Leitz 600 Series Condenser – Maintenance

Introduction

Leitz 600 series condenser (a.k.a. the “bathtub condenser”) is a centerable brightfield condenser with an aperture diaphragm and an interchangeable swing-out top element (Figure 1, Figure 2 and Figure 5.) Around 1963 it replaced the Berek condenser as Leitz’ general system condenser. It has a dovetail mount that makes it easily interchangeable on most of the later Leitz microscopes with 170 mm mechanical tube length (the later “black era” and the “gray era” microscopes.) The aperture diaphragm consists of 15 blades and is situated quite high up in the condenser house just below the primary condenser lens (Figure 1.) Through the years the condenser underwent some minor technical and design variations. The bare condenser house (Leitz mod. no. 600) was the basic component and could then be outfitted with a selection of different top elements and other auxiliary accessories to suit different microscopy conditions. The table below shows the available top elements and their model numbers:

Mod. no.	Top element print	Description of use	n.a. *
001	0.90 As	Aspherical, dry	0.90
002	Achr 0.90	Aspherical-achromatic, dry	0.90
003	Apl Oel 1.25	Aplanatic, oil immersion	1.25
004	Oel 1.33	Achromatic-aplanatic, oil immersion	1.33
005	Achr 0.70/L4	Achromatic, for long working distances	0.70
006	0.60/L11	For long working distances	0.60
007	0.45/L20	For long working distances	0.45
008	0.30/L35	For long working distances	0.30
009	Achr Oel 1.40	Achromatic-aplanatic, oil immersion	1.40
010	Oel 1.25	Oil immersion	1.25

* n.a. = numerical aperture

The model numbers for the complete condensers indicated the identity of the included top element, e.g., condenser no. 602 comprised the no. 600 condenser house equipped with top element no. 002.

The condenser house without any top element in the optical path has a n.a. of 0.25 and is suitable for use with objectives of up to n.a. 0.25. Any objective with higher n.a. requires that one of the top elements is switched into the optical path. The interchangeable top elements are attached by a thread in a swing-out yoke (Figure 2) on the top of the condenser.

Certain adapter lenses (Figure 3 and Figure 4) were available for use with some microscope models to compensate for different distances between the field diaphragm and the condenser. These lenses were attached into the bottom of the condenser.

An optional filter holder with slots for two filters was available for attachment to the bottom of the condenser (Figure 6 and Figure 7).

Condenser centering is accomplished with a regular two-knob centering mechanism.

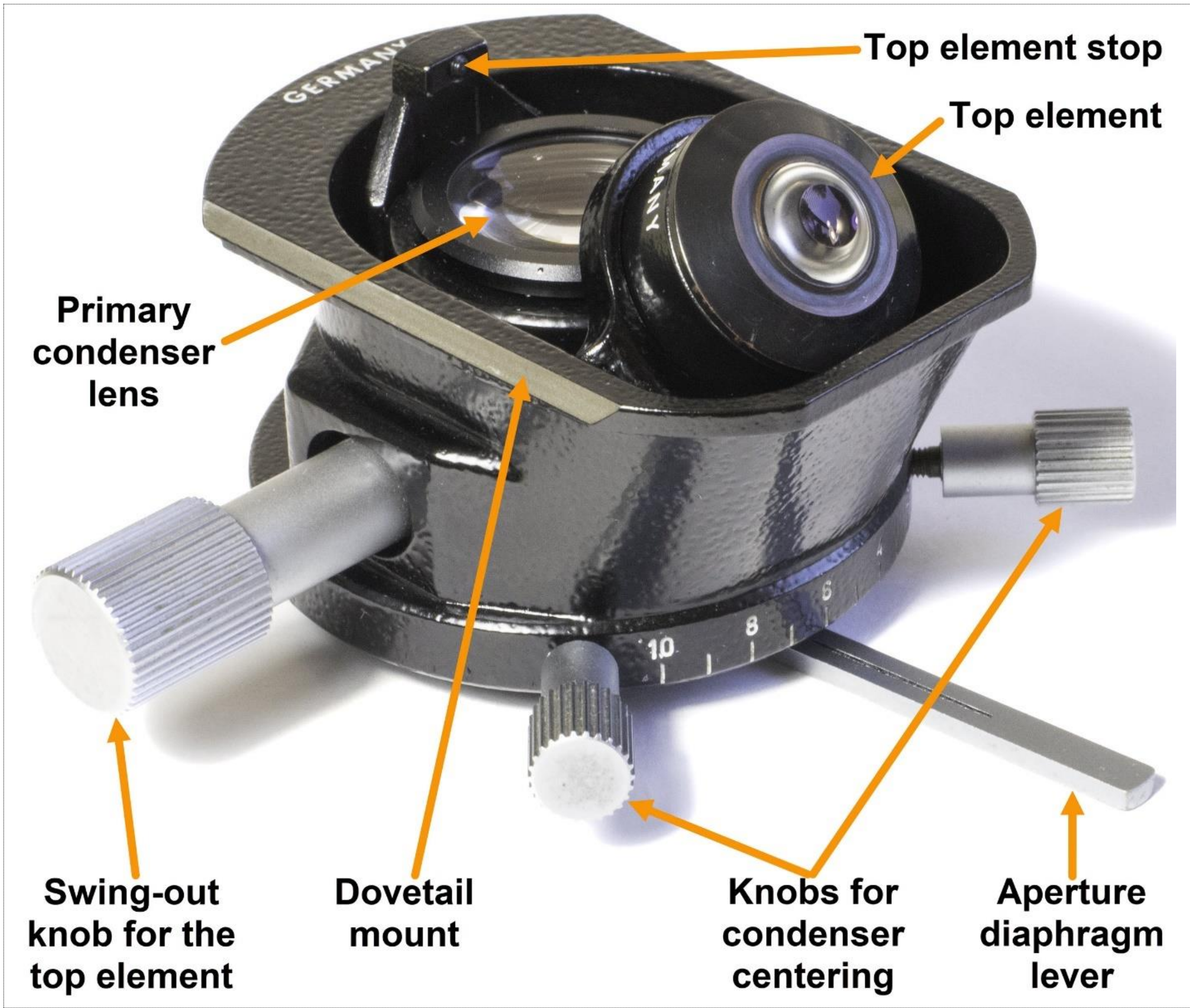

Figure 1: A Leitz series 600 condenser with the swing-out top element folded to the side.

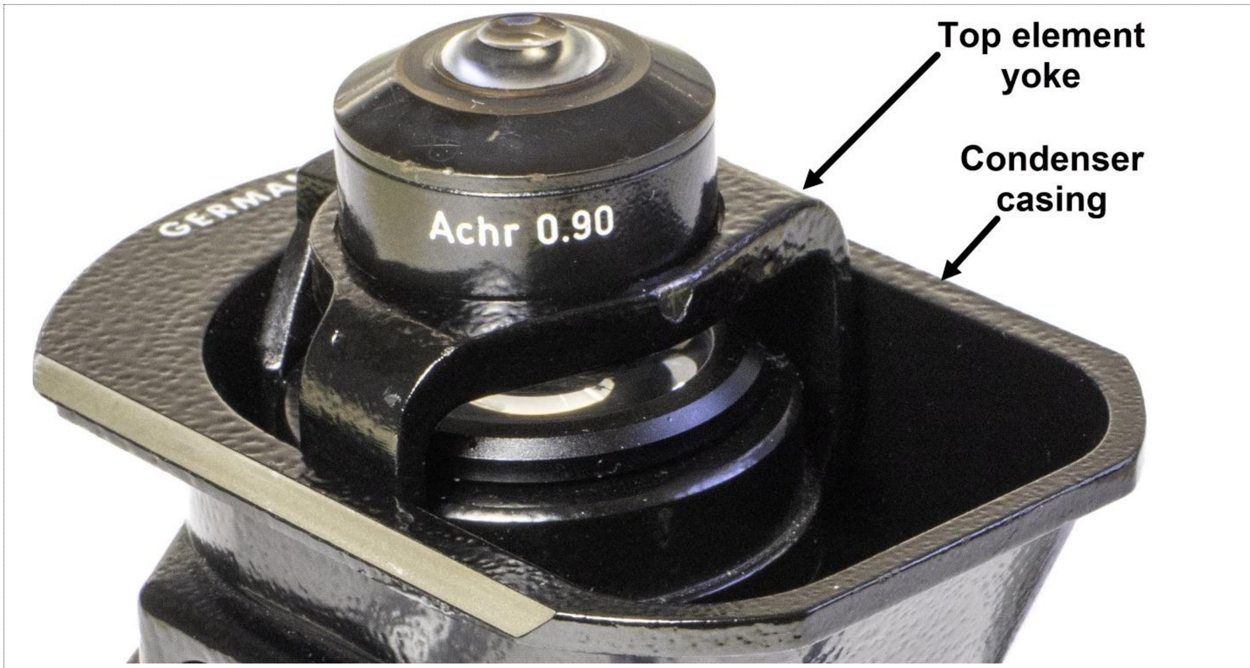

Figure 2: The upper part of the condenser with the top element switched into the optical path.

