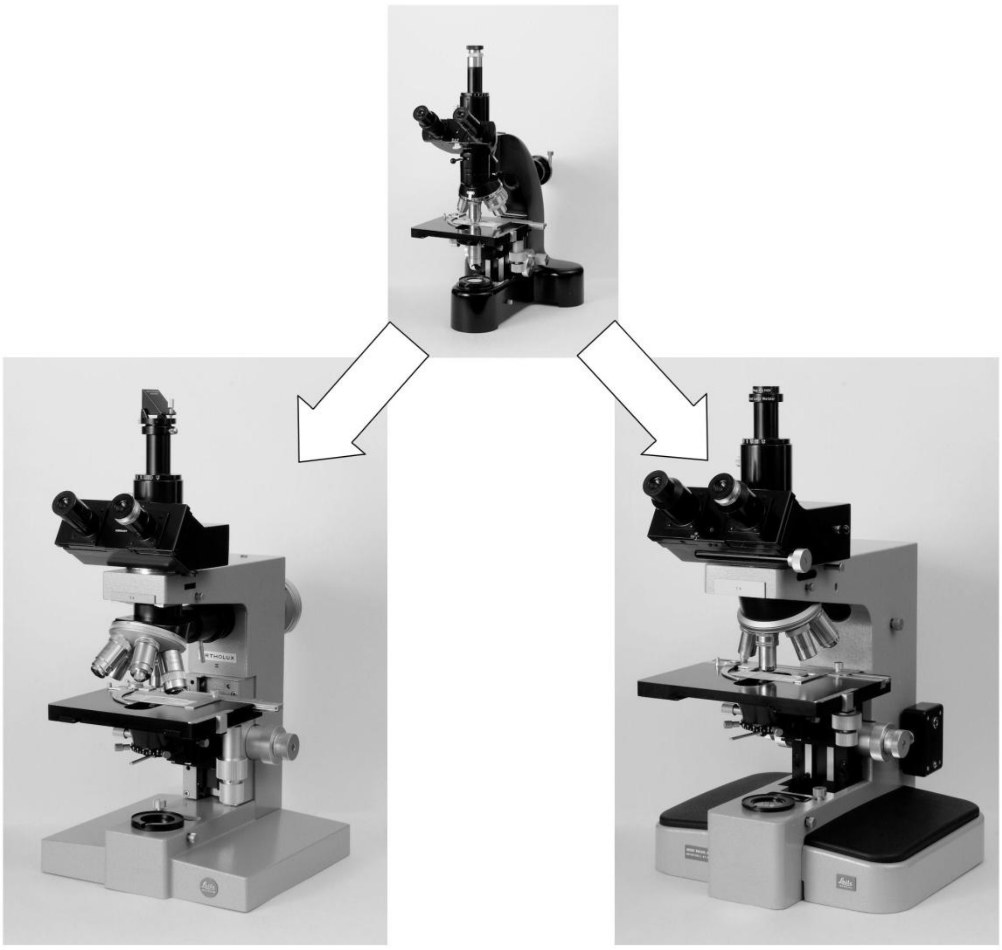
The Leitz Orthoplan and Ortholux II Research Microscopes

Normand L. Overney and Gregor T. Overney



The Leitz Orthoplan and Ortholux II Research Microscopes

4th Edition, April 2011

Table of Contents

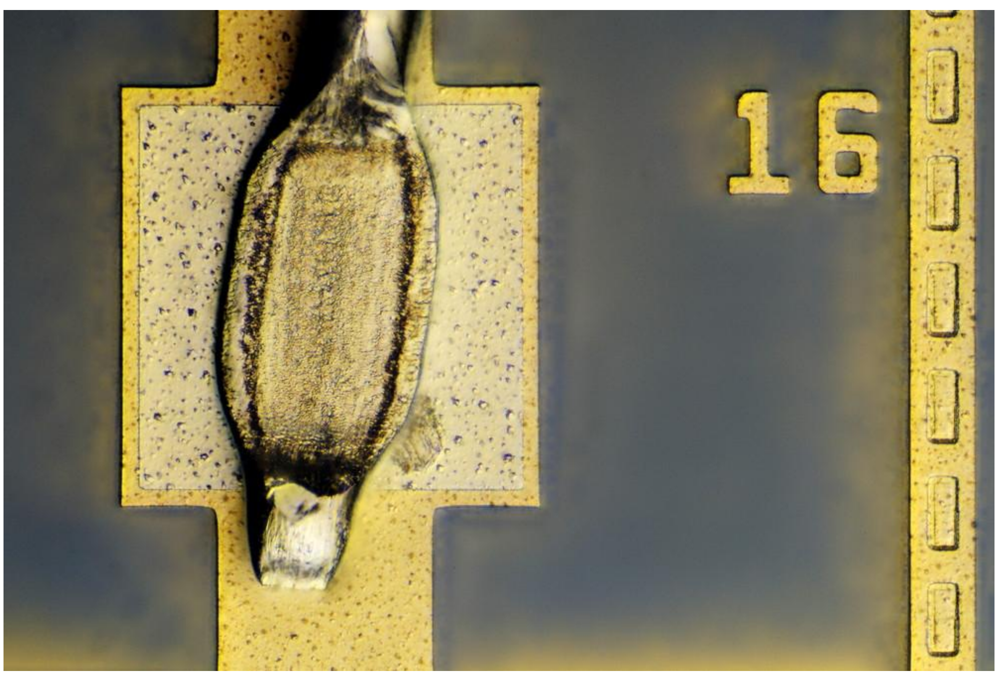


Figure 1 – Solder joint of B&W CCD in oblique, episcopic brightfield. CombineZP was used for the increased depth of field calculation [1]. Photomicrograph taken with a Nikon D300, a Leitz Variozoom and a Leitz Orthoplan microscope [11].

