers and balls get properly enclosed between the races. After joining, the bearing is fixed with screws to prevent it from falling apart. It’s important not to allow the bearing races to separate until the bearing has been fixed. If

the bearing separates, the balls may dislodge and end up where they shouldn't be, which jeopardizes the bearing and is impossible to check without taking the bearing apart. With the fine focus slide we need to join not only one, but two bearings, one of each side of the fine focus center bearing guide. Keeping the bearings joined until they can be fixed with the screws requires some dexterity, why it may be a good idea to first practice a few "dry joins", i.e., without grease, retainers, and balls.

Join the left bearing by carefully placing the left race of the fine focus center bearing guide against the inner race of the left bearing guide. Holding the guides joined with your hands move one of the guides a few mm back and forth to check that the bearing is working. Keep holding the guides joined with your hand and proceed to joining the right-side bearing. Place the joined left bearing in your hand into the middle of the fine focus base so the race on the right side of the centre guide is pressed against the race on the right side of the base. Let the left side of the joined bearing in your hand slip down so it comes down to rest on the left side of the base. It may require some careful wiggling to get it past the partly sticking out left axle guide, but once that is done, the axle guide will help to keep the bearings joined. Still holding the bearings joined insert the four large screws from the backside of the base (red circles in Figure 18) and tighten them lightly to attach the left bearing guide to the base. Now you can relax and let go of manually holding the bearings together. Adjust the tension of the four large screws so the left guide is snugly attached to the base but still can move laterally (sideways). Insert the two screws with excentric tips (Figure 11) into the screw holes indicated with orange circles in Figure 18. Turn the excentric screws until a suitable tension is applied across the bearings; the fine focus slide (center guide) should move freely up and down (within the fine focus range of only a few mm), just barely slightly restrained by the tension applied. This is a trial-and-error exercise, it takes some going back and forth adjusting the tension with the two excentric screws, testing the fine focus slide movement, and fixing the left bearing guide to the base with the four large screws. When finished, the slide should move freely, or minimally restrained, and the left guide should sit tightly attached to the base with the four large screws.

Grease and reassemble the coarse focus slide

Attach the coarse focus lock cover (Figure 20 and Figure 21) – it is attached by only one small screw on the top of the cover.

Put a thin layer of grease into the axle holes on the inner sides of the coarse focus knobs and also on the brass surface on the outside of the left knob. Attach the coarse focus knobs, making sure not to confuse the left and the right knob (Figure 19.) Press the knobs together onto the coarse focus axle as far it goes until there is no sideways play of the axle. This may require a certain amount of force over the knobs and can be accomplished by putting the focus block with one of the knobs facing down resting on a suitable (soft) support and pressing down on the other knob. Check that the coarse focus axle rotates freely and then attach the nuts into the centers of the knobs.

Next step is to attach the focus mechanism to the microscope stand. For better access remove the filter holder in the microscope foot, just below where the condenser would sit. Attach the focus assembly to the microscope stand by the four robust M5x15 screws (Figure 16) using a good quality screwdriver with a well-fitting tip and an enough long shaft. Tighten the screws well – the focus mechanism with the stage and condenser attached will be heavy.

Apply grease on the coarse focus buffer springs (Figure 15) and put them into the channels in the fine focus center bearing guide with the knobs facing upward (Figure 14.)

Don’t yet attach the buffer receiver. Apply grease sparsely to the surface of the coarse focus rack.

Grease generously the four bearing races involved in the coarse focus slide, i.e., the races on each side of the coarse focus center bearing guide, the race on the left bearing guide (which now is attached to the microscope, Figure 14), and the race of the right bearing guide (Figure 10.)

Put the microscope with its left side down on the table (in this way it’s easier to prepare the left bearing.) Grease one of the linear bearing retainers (Figure 13) on both sides allowing some grease to reach into the holes for the balls. Put the retainer on the race of the left bearing guide approximately 15 mm from the top.