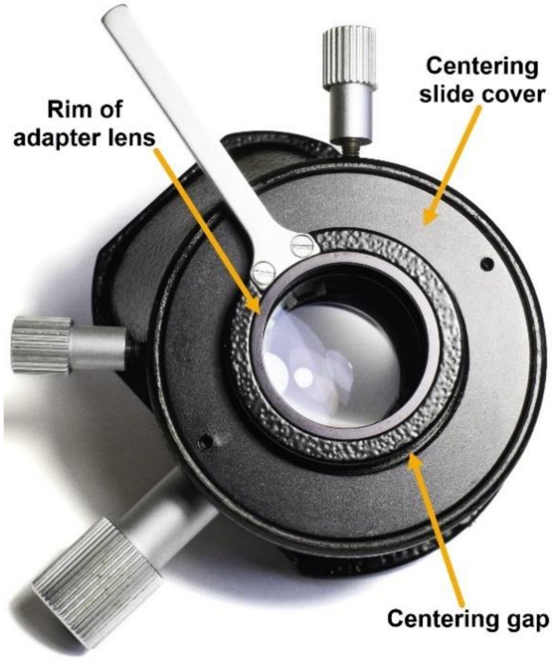

Figure 3: A 600 series condenser viewed from below.

Figure 4: A series 600 condenser with removed adapter lens.

Figure 5: Three different condenser top elements.
Left: Aplanatic, n.a. 1.25, oil immersion.
Middle: Aspherical-achromatic, n.a. 0.90, dry.
Right: Aspherical, n.a. 0.90, dry.

Leitz also manufactured a very similar 700 series of condensers tailored for applications using illumination with polarized light.

For some of the “gray era” microscopes (e.g., Leitz HM-LUX) Leitz manufactured a condenser similar to the 600 series condenser, but without the built-in centering mechanism as these microscopes had the centering mechanism integrated in the condenser holder. Apparently, it was sold as the “300 series” condenser. From the outside It looks confusingly similar to the 600 series condenser, the most conspicuous difference is that it lacks the two centering screws. Be aware of this if you need to buy a used condenser.

Figure 6: Separate filter holder with slots for two filters.

Figure 7: The filter holder clamped to the underside of a series 600 condenser.

Scope

Older microscope condensers may typically be dirty and suffer from sluggish or frozen aperture diaphragms and condenser centering controls. One common problem is accidental contamination with immersion oil. Another often observed issue is that the black paint applied on the top element's sloped sides has been compromised or even removed (Appendix 1), probably as a result of cleaning with harsh solvents.

These maintenance notes describe the disassembly, cleaning and regreasing of the Leitz series 600 condenser.

Be aware that there may be design variations between series 600 condensers due to product development through the several years when they were manufactured.

Some Special Equipment

Adjustable face pin spanner (Figure 8, a.k.a. face pin wrench, pin face spanner, etc.), with replaceable pins of varying sizes up to 3 mm diameter. Very useful, even indispensable, but typically expensive.

Camera lens spanner (Figure 9), with various, exchangeable tips. It is a somewhat inferior alternative to a face pin spanner. Usually affordable. Unfortunately prone to slipping.

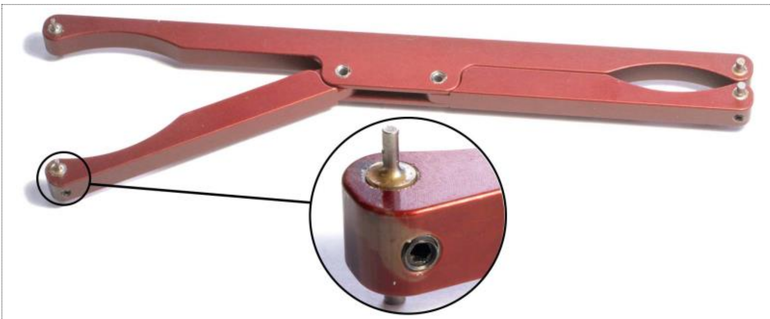

Figure 8: Face pin spanner with interchangeable pins.

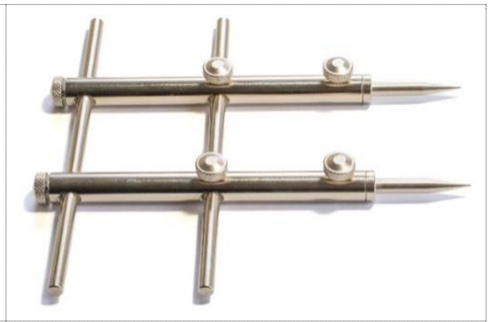

Figure 9: Camera lens spanner, with pointed tips.

Jar opener(s), various designs, one model that covers several diameters is shown in Figure 10, rubber lined. Available in kitchen utensil shops. Try to find an opener where the rubber lining provides good friction (e.g., silicon rubber is less suitable as it typically is slippery.) The jar opener is useful to release sensitive items that are stuck in their threads and difficult to get a good grip on.

Figure 10: A common jar opener design.

Strap wrench (Figure 11.) Provides a good grip and good torque around cylindrical and slippery surfaces. Available in various sizes - get the smallest size you can find.

Figure 11: An example of a strap wrench (wrapped around an eyepiece.)

Grease: *Mobilgrease 28* or *Super Lube Multi-Purpose Synthetic Grease with Syncolon (NLGI grade 2)* for lubrication of the condenser's moving parts. Other greases can certainly be used as well.

The Aperture Diaphragm

As hinted above the aperture diaphragm consists of 15 black steel blades (Figure 25) and sits just below the primary condenser lens (Figure 1.) Both ends of every blade have small pivot pins (1.6 mm wide and 1.0-1.1 mm deep) on opposite sides of the blade (Figure 12.) The pivot pins in the rounded end of the blade ("B" in Figure 12) fit into holes in the stationary diaphragm base (Figure 23), while the pivot pins in the end with two rounded corners ("A" in Figure 12) fit into slots in the rotating diaphragm actuator (Figure 22.) The actuator is turned by the aperture diaphragm lever (Figure 1) which determines the opening (aperture!) of the aperture diaphragm.

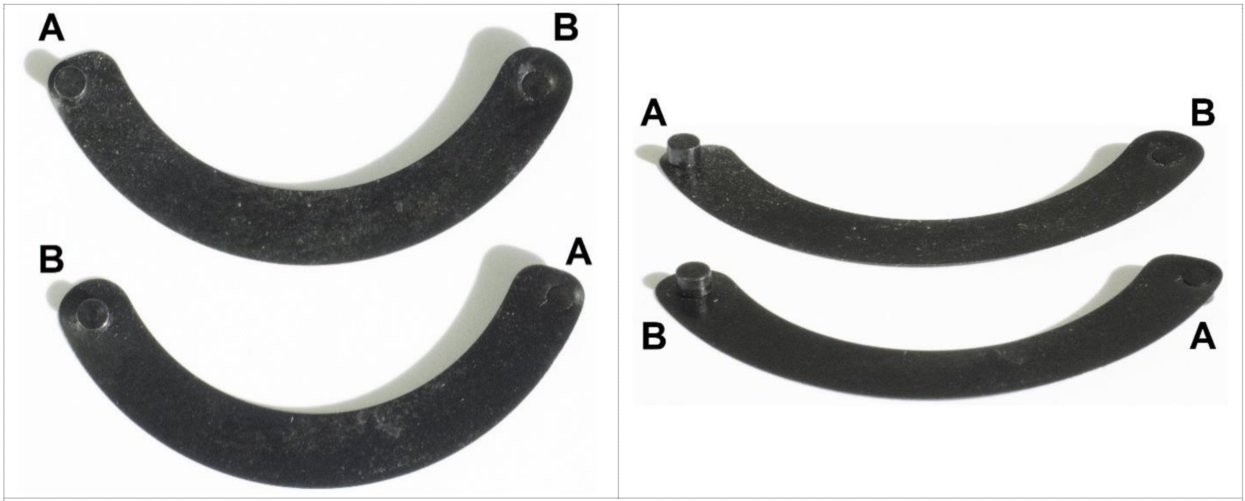

Figure 12: Two of the condenser's 15 aperture diaphragm blades. Face view on the left, and oblique view on the right.
A = Actuator end of the blades (the actuator is the rotating component of the diaphragm.)
B = Base end of the blades (the base is the stationary part of the diaphragm.)

Detailed descriptions of how aperture diaphragms work can be found on the Internet.

To take apart an iris diaphragm is easy but putting it together again with all the blades can be challenging. Constrained space, like in the inside of a condenser, doesn't make the task easier. And if the diaphragm blades are bruised or not completely flat and even, then your patience will face the ultimate test. But it certainly *can* be done, for some successful attempts see this article and this video clip. In these maintenance notes, we will attempt to clean the iris diaphragm without disassembling it first. The restriction is that the diaphragm must be separated from any parts that are not compatible with solvent soaking, for example certain plastics, and, of course, any optical components.