Introduction

The main focus of this paper is to compare the Leitz Orthoplan with the Leitz Ortholux II.[1] *The suitability for photomicrography of the Orthoplan and Ortholux II is discussed.*

The company *Ernst Leitz GmbH* is well known for its excellent microscopes. When thinking about Leitz microscopes, many famous models known as the *Ortholux*, *Dialux*, *Laborlux*, and *Orthoplan* come to mind. With the introduction of these microscopes, the company became very successful. Leitz sold over one million microscopes during ~130 years (see Figure 2).

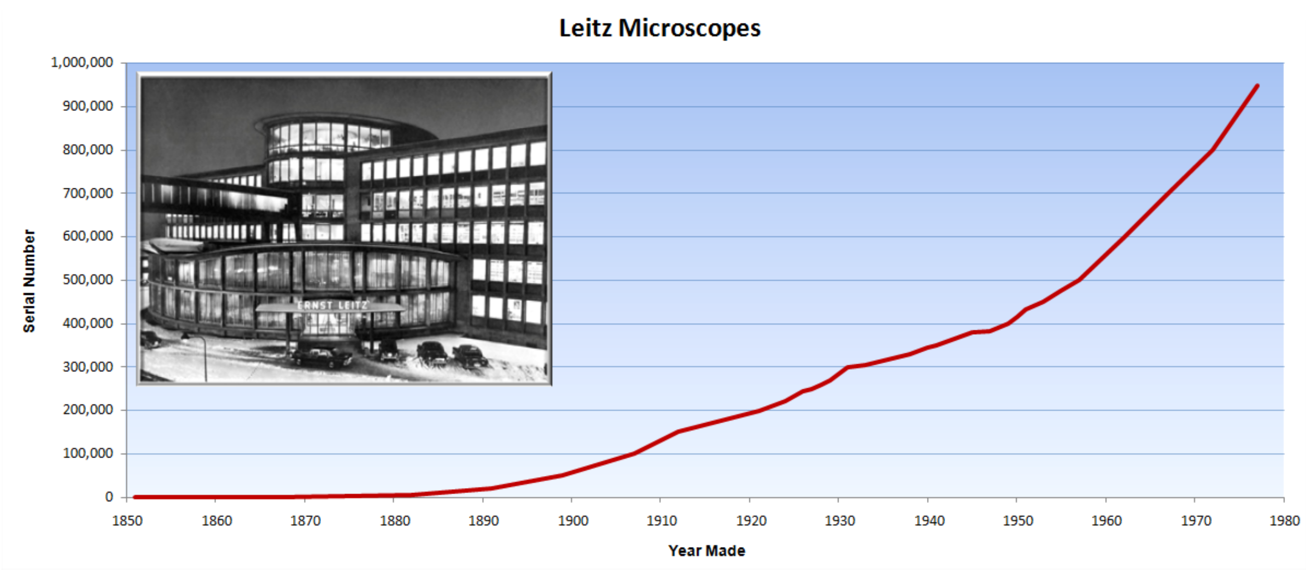


Figure 2 – Accumulative sales of Leitz microscopes from 1850 until 1980. Inset shows the administration office building of Leitz, which was built around 1954. Inset is © Ernst Leitz GmbH, Wetzlar.

The Ortholux was introduced in 1937 and sold until the mid seventies. It was the first truly modular microscope system that was greatly appreciated by the scientific community. The Ortholux system consists of a vast amount of components and accessories satisfying almost any light microscopy requirement [2].[2]

The first microscope, which replaced the Ortholux, was the **Leitz Orthoplan**. The Orthoplan was first introduced in 1965 and sold until the early nineties. The second one is the **Leitz Ortholux II**, which was introduced at the beginning of the seventies and sold until the mid eighties. At the dawn of the grey Ortholux II (beginning of the 70s), Leitz also introduced three smaller siblings, the HM-LUX, SM-LUX and DIALUX (see Figure 3).

[1] The manuals and brochures mentioned in the text provide important additional information. We recommend that you take the time to download a few of them. Links and references are available at the end of this paper in the section "References".
[2] References are listed at the end of this document.