Grease the remaining linear bearing retainer on both sides allowing some grease to reach into the holes for the balls. Put the retainer on the race of the right bearing guide approximately 15 mm from the top.

Use tweezers to pick the 3.5 mm bearing balls and place them into the retainer holes of both bearings. Use a toothpick to push them fully down into the holes and align them in the race. Check that all bearing balls are present and properly seated.

Put the microscope back into its normal upright position. The bearing retainer and the bearings balls will stick to the grease which prevents them from falling off.

Now everything is prepared for joining and securing the two bearings of the coarse focus slide. The procedure is very similar to what was done with the fine focus slide, but no worries, the coarse focus slide is much easier to handle than the fine focus slide. It’s however still important not to allow the bearing races to separate until the bearing has been fixed.

Begin by checking Figure 8, Figure 9 and Figure 12 to understand the correct orientation (upside vs. downside, front vs. backside, and right side vs. left side) for assembling the coarse focus center bearing guide. Join the left side bearing first by carefully placing the race of the coarse focus center bearing guide against the race of the left bearing guide. Place the center guide a few mm lower than the left guide. The rack and pinion for the coarse focus will prevent the center guide from sliding up or down. Keep holding the left bearing joined with your hand and proceed to join the right-side bearing. Grab the right bearing guide with the recessed screw holes facing you (the screw holes on the backside are not recessed), position it vertically aligned with the base and press its race against the right race of the center bearing guide. Still holding the bearings joined insert the four large screws into the right bearing guide and tighten them lightly. Now the screws will hold the bearings joined and you can loosen your grip. Adjust the tension of the four large screws so the right guide is tightly attached to the base but still can move laterally (sideways). Insert the two screws with excentric tips (Figure 11) and screw them as far as it goes; it is important that the screws go deep enough so the heads don’t stick up above the surface of the right guide. Adjust the screws until a suitable tension is applied across the bearings; the coarse focus slide (center guide) should freely move up and down, but without any play. As before with the fine focus slide, it’s a trial-and-error exercise going back and forth adjusting the tension with the two excentric screws, testing the coarse focus slide movement, and fixing the right bearing guide to the base with the four large screws. When finished, the coarse focus slide should move freely without any play and the right guide should sit tightly attached to the base. Also check that the heads of the excentric screws still don’t stick up above the surface of the right guide.

To attach the coarse focus buffer receiver (Figure 12), turn the coarse focus to its highest position. Place the buffer receiver with its two arms positioned just on top of the buffer springs and press it down with the arms sliding into the grooves with the buffer springs. The force from the springs will make the receiver to tilt forwards which makes it difficult to attach with the screws without damaging the threads.

The tilt can be mitigated by pressing the buffer receiver down with a screwdriver put on top of one of the receiver arms just above the springs. Press the receiver down with the screwdriver, peek through the screw holes in the center bearing guide to see when the receiver's screw holes are properly aligned, attach the two screws, and tighten them. It also helps to dab a little grease on the tips of the screws.

Lightly grease the threads of the coarse focus lock lever (Figure 3) and screw it into the clamp at the left coarse focus knob. Turn it clockwise as far as it goes and then turn it slightly back so the lever points down.

Slide the shield (Figure 8 and Figure 9) down into its grooves in the coarse focus center bearing guide.

Turn the microscope on its back with the hollow bottom facing you. Grease the fine focus buffer spring (Figure 6), put it into its opening in the bottom of the focus block, and attach the bottom cover. The screws for the bottom cover are of the same size as the screws for the top covers, but the top cover screws have black heads that look nicer than the bottom cover screws with their gray steel heads.

Attach both top covers (Figure 5) to the microscope.

Attach the front plate (Figure 7) to the center bearing guide - be careful not to attach it upside-down. Remember, if applicable, to return any shims in the same way as they originally appeared between the front plate and the center bearing guide.

Put back the filter holder into the foot of the microscope stand.

Attach the stage.

The microscope is ready for use.