Should aperture diaphragm blades be oiled? Oil protects the blades from jamming (which can damage them) and corrosion, and makes the diaphragm movements very nice and smooth, but oil is also prone to harden with time and to collect dust (although the dust problem should be negligible in the series 600 condenser where the aperture diaphragm is well protected.) I don't have any final answer, but lean toward an oil and grease free approach.

Work Notes

Before beginning work with the condenser there are two things to consider:

i. Check that the condenser's top element is in good condition. Check the condition of the black paint that normally should mask the sloped side of the upper lens (Appendix 1: Worn paint on the condenser's top element.) Unscrew the top element from the yoke (Figure 2) where it is attached and inspect its lens surfaces, both the external and the internal (the simpler top elements only have a single lens, so these of course only have external surfaces.) Look for any defects, like haze, particles, fungus, delamination or scratches. This is best done with a stereo microscope. If required, clean the top element's outer lens surfaces according to your favorite lens cleaning protocol. If the inner lens surfaces appear dirty or hazy, you may be able to clean them if you can manage to take apart the top element, see Appendix 2: Disassemble and Clean the Top Element. The top element is the most critical component of the condenser, so it is a good idea to make sure that it is in good condition before you invest any more time to service the other parts of your condenser.

ii. Get an idea of which parts of the condenser you need to fix. Then you can focus on these parts only and save time and effort by avoiding disassembling the entire condenser. Here are some of the problems that you may wish to fix on your 600 series condenser:

Problem	**Required disassembly**
Sluggish or frozen aperture diaphragm	This can happen for two reasons: Either the aperture diaphragm blades have seized due to oil contamination and subsequent oil aging, or the grease once applied to the sliding surfaces between the actuator and the inside of the condenser core has decomposed and hardened. The entire condenser needs to be taken apart to access and clean the aperture diaphragm.
Sluggish or frozen centering mechanism	The condenser core must be removed from the condenser casing, but the core doesn't need to be disassembled. Follow the work notes in subsections 1 - 5 and then 11 - 13.
Oil and dirt on the inside of the condenser casing	A superficial cleaning of accessible surfaces can be done without taking apart the condenser. For a thorough cleaning the condenser core must be removed from the condenser casing, but the core doesn't need to be disassembled. Follow the work notes in subsections 1 - 5 and 11 - 13.
Dirty lens surfaces of the top element	Unscrew the top element from the yoke. If it is stuck refer to subsection 1.a. Clean the external lens surfaces according to your preferred lens cleaning protocol. For cleaning of the inner lens surfaces (if required) refer to Appendix 2: Disassemble and Clean the Top Element.
Dirty primary condenser lens (Figure 1)	If the lens retainer is easy to remove it may be sufficient to work only according to subsection 8. Otherwise, it may be necessary to go through all steps to take apart the entire condenser. Clean the lens surfaces according to your preferred lens cleaning protocol.
Dirty adapter lens (if present)	There is no need to disassemble the condenser. Pull out the adapter lens (subsection 1.c) and clean the surfaces according to your preferred lens cleaning protocol.
Eroded black paint on the top element	Unscrew the top element. If it is stuck refer to subsection 1.a. Consider paint repair according to Appendix 1: Worn paint on the condenser's top element.

As mentioned above used condensers may be contaminated with immersion oil, sometimes seriously so. Also, many moving parts may be sluggish or stuck due to old, hardened grease and oil, and need to be cleaned and relubricated. Generally, you should thoroughly remove all old grease before regreasing. To avoid tedious repetitions, only a few cleaning reminders will be specifically mentioned below. We'll leave it to you to decide whether you wish to clean the parts as they become disassembled, or if you prefer to leave the cleaning to be done after everything has been taken apart.

1. **Remove the condenser's external optical parts.**

   Protect the following more sensitive optical parts from damage, dust, or dirt during the work by removing them from the condenser and store them somewhere safe:

   a. **The top element (Figure 1, Figure 2 and Figure 5.)**

      Unscrew and remove the top element from the yoke (Figure 2.) The top element should normally be easy to unscrew, but contamination with hardened immersion oil may make its removal very difficult. Use a jar opener (Figure 10) or a strap wrench (Figure 11) to remove it gently without damaging it. If you need to use pliers make sure to line the jaws with plastic or rubber foil, or perhaps thick tape, to protect the top element's surface. And don't slip with the pliers! Releasing a stuck top element with tools, heat, penetrating oil, or solvent is dangerous due to the proximity to the sensitive lenses, so perhaps the safest option may be to leave it as it is in the yoke.

   b. **The primary condenser lens (Figure 1.)**

      The primary condenser lens is difficult to remove because the top element yoke and the top element stop are in the way. Therefore, we will leave it as it is for now.

   c. **The adapter lens (Figure 3 and Figure 4), if present.**

      Pull out the adapter lens from the bottom of the condenser. On the inside of the lens' outer rim is a slight ledge that is helpful for getting a grip and pulling it out. It may be necessary to use a screwdriver, or better, some flat plastic tool, to carefully pry out the lens.

2. **Remove the aperture diaphragm lever.**

   The aperture diaphragm lever is attached to the aperture diaphragm actuator on the underside of the condenser by two M2x3 screws (Figure 1 and Figure 3) that are easy to remove.

3. **Remove the swing-out knob (Figure 1) for the top element.**

   The swing-out knob's shaft is attached to the top element yoke by a thread. Remove the knob by unscrewing it. If it is stuck, protect the knurled knob by pushing a short piece of a PVC tube over it (Figure 13), and use combination pliers to release the knob. Although PVC tubes are rather soft, they are surprisingly rupture resistant. Still, it makes sense to pay attention that the teeth of the pliers don't break through the tube. If the tube is to narrow for the knob, the tube can be cut up along one side.

Figure 13: The swing-out knob for the top element protected with a piece of PVC tube.

With the swing-out knob out of the way, a bearing screw (Figure 24) for the yoke can be seen through the hole in the side of the condenser casing (Figure 14.) Use a screwdriver to remove the screw and retrieve the black wave washer(s) under its head.

The top element yoke will still be attached to the condenser because it is held by the pivot & guide screw on the other side of the condenser (Figure 20 and Figure 24.)

Figure 14: View of the side of the condenser casing (a.k.a. the "bathtub") after the swing-out knob has been removed.

4. Remove the centering slide cover (Figure 3)

Use the centering knobs (Figure 1) to move the condenser core roughly into its middle position. Watch the centering gap (Figure 3) on the bottom of the condenser along the inside of the centering slide cover – the gap should be of the same width on all sides when the core is in the middle. This will make space for the removal of the centering slide cover.

Use a face pin spanner (Figure 8) to unscrew and remove the black centering slide cover from the condenser. The centering slide and centering mechanism, all covered in grease, are now accessible (Figure 15.) But be careful not to push out the condenser core (Figure 19) from the inside of the condenser casing yet. First the centering mechanism needs to be properly disassembled to avoid that springs and other parts pop away and get lost.

Figure 15: View of the condenser underside and the centering slide after the centering slide cover (on the right side) has been removed.

5. **Disassemble the centering mechanism and remove the condenser core from the condenser casing.**

There are (at least) two design variants for the springs in the centering mechanism, one uses two small compression springs (Figure 16) and the other uses two leaf springs (Figure 17.)

Remove the centering knobs.

Use tweezers to first remove both pushers and then both springs from the centering mechanism (Figure 16 or Figure 17.) Now the condenser core is unconstrained and ready for removal.

Remove the condenser core with the top element yoke still attached by the pivot & guide screw. Pull it out through the underside of the condenser casing (Figure 19.) Some wiggling of the core may be required to get it out (Figure 20 and Figure 21.)

Do not yet remove the pivot & guide screw from the side of the core!

Use solvent (for example, white spirit) to clean all accessible moving parts and sliding surfaces from old grease.