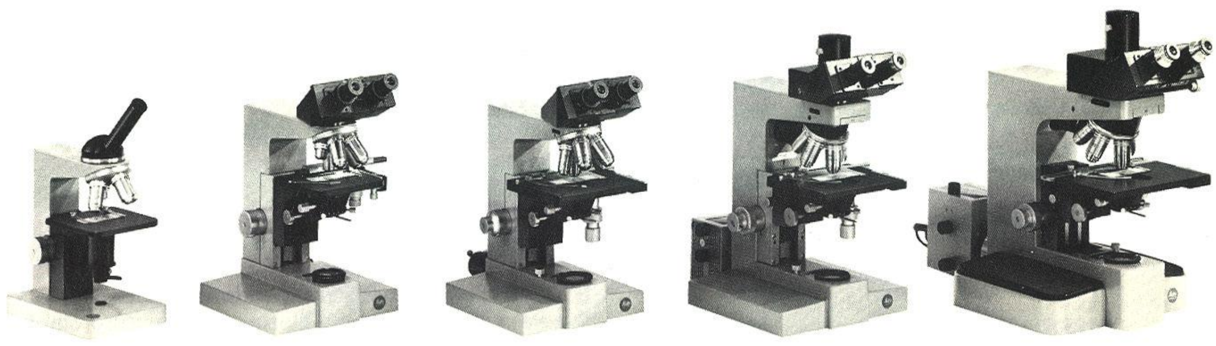


Figure 3 - Range of Leitz microscope stands from the 70s and early 80s. From left to right: HM-LUX student microscope, SM-LUX routine microscope, DIALUX laboratory microscope, Ortholux II (or Ortholux 2) research microscope, and Orthoplan largefield microscope. © 1977 by Ernst Leitz GmbH, Wetzlar.

There are many similarities between the Ortholux II and its bigger sibling, the Orthoplan. We will compare the two in more detail in the chapter "The Ortholux II and Orthoplan – A Comparison".

Before 1976, Leitz used the 170mm mechanical *tube length* (TL) for its research microscopes of the biological type (using diascopic illumination or transmitted light). Of course, the Ortholux, Ortholux II and Orthoplan can also be used as metallographic microscopes. In this case, a 170mm mechanical tube length is no longer an acceptable choice.[3]

Leitz objectives made for the 160mm and 170mm TL can be used on all the Orthoplan and Ortholux II microscopes of the biological type.[4] The reason for this compatibility is explained in more detail in our paper entitled "The Excellent Leitz Microscopes with Black Enamel Finish" published in 2008 [2].

We also discuss the use of these microscopes for photomicrography. We introduce three different configurations. The first one uses a "prosumer" digital camera, the Nikon D300. The Nikon Coolpix 990 is used in the second configuration. Last but not least, a dedicated camera for photomicrography using 35mm film is introduced.

The majority of Orthoplan and Ortholux II microscopes are now more than three decades old. These microscopes are of very high quality and most of them are still in serviceable condition.[5]

For additional information about Leitz microscopes, we highly recommend visiting the following Web sites:

- Bernard Doudin's Web site at http://microscope.database.free.fr/Welcome.html
- Gordon Couger's Web site at http://www.science-info.net/docs/leitz
- Greg McHone's Web site at http://earth2geologists.net/Microscopes/LeitzScopes.htm.

[3] The mechanical tube length (TL) is the distance between the flange of the objective lens and the seating surface on which the eyepiece rests. To complicate matters, an appropriate tube lens is added to the nosepiece to accommodate a certain design of the microscope. For a discussion about the mechanical tube length, please see "Appendix A – The Mechanical Tube Length".

[4] In 1976, Leitz adopted German Standard Commission DIN 58887, which recommends a mechanical tube length of 160mm.

[5] The focusing mechanism must be serviced in order to restore its great performance. Proper alignment has to be reestablished using a so-called circular level tool (see http://couger.org/microscope/Roseoptics/Circlar-level-tool.pdf for more information about this tool), and a well calibrated stage micrometer must be used to verify alignment.

The Leitz Orthoplan – An Overview

In 1965, Leitz introduced the Orthoplan research microscope. The company referred to the Orthoplan as the "Plano Extra Large Field Research Microscope" and later as the "Universal Large-Field Microscope". This microscope supports a field of view (FOV) index of up to 28.[6] When examining histological preparations, this very large field of view is particularly useful. In this case, the use of Leitz Plano objectives (objective designation "Pl"), which are flat-field corrected over the entire FOV, are recommended.[7] – With a standard condenser for diascopic illumination (such as the condenser system 600) and wide field oculars, a flat-field corrected FOV of up to 28mm is supported over the entire range of objective magnifications from 2.5× to 100×. For the Pl 1× objective, a special condenser lens must be used to ensure even illumination.

The foot of the compact stand (length × width = 300 × 295mm) is supported by four dampers protecting the instrument against external vibration. It is a heavy stand of around 17kg. The height of the eye level is 413mm and the total height with tube is around 517mm. For the Leitz Orthoplan research microscope, there is an almost limitless collection of components and accessories. – Very obvious are the two plastic hand rests on either side of the stand. Over time, Leitz released the Orthoplan in different colors. Depending on the time of introduction, the hand rests are either grey or black and the color of the stand changed from black (first incarnation of the Orthoplan sold until 1967), hammertone grey (mid sixties and early seventies), light grey (mid seventies) to ivory (from late seventies).

The Orthoplan is equipped with a wide field binocular tube (also referred to as viewing head) FSA-GW, which is a combination of binocular observation- and phototube. The FSA-GW offers a mechanical tube length compensation, which ensures parfocality of the film plane (or image sensor) and the image in the eyepiece for any interpupillary distance. In Figure 4, the eyepieces '**A**' and '**B**' are shown both at their narrowest and their widest separation. For the narrowest position, '**y**' is the distance between the prisms '**1**' and '**2**' and '**x**' is the distance between the prisms '**3**' and '**4**'. When moving the pair of eyepieces from the narrowest into the widest position, the prisms '**1**' and '**2**' are moved apart to the distance '**y′**' and the set of prisms '**1**', '**2**' and '**3**' are lowered in the direction of prism '**4**'. The distance '**x′**' is now the new separation between prisms '**3**' and '**4**'. The distance '**x′**' is appropriately changed so that the optical path length from prism '**4**' to the intermediate image plane is kept constant. This applies to all interpupillary distances from 55 to 75mm.

The square mechanical object stage (No. 660) is 210mm by 150mm and offers a traversing range of 76mm by 50mm.

Several revolving nosepieces are available. The ones for the 170mm TL can have a 1× or 1.25× tube lens. While NPL objectives corrected for a 170mm or 160mm TL should be used with a 1.25× tube lens, the appropriate Pl objectives can be used with a 1× tube lens to provide the maximum FOV for diascopic illumination.

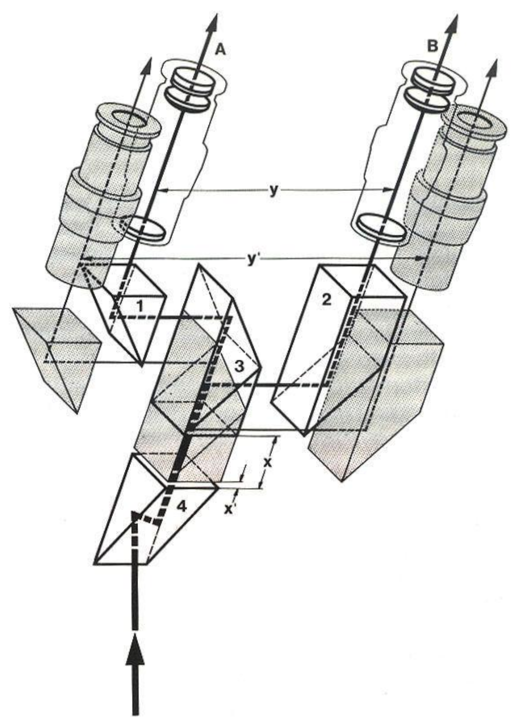


Figure 4 – Optical structure elements of Leitz binocular photo tube FSA. From [4], © 1977 by Ernst Leitz GmbH, Wetzlar.

[6] The field of view index represents the diameter in mm of the intermediate image visible with the eyepiece.
[7] The degree of correction for image flatness varies. Pl objectives are corrected for image flatness over a FOV index of 24 to 28. NPL objectives are corrected over 18 to ~24, and EF objectives are corrected over 14 to ~18.

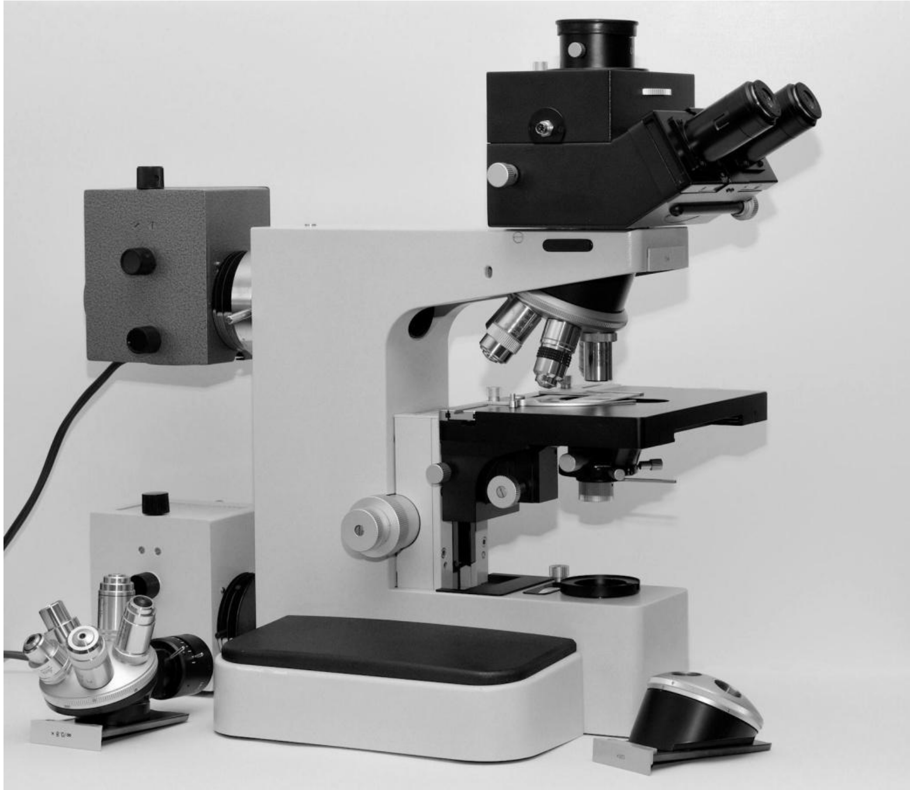


Figure 5 – Shows Leitz Orthoplan (built 1977) with two Leitz Lamp housings (100 and 100Z) and a 6-tuple nosepiece corrected for the 170mm TL (contains a 1× tube lens). Also shown are an episcopic nosepiece (∞/0.8×) and a 5-tuple nosepiece for the 170mm TL (contains a 1.25× tube lens). The binocular viewing head FSA-GW has two 38mm photo ports. The oculars are Periplan GW 8× M (one with a photo mask).

The following table lists field of view index values and eyepiece diameters.

Periplan Oculars	Eyepiece Diameter	Field of View Index
GW 6.3× M	30 mm	**28**
GW 8× M	30 mm	26
GW 10× M	30 mm	24
GF 10× (with adapter sleeve)	23.2 mm	18

Table 1 - Various Leitz Periplan oculars for the Leitz Orthoplan microscope.