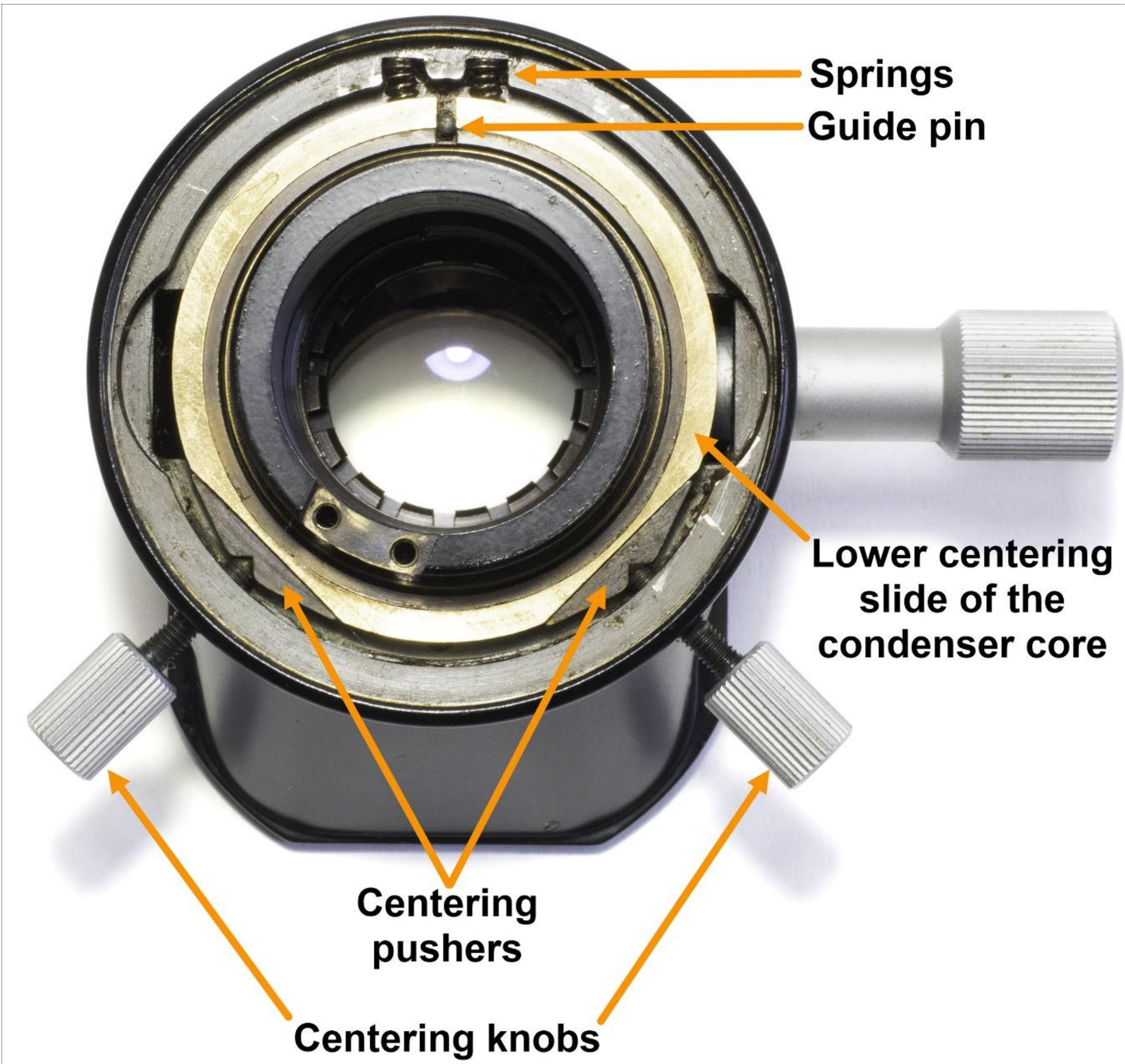

Figure 16: View from the underside of the condenser of the centering mechanism with explanation of the parts. The mechanism in this image uses two compression springs.

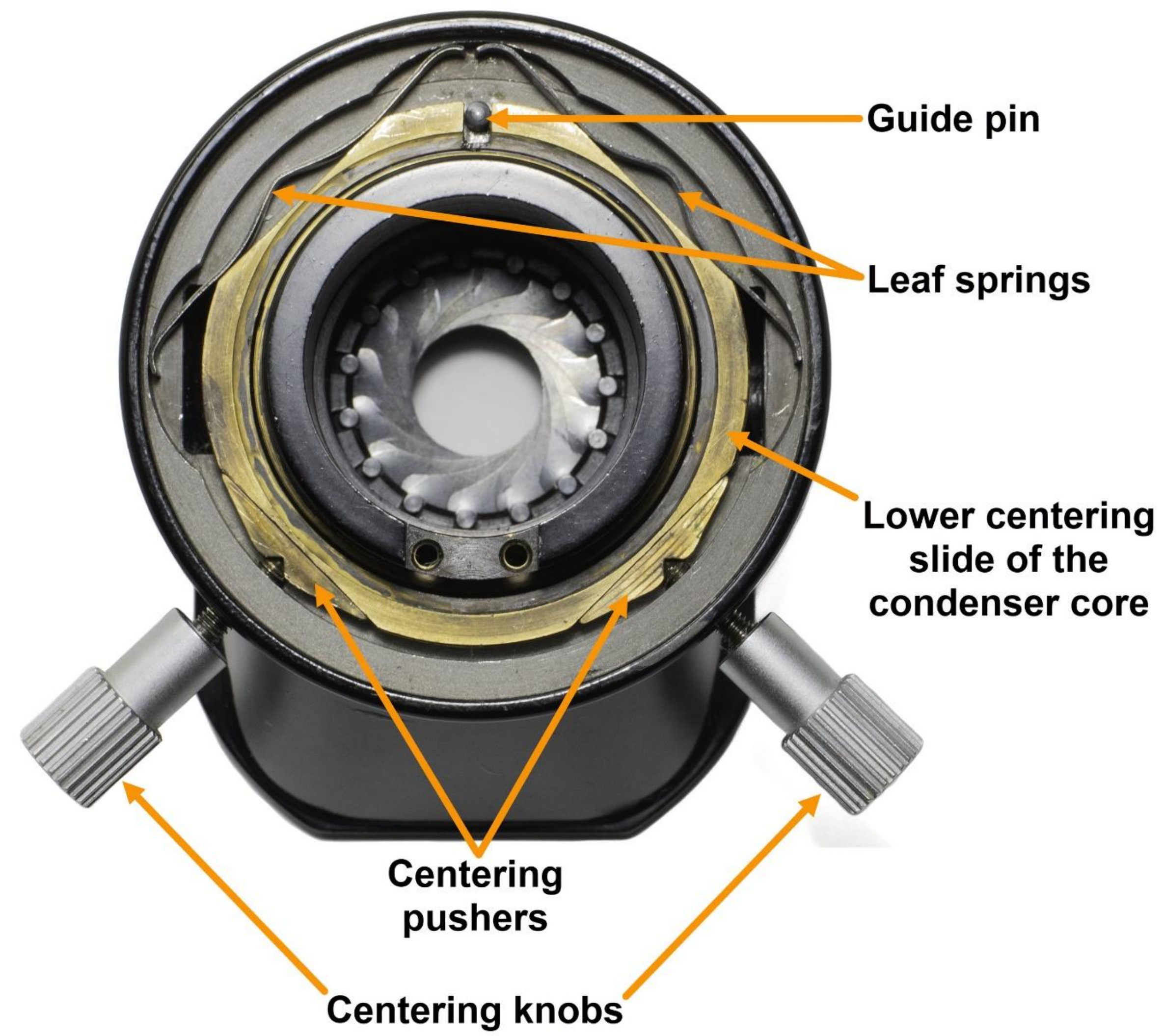

Figure 17: View from the underside of the condenser of the centering mechanism with explanation of the parts. The mechanism in this image uses two leaf springs.

Figure 18: Exploded view (from above) of the condenser core with the parts of the centering mechanism (the compression spring variant to the left and the leaf spring variant to the right.)