With its tremendous FOV index of 28, the GW 6.3× ocular forms an image that appears to have the same dimension as the diameter 176mm (6.3 × 28mm) of an area at a distance of 250mm in front of the observer. At this size, the image can also be reproduced 250mm above the eyepiece on a ground-glass screen.

In 2006, Mike Andre published a beautifully illustrated summary about the Orthoplan microscope [8].

A brochure of the Orthoplan can be found at [9] and the manual is available at [7].

The Leitz Ortholux II – An Overview

The Leitz Ortholux II (see Figure 6) was sold in the seventies and early eighties. It is a well built microscope that offers great flexibility. Like the Orthoplan, the foot of the compact stand is supported by four dampers protecting the instrument against external vibration. The stand weighs around 10.5kg with a height of the eye level at 385mm. The square shaped base has a width of 253mm.

The Ortholux II provides support for an exchangeable nose piece, episcopic fluorescence illumination (Ploemopak 2.2), all major illumination types, and polarization microscopy. However, the Ortholux II does not have the Orthoplan's legendary wide field of up to 28mm FOV. For the Ortholux II, Leitz offered the FSA binocular viewing head with photo port providing an 18mm FOV. Of course, this viewing head also offers the mechanical tube length compensation explained in the previous chapter.

While the Ortholux II looks less imposing than the Orthoplan and less intriguing than the magnificently designed Ortholux, it offers some good improvements when compared with many research stands from the same time period. If one does not require the Orthoplan's wide field optics, the Ortholux II is an excellent choice.[8]

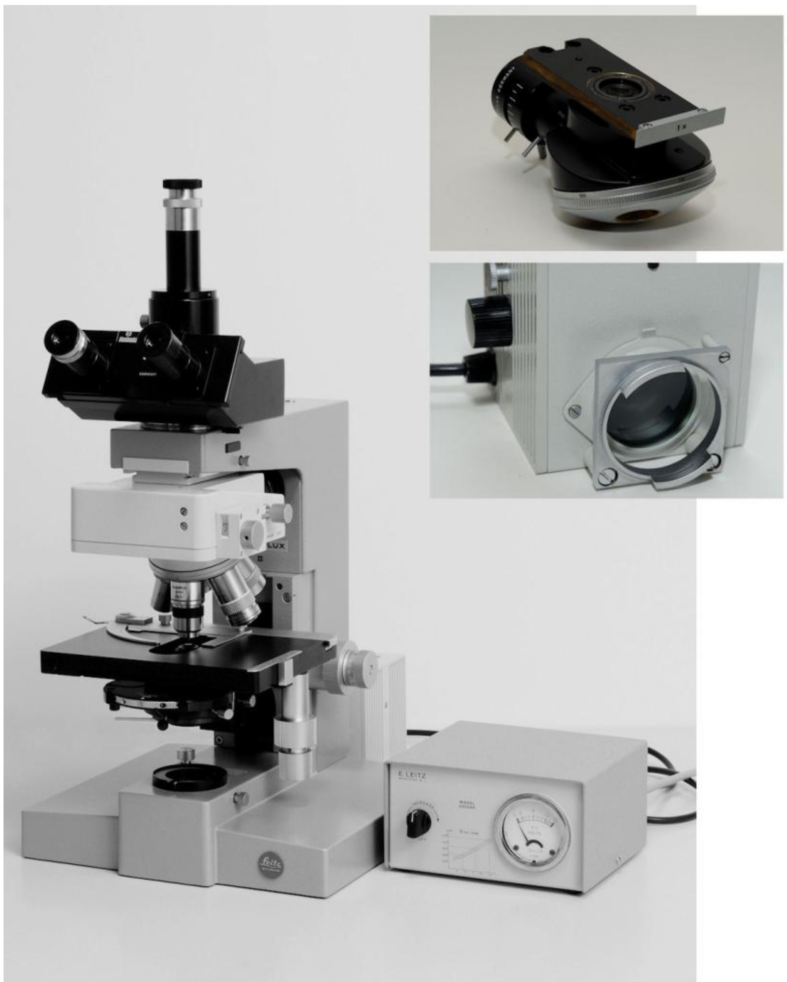


Figure 6 - Leitz Ortholux II with Ploemopak 2.2, FSA viewing head and Leitz 402a phase contrast condenser. The locking device of the Leitz Lamp Housing 50 and the episcopic nosepiece with a 1× tube lens are shown in separate insets.

[8] While the authors were able to obtain the instruction manual for the Ortholux II (see "References" at the end of this document), no Leitz brochure of the Ortholux II could be located.

The Ortholux II and Orthoplan – A Comparison

Compatibilities between the Orthoplan and Ortholux II:

1) Both use the 170mm mechanical tube length
2) Both share the same objectives (diascopic and episcopic types)
3) Both use the same oculars with 23.2mm diameter (sleeve is required for Orthoplan)
4) Both use the same dovetail mount for condensers
5) Both use the same condensers with dovetail mount[9]
6) Both use the identical dovetail changer for the mechanical stage
7) Both can share the same mechanical stages (although, the Orthoplan uses slightly larger ones)
8) Both use the same fine and coarse focusing adjustment mechanism

The Consequences of the Orthoplan's Wide Field of View

The Orthoplan supports oculars with a diameter of 30mm (e.g. Periplan GW 8× M) and 23.2mm (e.g. Periplan GF 10×). A sleeve is required for the ones with a diameter of 23.2mm (see Figure 7). The Ortholux II does not support the 30mm oculars.

Figure 7 – Leitz sleeve for ocular

Figure 8 – Horizontal dovetail of the revolving nosepiece of the Ortholux II (left) and the Orthoplan (right).

The diameter of the dovetail mount of the viewing head for the Orthoplan is 50.0mm and for the Ortholux II 43.0mm.[10]

The horizontal dovetail of the Orthoplan's revolving nosepiece does not fit on the Ortholux II (see Figure 8 and Table 2). Therefore, the fluorescence vertical illuminator Ploemopak 2.2 (see Figure 9) for the Ortholux II, which is used for fluorescence microscopy, cannot be used with the Orthoplan. The Orthoplan uses the Ploemopak 2.1 instead.

Table 2 – Dimensions of horizontal dovetail of revolving nosepiece for Ortholux II and Orthoplan

	Ortholux II	Orthoplan
Length	103.5mm	108.7mm
Width	44.5mm	51.0mm

[9] Since most condensers with dovetail mount for the Ortholux II and Orthoplan work on the old Ortholux, the authors refer the reader to the chapter "The Leitz Condensers" in [2] for more details about different condensers available for these microscopes.
[10] For more details about different viewing heads, please see section "Differences in Available Viewing Heads" on page 11.

Figure 9 – Ploemopak 2.2 for the Leitz Ortholux II with four phase contrast objectives and one Olympus SPlan 40x objective. This vertical Leitz illuminator is used for fluorescence microscopy. It is corrected for objectives made for the 170mm mechanical tube length.

The filter slide of the Orthoplan, which is located immediately below the tube change, uses filters with a diameter of 25mm vs. 18mm for the Ortholux II. The diaphragm tube with filter slot of the Orthoplan, which is used for episcopic illumination, has a diameter of 50mm vs. 38mm for the Ortholux II.

Differences in Available Lamp Housings

The bayonet mount for attaching a lamp housing is different. The lamp housing of an Orthoplan (e.g. Leitz Lamp Housing 100 Z or Lamp Housing 250, see Figure 10) can only be attached to an Ortholux II by means of an adapter (see Figure 11). We do not know of any adapter that would enable the lamp housing of an Ortholux II to be used on an Orthoplan (e.g. Leitz Lamp Housing 50 or Lamp Housing 102 Z, see Figure 10).

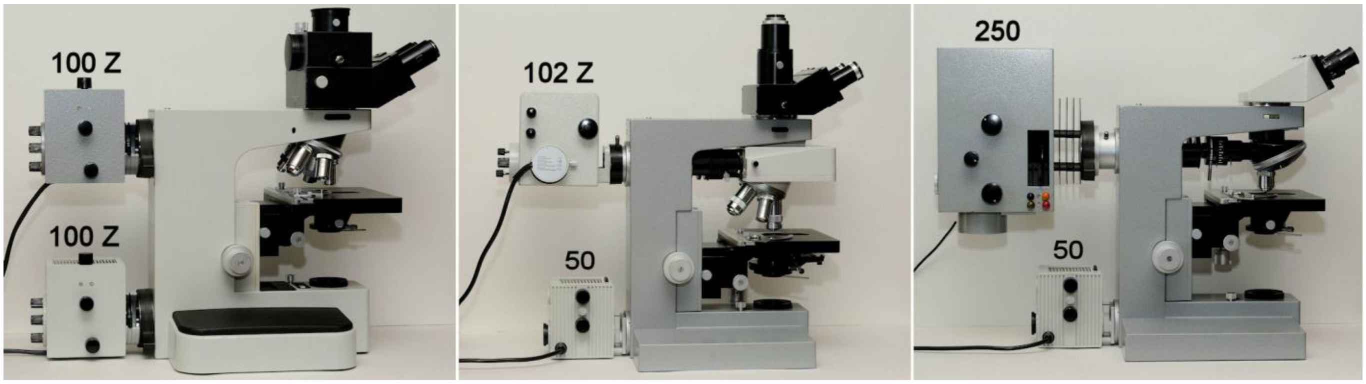


Figure 10 – Various Leitz lamp housings attached to the Orthoplan (left), Ortholux II (middle and right). The Leitz Lamp Housing 250 is attached via an adapter to the Ortholux II (see image to the right).