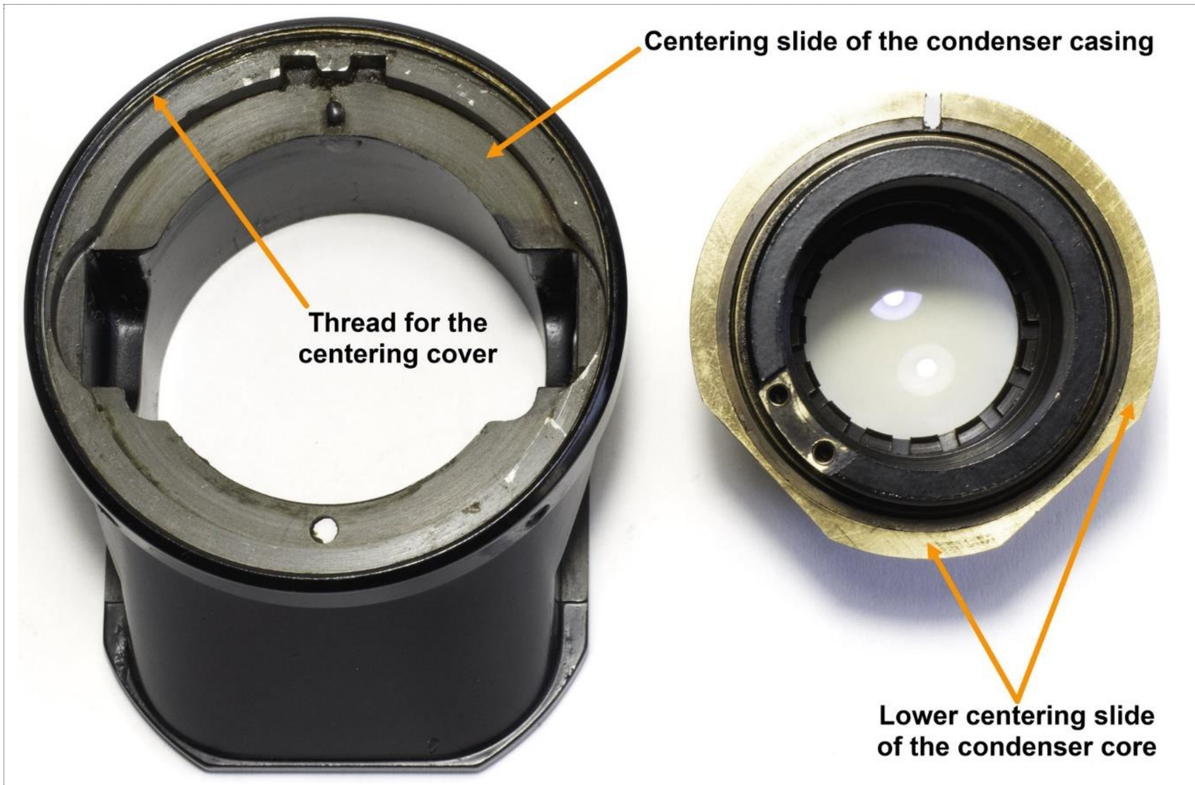

Figure 19: Views from below of the separated condenser casing (on the left side) and the condenser core (on the right side.)

Figure 20: The removed condenser core viewed from the side. The arrow points to the pivot & guide screw that sits on the opposite side of the swing-out knob.

(The top element yoke has prematurely been removed.)

Figure 21: The removed condenser core viewed from the backside. The arrows point to the holes for the compression springs.

(The top element yoke has prematurely been removed.)

6. **Remove the top element yoke from the condenser core.**

The top element yoke (Figure 2) is now only held to the condenser core by the pivot & guide screw (Figure 20 and Figure 24.) This screw has three functions: 1) Its rather tall head acts as a greased plain bearing around which one leg of the top element yoke pivots, 2) its tip reaches into a slot in the aperture diaphragm actuator (Figure 22) thus protecting the aperture diaphragm from being turned beyond safe limits, and 3) it also prevents the aperture diaphragm blades from falling apart by holding the actuator in close proximity to the aperture diaphragm base (Figure 23.)

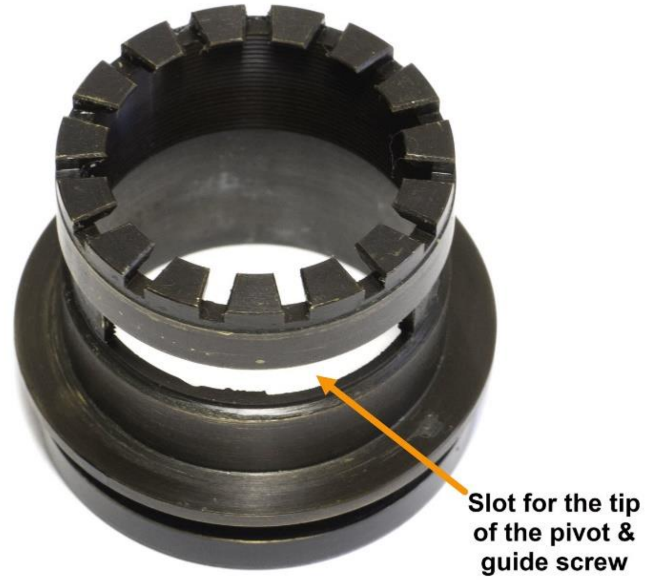

Figure 22: The aperture diaphragm actuator (after being removed from the condenser core.)

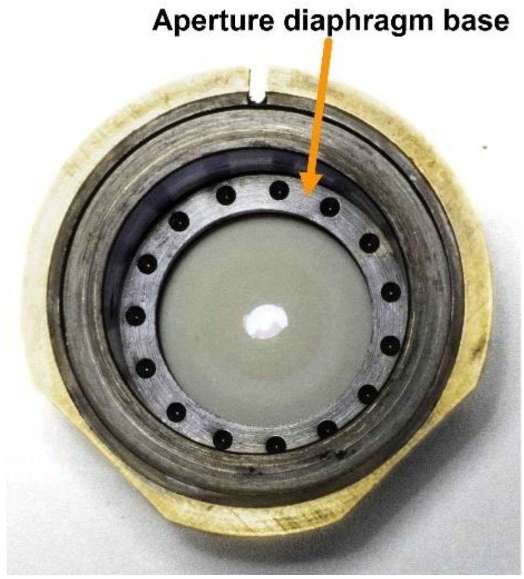

Figure 23: The bare condenser core viewed from the underside with the aperture diaphragm actuator and blades entirely removed. (This is a view you don't want to see with your condenser, because it means that you will need to reassemble the aperture diaphragm.)

To remove the yoke from the condenser core, the pivot & guide screw must be unscrewed. But removing that screw is potentially dangerous, because, as indicated above, this could allow the aperture diaphragm actuator to separate from the aperture diaphragm base and letting loose the aperture diaphragm blades. To prevent that accident, it is important to ensure that the actuator isn't allowed to separate from the base. Gravity can help with this; therefore, make sure that the condenser core is held upside down while the pivot & guide screw is removed. Also refrain from pulling or moving the actuator during this time. Reattach the pivot & guide screw immediately after the yoke has been removed.

Figure 24 shows an exploded view of the yoke and the associated parts of the top element's swing-out mechanism.

Figure 25 shows how the aperture diaphragm looks when viewed from the underside of the condenser (after the adapter lens has been removed.) It's the same view as in Figure 3 but with the aperture diaphragm partly closed.

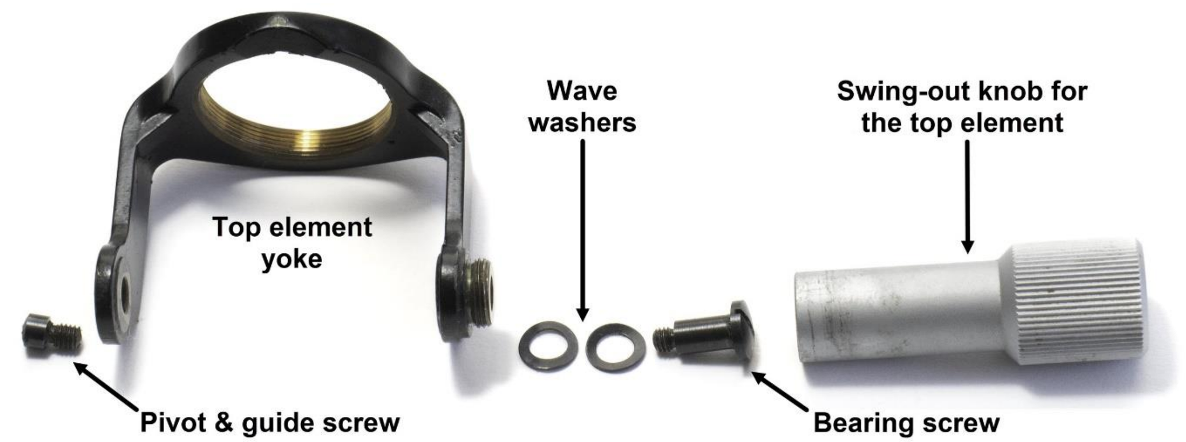

Figure 24: Exploded view of the swing-out mechanism for the top element.

The swing-out mechanism for the top element consists of the following parts (from the left to the right in Figure 24):

- The black pivot & guide screw.
- The black top element yoke. The insides of the yoke legs around the screw holes are greased.
- Two (perhaps only one in some condensers) black wave washers, situated together between the yoke and the bearing screw head. Both are o.d. 6.0 mm, i.d. 3.7 mm, with thickness 0.3 mm, although the dimensions may vary in different condensers. The washers are greased.
- The bearing screw attaching the yoke to the condenser core.
- The swing-out knob for the top element. It attaches into the threads of the nearest leg of the top element yoke. The knob shaft is hollow leaving space on its inside for the head of the bearing screw.