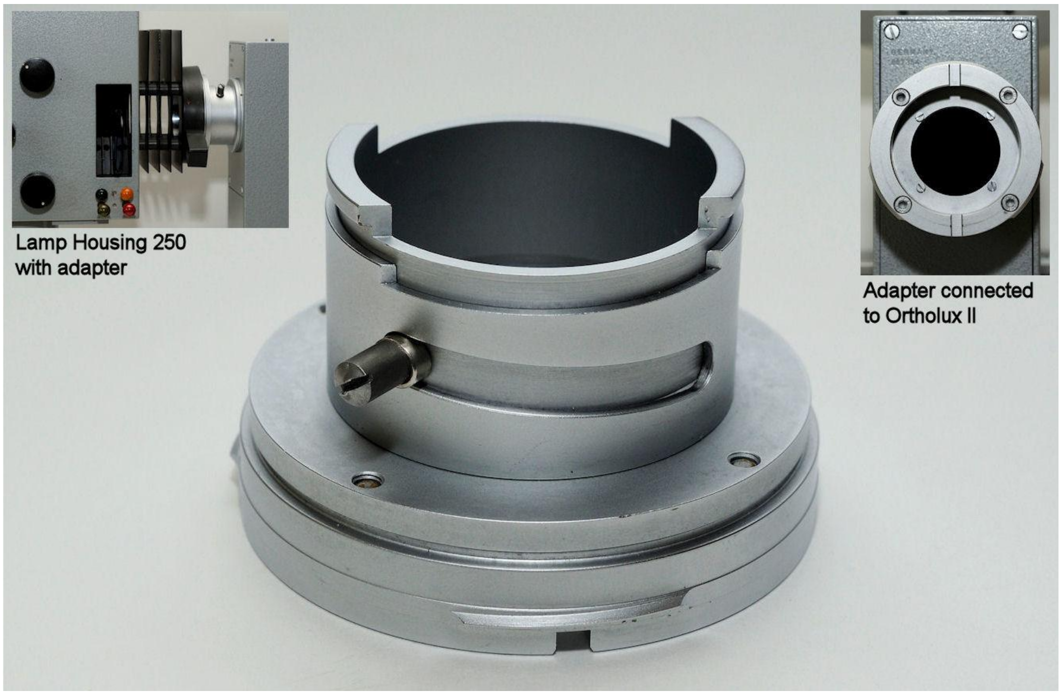


Figure 11 - Special adapter made by Leitz to use a lamp housing made for the Orthoplan on an Ortholux II.

For the Orthoplan, Leitz produced four very versatile mirror housings, which allow many combinations of lamp housings to be used on one stand.[11] The Leitz Mirror Housing 500 (see Figure 12) offers the greatest flexibility and is required for the very large Lamp Housing 500. Using the special adapter mentioned above (see Figure 11) and an appropriate support to elevate the microscope, the Leitz Mirror Housing 250/D can be used with an Ortholux II. Leitz offered a special version of the Mirror Housing 500 for the Ortholux II. – The possibilities of illumination with the Leitz Mirror Housing 500 are truly remarkable. Three lamp housings can easily be attached to this very stable platform. Controlled by two levers and one slider, almost any meaningful combination can be selected.

Figure 12 – Leitz Orthoplan with Leitz Mirror Housing 500 and Lamp Housing 250.

The Mirror Housing 250 and 500 are well suited for adding a computerized micro-flash (speedlight). A mirror position is selected that combines the speedlight illumination with the illumination coming from one of the other attached lamp housings. Of course, a collector lens must be positioned in front of the tube of the speedlight to establish Köhler illumination. For more details, please take a look at chapter 13 in [12].

[11] Leitz Mirror Housing 250/D, Mirror Housing 250/O, Mirror Housing 250/S and Mirror Housing 500.

Differences in Available Viewing Heads

The viewing heads for the Dialux 20/20EB, Laborlux 11/12, Laborlux K/D, Fluovert, Labovert, and Dialux 22/22EB can neither be used with the Ortholux II nor with the Orthoplan.[12] – Using eyepiece tubes for a 170mm TL, the improved FSA-GW viewing head (see Figure 13), which was also offered for the Aristoplan, works perfectly on the Orthoplan.[13]

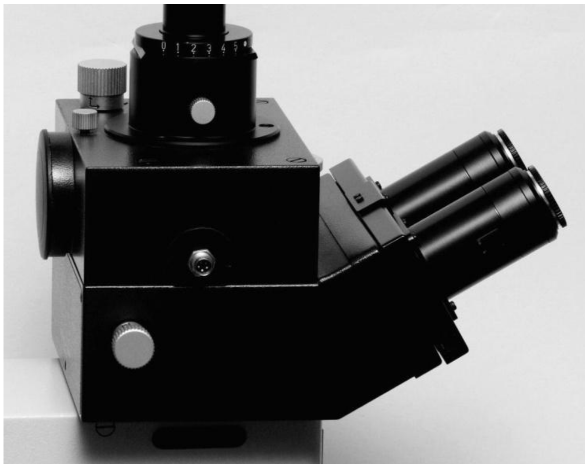


Figure 13 – Leitz FSA-GW viewing head with two beam splitters for the Orthoplan microscope. Two Periplan GW 8x M are shown. Supports 100/0, 20/80 and 0/100 for visual/photographic.

Figure 14 – Inclined monocular tube with attachable swing-out drawing mirror.

Most components are exchangeable between the Leitz SM-LUX, Dialux and Ortholux II from the 70s and early 80s (see Figure 3). All of these stands were built for a 170mm mechanical tube length. The inclined monocular tube P (frequently found on a Leitz HM-LUX student microscope) together with an attachable swing-out drawing mirror can be used for projecting and tracing a microscopic image on paper (see Figure 14). Since plenty of light is required for this type of drawing attachment, a monocular viewing head is preferred.

For visual observation of a faint fluorescence response, a Periplan 6.3× with a monocular viewing head is highly recommended. For photomicrography of very faint signals, the straight tube O is the best choice for the Ortholux II, since its binocular photo head FSA can only be switched to 20% visual and 80% photographic. Of course, neither the inclined monocular tube P nor the straight tube O will fit on the Orthoplan. For the Orthoplan, the FSA-GW viewing head shown in Figure 13 supports three modes 100% visual, 20/80 and 100% photographic. The “standard” FSA-GW viewing head, which has only one ISO 38mm port, does not allow 100% illumination to be directed to the photo port. In the earlier days of the Orthoplan, the FSA 55 viewing head was sold, which supported 100% visual or 100% photographic. In 1969, Leitz offered the FP-GW monocular tube with photo port for the Orthoplan.