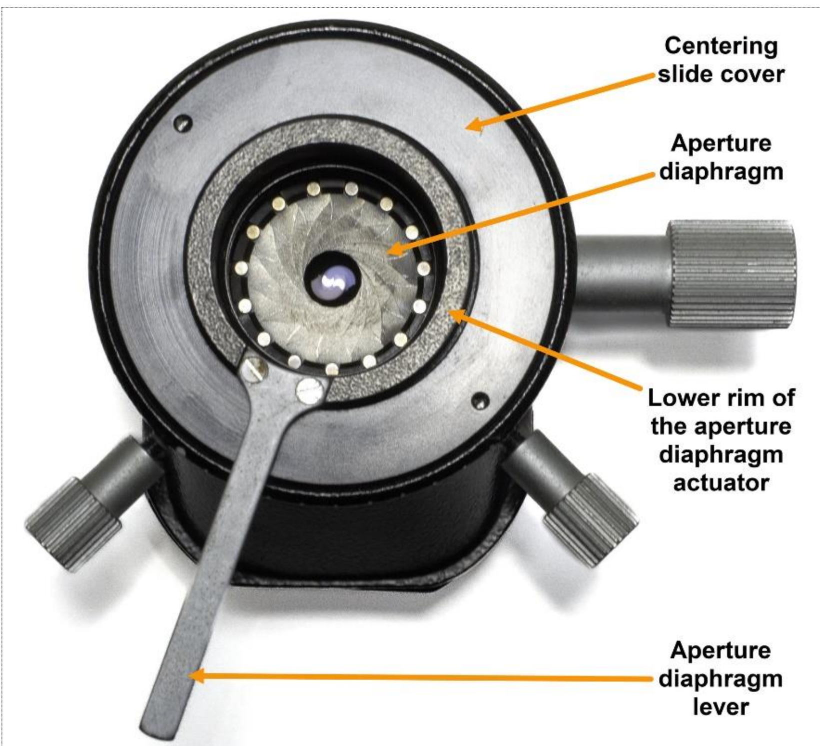

Figure 25: The aperture diaphragm viewed from the underside of the condenser.

7. **Remove the top element stop from the condenser core (optional.)**

The top element stop (Figure 1) can in most cases be left attached to the condenser core. The only exception may be if more working space is needed, perhaps due to the primary condenser lens retainer (Figure 26 and Figure 28) being difficult to remove.

The top element stop is attached by two M2.5x6 screws on its backside (Figure 21.) Don't touch the small screw at the top of the stop – it is factory adjusted for correct alignment of the top element in the optical path.

8. **Remove the primary condenser lens from the top of the condenser core.**

The primary condenser lens (Figure 1 and Figure 26) is attached to the top of the condenser core (Figure 27) with a threaded lens retainer (Figure 28.)

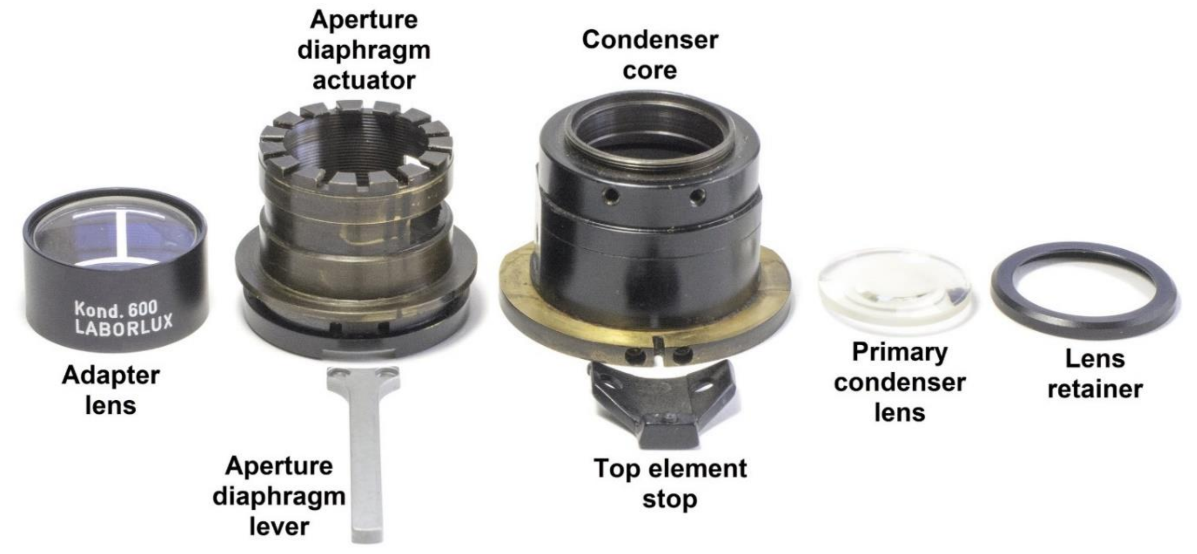

Figure 26: Exploded view of the parts of the condenser core (screws and the aperture diaphragm blades are omitted in the image.)

Figure 27: The top of the condenser core showing the primary condenser lens after the lens retainer has been removed.

Figure 28: The removed lens retainer.

There are two scenarios when the primary condenser lens must be removed: 1) If the lens is dirty and it is impractical or impossible to clean it while it is attached in the condenser, or 2) if the aperture diaphragm blades need cleaning from old oil. The lens does however not need to be removed if you only wish to clean and regrease the sliding surfaces between the condenser core and the aperture diaphragm actuator (Figure 31.)

Remove the lens retainer by unscrewing it. It should typically be easy to loosen with the fingers, but it could also be stuck in the thread due to hardened grease and therefore require some tools and tricks for removal. It is made of thin metal and must therefore be handled carefully. Try one or some of the following methods to release a stuck retainer from its threads:

- Use a jar opener (Figure 10) to get a good grip around the retainer and screw it off from the thread. Be sure to protect the retainer from scratches or damage. It is therefore best to avoid using pliers, but if you don't have any choice, be sure to put some reliable protection between the jaw teeth and the retainer.
- If the lens retainer still is stuck, treat its thread with white spirit to soften the hardened grease. Wrap a 1-2 mm thick yarn string around the periphery of the lens retainer and wet the string thoroughly with white spirit (Figure 29.) Use a pipette or dropper to apply the solvent dropwise. Avoid overflowing and try to avoid getting solvent on the lens. As the solvent slowly evaporates, more of it must be added every few hours to make sure that the yarn is well wetted all the time. Let the solvent work for at least one day before wiping off the solvent and again trying to release the lens retainer with the jar opener.
- Alternatively, gently heat the retainer with an electric heat gun or in a warming cabinet before trying to release it, or
- put the condenser core in the freezer for a few hours before trying to release the retainer.

Figure 29: A yarn string (red) wetted with white sprit and put around the periphery of the lens retainer.

Once the retainer is removed the lens can be carefully removed by turning the condenser core upside down and letting the lens fall out on a clean, soft cloth. If the lens is stuck, open the aperture diaphragm and carefully push out the lens with the help of a cotton swab from the bottom side of the condenser core. If the aperture diaphragm is stuck in a closed position, release it by adding one drop of white spirit to its underside and spread the drop over the blades. Repeat adding solvent, if required, but don't overdo it – the solvent should preferably not be allowed to seep down to the lens.

If necessary, clean the lens surfaces according to your preferred lens cleaning protocol.

9. Clean the aperture diaphragm mechanism from hardened oil and reassemble it.

Two procedures will be described, the first for cleaning of only the sliding surfaces between the condenser core and the aperture diaphragm actuator (Figure 31), and the other for additionally also cleaning the aperture diaphragm blades. Choose the procedure that best fits the condition of the condenser you work with.

a. Cleaning and regreasing only the sliding surfaces between the condenser core and the aperture diaphragm actuator (Figure 31.)

This procedure only deals with the factory applied grease on the sliding surfaces between the condenser core and the actuator. It does not require prior removal of the condenser's primary lens (as described in subsection 8 above.) During this procedure, be mindful to prevent that the aperture diaphragm accidentally falls apart.

Begin by putting the condenser core steadily upside-down on the table (i.e., with its centering slide facing upward, like in Figure 30.) Close down the aperture diaphragm to an approximately 3 mm opening. On the centering slide mark the positions (use a marker pen or thin colored tape strips) of the two screw holes for the aperture diaphragm lever (as in Figure 30.) The markings are important to ensure that the actuator is correctly turned when it is reattached over the aperture diaphragm blades after the regreasing.

Remove the pivot & guide screw from the side of the core.

Figure 30: The condenser core viewed from the underside. The arrows point to the markings (in this image two small orange tape strips) on the underside of the centering slide that should be adjacent to the screw holes for the aperture diaphragm lever.

Figure 31: The aperture diaphragm actuator. The green arrows point to the sliding surfaces where grease should be applied. Don't grease the sliding surface marked with red X's

Use a dry cotton swab to lightly hold down on the aperture diaphragm blades so they remain reliably seated in the stationary diaphragm base below (Figure 23) and carefully pull the actuator straight up to separate it from the blades. Don't rotate the actuator during this operation, keep the condenser core steadily on the table, and be very careful not to disturb the diaphragm blades or move them sideways (if the blades are allowed to move ever so slightly it may be impossible to reattach the actuator properly to the blades and you will end up with the daunting task of reassembling the diaphragm.)

Use cotton swabs wetted with white spirit to clean the removed actuator and the inside of the condenser core from all residues of old grease. During the cleaning be careful not to disturb the diaphragm blades!

Now you need to decide whether you wish to regrease the actuator's sliding surfaces, or not. The advantage of greasing is that it will allow the aperture diaphragm lever to move smoothly and pleasantly. The disadvantage is that the grease eventually also will age and harden, and again require cleaning and regreasing some time in the future. Without grease the aperture diaphragm lever may get a somewhat "dry" feeling, but you (or your grandchildren) will not need to worry about sluggishness due to grease aging.

If you decided to reapply grease, then apply a thin layer of grease (refer to section Some Special Equipment for some grease suggestions) to the sliding surfaces on the outside of the actuator as indicated in Figure 31.)

Slowly put back the actuator down into the condenser core and onto the aperture diaphragm blades while keeping the actuator aligned with the core according to the marks you made earlier. The upward facing pivot pins of the diaphragm blades should catch into their respective slots on the edge of the actuator. It may be necessary to rotate the actuator back and forth a fraction of a millimeter to let all pivot pins find their holes. Once the actuator is properly seated attach the pivot & guide screw to secure the aperture diaphragm. Check that the aperture diaphragm opens and closes properly.

b. Cleaning and regreasing the entire aperture diaphragm mechanism including the diaphragm blades.

This procedure requires prior removal of the condenser's primary lens (as described in subsection 8 above.)

We start with the condenser core liberated from the top lens and containing only the intact aperture diaphragm held together by the pivot & guide screw. It is ready for cleaning, not only from any oil contamination on the aperture diaphragm blades, but also from the factory applied grease between the core and the actuator.

Put the core with the aperture diaphragm facing down into a small glass vial and cover it entirely with a solvent that is capable of dissolving grease (white spirit is a good choice.) Let it soak in the solvent for a few hours and occasionally rotate the aperture diaphragm back and forth to allow the solvent to penetrate and dissolve the grease. Repeat with fresh solvent at least two more times. Make a last soaking in iso-propanol, blot off excess solvent, and let it all dry completely in the air (the last iso-propanol bath speeds up the drying.) Check that the aperture diaphragm moves easily; if it doesn't, more solvent soaking may be necessary.

I prefer to grease only the sliding surfaces between the core and the actuator leaving the aperture diaphragm blades ungreased, but you may choose differently.

If you decide to oil the aperture diaphragm start by closing the diaphragm fully. Wet a cotton swab with a high quality, non-drying oil and dab it carefully and sparsely on the aperture diaphragm blades. Spread the oil evenly over the blades by opening and closing the diaphragm repeatedly. Don't overdo the oiling!

If you wish to apply grease between the condenser core and the actuator you must be mindful to prevent that the aperture diaphragm accidentally falls apart. Begin by putting the condenser core steadily upside-down on the table (i.e., with its centering slide facing upward, like in Figure 30.) Close down the aperture diaphragm to an approximately 3 mm opening. On the centering slide mark the positions (use a marker pen or thin colored tape strips) of the two screw holes for the aperture diaphragm lever (as in Figure 30.) The markings are important to ensure that the actuator is correctly turned when it is reattached over the aperture diaphragm blades after the regreasing. Remove the pivot & guide screw from the side of the core. Use a dry cotton swab to lightly hold down on the aperture diaphragm blades so they remain reliably seated in the stationary diaphragm base below (Figure 23) and carefully pull the actuator straight up to separate it from the blades. Don't rotate the actuator during this operation, keep the condenser core steadily on the table, and be very careful not to disturb the diaphragm blades or move them sideways (if the blades are allowed to move ever so slightly it may be impossible to reattach the actuator properly to the blades and you will end up with the daunting task of reassembling the diaphragm.)

Check that the removed actuator and the inside of the condenser core are free from residues of any old grease. If required, use cotton swabs wetted with white spirit to clean the sliding surfaces. (But don't disturb the diaphragm blades!)

Apply a thin layer of grease to the sliding surfaces on the outside of the actuator as indicated in Figure 31.) Slowly put back the actuator into the condenser core and onto the aperture diaphragm blades while keeping the actuator aligned with the core according to the marks you made earlier. The upward facing pivot pins of the diaphragm blades should catch into their respective slots on the edge of the actuator. It may be necessary to rotate the actuator back and forth a fraction of a millimeter to let all pivot pins find their holes. Once the actuator is properly seated attach the pivot & guide screw to secure the aperture diaphragm. Check that the aperture diaphragm opens and closes properly.

10. Reassemble the condenser core.

To protect the primary condenser lens we will wait with attaching it to the condenser core until later.

If the top element stop (Figure 1 and Figure 21) has been removed from the condenser core, reattach it now with its two M2.5x6 screws.

Thinly apply grease to the following friction surfaces of the top element yoke (Figure 24): To the insides of the screw holes in the yoke's legs, and to the area just around the screw holes on the insides of the yoke legs.

Put the condenser core on the table with its bottom facing down. Remove the pivot & guide screw from the side of the core. (Remember that this screw prevents the aperture diaphragm from falling apart. So, make sure to leave the core steadily resting on the table and don't lift it up or turn the aperture diaphragm until the screw has been reattached.)

Loosely fit the top element yoke to the condenser core so the screw holes in the yoke legs are in line with the corresponding screw holes in the side of the core. Be sure to turn the yoke the right way (refer to Figure 2.) Put the pivot & guide screw through the screw hole in the proper yoke leg (don't confuse the legs, refer to Figure 24) and screw it all the way down into the core. Make sure that the screw head goes all the way down into the yoke leg's screw hole - the surface of the screw head should be flush with the outside of the yoke leg. Check that the aperture diaphragm indeed is secured now and that it works properly. This leaves us with the yoke attached to the core by only one of its legs.

11. Attach the condenser core to the condenser casing.

Grease the centering slide of the condenser casing (Figure 19.) Apply the grease both on the sliding surfaces that face upward and on the sliding surfaces that face inward around the slide circumference.

a. If your centering mechanism uses compression springs:

Lightly grease both centering springs (Figure 18) and put them into the holes in the side of the condenser core's centering slide (Figure 21.) The grease will help to hold them attached in the holes.

Clamp the condenser casing in a vise (with soft jaws or with a suitable jaw protection) with the centering slide facing up. Place the condenser core so it rests on the casing's centering slide, align it so the casing's guide pin (Figure 16) fits into the notch just between the holes in the core that hold the springs. With the core's upper centering slide resting on the casing's centering slide the ends of the compression springs that stick out will become bent upward. Use a very small screwdriver and/or a steel needle to compress the springs toward the core and push the free ends down into the notches in the casing slide.

b. If your centering mechanism uses leaf springs:

Clamp the condenser casing in a vise (with soft jaws or with a suitable jaw protection) with the centering slide facing up. Place the condenser core so it rests on the casing's centering slide, align it so the casing's guide pin (Figure 17) fits into the notch in the core slide.

Use long nose pliers (or sturdy forceps) to push the leaf springs into the centering slide as shown in Figure 17.

Grease the centering pushers (Figure 16 or Figure 17, as applicable) making sure that the notches that face the centering screws get a good blob of grease. With the fingers push the condenser core on the slide against the springs and put the centering pushers on the casing slide as shown in Figure 16 or Figure 17.

Lightly grease the threaded tips of the centering knobs (Figure 16 or Figure 17) and attach them to the casing. Check that the tips reach into the pusher notches - if necessary, align the pushers with a small screwdriver.

Apply grease to one side of the centering slide cover (Figure 15.) It's not necessary to grease the entire area, you only need to grease the inner part of the area that makes contact with the condenser core's slide. Also lightly grease the thread along the periphery of the cover.

Use the centering knobs to move the core approximately into the center of the casing slide.

Carefully screw the cover into the thread around the slide of the condenser casing. The cover should catch the threads smoothly, otherwise the threads may cross and jam. Using a face pin spanner helps greatly. Tighten the cover only lightly. Wipe off any excess grease from the cover thread.

Check that the centering mechanism works as expected.

12. Attach the swing-out knob for the top element.

Apply some grease to the wave washer(s) (Figure 24) and put them over the bearing screw all the way to the underside of its head (Figure 24). Attach the screw through the hole in the yoke leg and into the thread in the side of the condenser casing. Tighten the bearing screw.

Attach the swing-out knob (Figure 24) over the bearing screw and to the yoke. Tighten it hard with your fingers, it should be tight enough so it doesn't release during routine use of the condenser.

13. Finish the condenser reassembly.

Attach the aperture diaphragm lever to the bottom of the condenser (Figure 3.) It's attached with two M2x3 screws.

Swing the yoke out if the condenser's optical path. Put the primary condenser lens (make sure that it is perfectly clean) with its most convex side facing downward into its groove on the top of the condenser core (Figure 27.) The lens is biconvex, i.e., both lens surfaces are curved outward, with its lower side being more convex than its upper side. Carefully attach the lens retainer (Figure 28) over the lens making sure to avoid cross threading. Tighten the retainer only very lightly.

Attach the top element (Figure 2) to the yoke.

If applicable, attach the adapter lens to the bottom of the condenser. Push it as deeply as it goes into the opening.

Appendix 1: Worn paint on the condenser's top element

It seems that it's not uncommon that the black paint applied on the top element lens' sloped sides becomes compromised or even removed (Figure 32, Figure 33 and Figure 34), likely as a result of cleaning with some incompatible solvent. The purpose of the paint is presumably to shield the observed microscope object from stray light. Stray light is a known cause of impaired contrast in microscope images. I'm not able to tell how much the lost paint on the top element affects contrast in the microscope image, but my guess would be that loss of contrast is negligible.

Figure 32: Condenser top elements (Aspherical-achromatic, n.a. 0.90 dry.)
Left top element: The sloping side of the upper lens surface is missing the black paint. The surface has a frosted appearance.
Right top element: The sloping side of the upper lens surface with intact black paint.

It is possible to repair the missing paint with a fine brush, a light hand, and a suitable matte black paint (either acrylic or oil), although it is difficult to get the border between the covered and the clear lens surfaces even and nice. (It's somewhat embarrassing when I check my own painting efforts in the stereo microscope.) The sloped glass surface is frosted which helps to keep the black paint in place while it dries.

Figure 33: An "Achr 0.90" top element viewed from above in a stereo microscope. The black paint is largely intact. The bright dotted circles on the clear lens surface are reflections of the circular LED illumination.

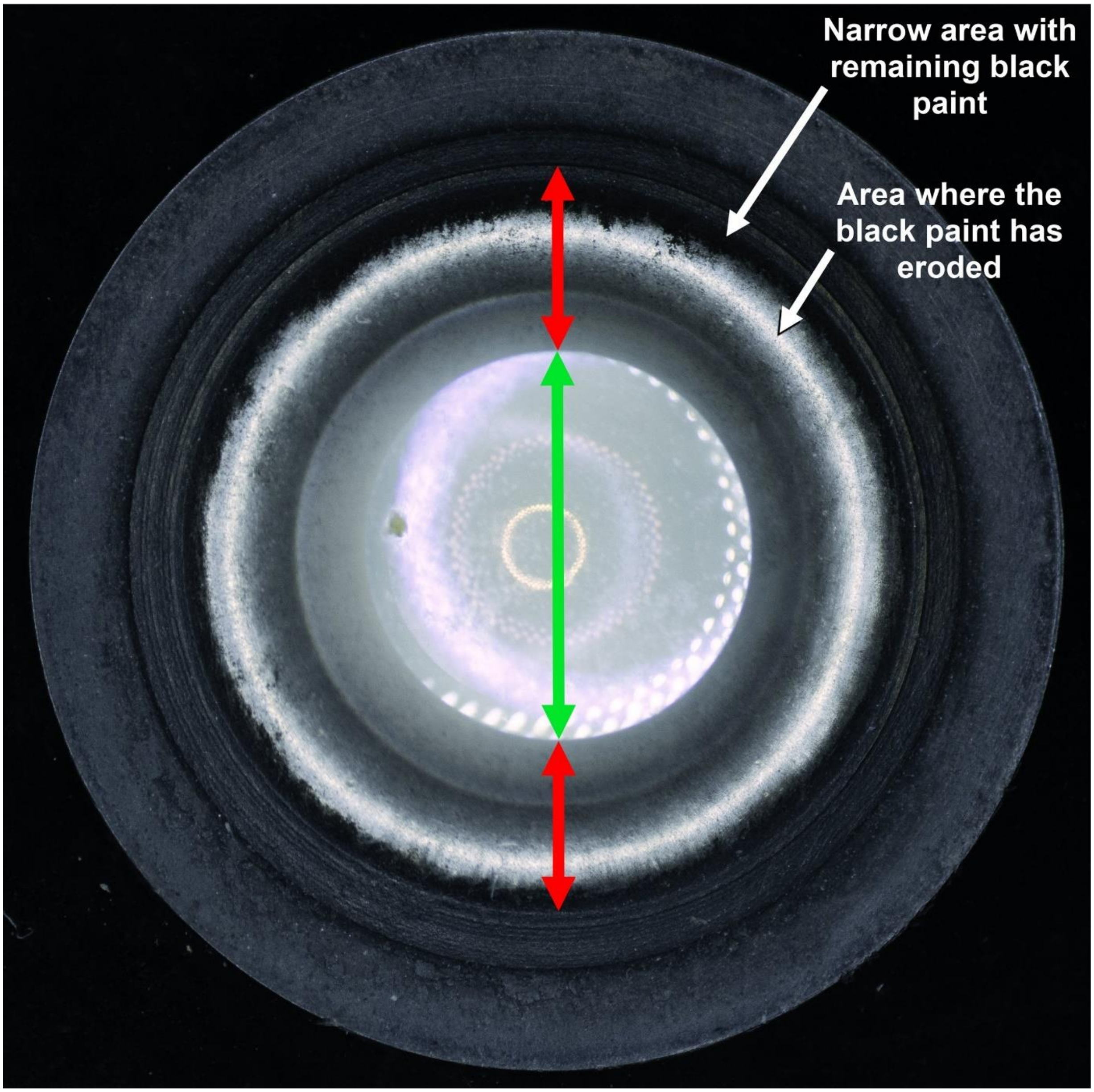

Figure 34: An "Achr 0.90" top element viewed from above in a stereo microscope. A significant swath of the black paint has disappeared.

The green arrow indicates the diameter of the clear, slightly concave area of the top lens that provides the required light cone for the microscope. The red arrows indicate the sloped annulus of the top lens that originally was entirely covered with black paint.

Appendix 2: Disassemble and Clean the Top Element

The top element's inner lens surfaces are well protected and therefore much less vulnerable to contamination than the outer surfaces. After many years of use it may in rare cases still be possible that the inner lens surfaces develop problems, for example, haze, condensed matter, or fungus.

As listed in the table in the Introduction there are several different kinds of top elements that can be used with the 600 series condenser. The simpler top elements have only one lens that is easily accessible for cleaning, while the more advanced top elements have two or even three lenses or lens groups. The inner lens surfaces of the more advanced top elements are not accessible from the outside but can still to some extent be inspected from the outside with a stereo microscope. By moving the focus down below the top element's top surface first the underside of the upper lens can be inspected and then further down the upper side of the lens below. Similarly, the inside lens surfaces can also be inspected from the bottom side of the top element. The illumination strongly affects the visibility of any contamination or defects - try to illuminate from the bottom through the top element as well as from above, and vary the illumination angles.

The more advanced top elements consist of two or three parts that can be screwed apart to access the inner lens surfaces (Figure 35 and Figure 36.) There are however a few factors that can make the disassembly of a top element challenging:

- The parts may be stuck in the threads, either from just having been tightened too hard, or due to ingress of oil and perhaps other unknown fluids that have hardened in the threads or corroded the metal.
- The top element is a brass casing that contains sensitive optical components. The casing is rather soft and therefore vulnerable to bruising, deformation, and damage.
- It is very difficult to get a good grip with pliers (or any other tool) around the narrow rim of the top element's upper part. The rim may be only 1 mm wide.

Try first to unscrew the top element parts with your fingers only. Avoid touching any of the lens surfaces. A piece of a thin rubber mat (available in kitchen utensil shops and used to open cans with tight screw lids) around the rim of the upper top element part can help you to get a firmer finger grip.

Next step up to escalate the efforts is to use pliers to get good and safe grips around the top element parts, and then try to unscrew them without damaging them. It is very important to protect the delicate parts from the sharp teeth of the pliers, to avoid squeezing the objects too hard with the pliers, and to avoid slipping. Double sided tape can improve the grip, but is quite challenging to attach to the narrow 1 mm rim of the top element's upper part. Pliers with plastic jaws are gentler to the objects but more prone to slipping.

If the parts still are stuck your only option is to either give up, or to proceed with alternative (and probably more dangerous) methods until you either succeed or damage the top element.

Once the top element parts are separated, clean their threads with cotton swabs wetted with solvent. Inspect the inner lens surfaces, and if required, proceed by cleaning them by blowing with compressed air and/or with cotton swabs wetted with lens cleaning solution or a suitable solvent (for example, isopropanol.)

After cleaning wait one day before reassembling the top element parts to be sure that all traces of the lens cleaning solution or solvent have evaporated.

Figure 35: An aspherical-achromatic 0.90 n.a. top element (on the top of the image.) Below its two disassembled parts.

The red arrow indicates the crevice between the top element parts.

Figure 36: An aplanatic 1.25 n.a. top element (on the top of the image.) Below its three disassembled parts.

The red arrows indicate the crevices between the top element parts.

References

An article describing the function and repair of aperture diaphragms:
https://www.microscopy-uk.org.uk/mag/artfeb07/pj-iris.html

YouTube movie that illustrates the dexterity and patience required to reassemble an iris diaphragm:
https://www.youtube.com/watch?v=oH6GfyxpK9o