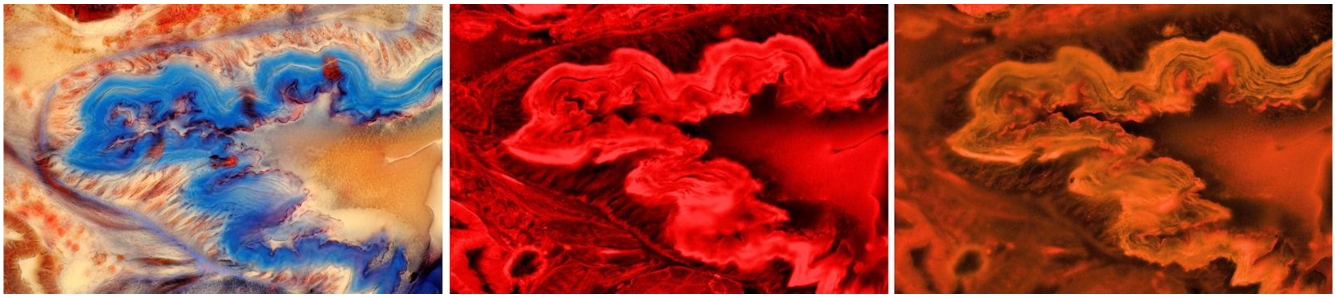


Figure 15 – Photomicrographs of tissue layers inside a caterpillar (t.s. of body) using a Leitz Ortholux II with Ploemopak 2.2 and Nikon D300 DSLR. Left image shows specimen in bright field, center image shows fluorescence response using filter cube N2 and right image shows fluorescence response using filter cube I2.

[12] For instance, the diameter of the dovetail mount of the viewing head for the Laborlux 11 is 42.0mm. The Laborlux 11 is corrected for a 160mm TL.

[13] A different version of the enhanced FSA-GW viewing head is available for the Diaplan, which uses eyepiece tubes for a 160mm TL. It also contains a different sliding prism that offers 100/0, 50/50 and 10/90 for visual/photographic.

Photomicrography with the Orthoplan and Ortholux II

The solid construction of the Orthoplan and Ortholux II provides a stable platform for photomicrography. Regarding vibration considerations, the massive base of the Orthoplan absorbs very effectively vibrations of low energy.[14]

The Orthoplan is suitable for supporting a large format camera without using a special stand. While Leitz recommends the use of the **Aristophot**[15] for the Ortholux II when using a 4”×5” bellows camera, the heavy stand of the Orthoplan just requires a camera holder that is directly attached to the back of the microscope.

We use the following cameras with the Orthoplan and Ortholux II:

- The Nikon Coolpix 990 (and 950)
- The Nikon D300 DSLR
- Wild Leitz MPS 46/52 Photoautomat (using 35mm film)

The Ortholux II and Orthoplan can be equipped with a viewing head providing a 38mm ISO port. Both microscopes require compensating photo eyepieces to fully correct the image prior to projection onto the image sensor.

Figure 16 –Leitz Orthoplan with Leitz Aristophot and 4”×5” bellows camera.

For the **Nikon D300 DSLR**, we use two rather complex setups that will be described elsewhere in more detail [11]. One setup consists of an Olympus NFK 2.5× photo eyepiece. For the other one, we use a Leitz 0.32× relay lens or a Nikkor 50mm objective in combination with a Leitz Periplan ocular. To eliminate the impact of unwanted shutter vibrations, we also make use of the Leitz Aristophot stand. This stand allows adjusting the distance between various different photo eyepieces/oculars and the image sensor via a focusing rail.

When using the Leitz Aristophot, the Nikon D300 is no longer directly connected to the photo port but uses a special adapter consisting of an upper light excluding collar (connected to the bellows support) and a lower light excluding collar (connected to the external shutter). In order to merge the two collars, the bellows support is lowered until the light excluding collar is in line with the white ring of the lower light excluding collar.

Figure 16 shows the Leitz Orthoplan microscope with a 4”×5” bellows camera in place of the D300. Already in 1965, this universal photomicrographic apparatus (without the Orthoplan microscope) sold for $878.00. The Microsix-L exposure meter cost an additional $157.00.

The Nikon MC-30 remote cable for the D300 is highly recommended. We always ensure that the image sensor is parfocal with a photo mask inside one of the two oculars of the binocular tube.

[14] Using a microscope, we can easily detect even minor vibrations by observing dust particles floating on top of a drop of water.
[15] The Leitz Aristophot is a versatile photographic apparatus for photomicrographic and photomacrographic work using diascopic and episcopic illumination.

The **Nikon Coolpix 990** setup is less sophisticated. A Nikon Coolpix 990 is directly connected with a Leitz Periplan 10× ocular (type 519,748), which perfectly fits into the filter thread of the Coolpix camera. Since this particular ocular is corrected for the 160mm mechanical TL, a custom adapter is provided that moves the fixed diaphragm of this ocular to the position of the intermediate image formed by the tube lens (see Figure 17).

Figure 17 – Nikon Coolpix 990 with Periplan 10× ocular and custom adapter for the 38mm ISO port of the FSA binocular photo tube.

The Nikon D300 is more suitable for darkfield illumination, phase contrast and fluorescence microscopy due to its better low-noise performance. However, the Nikon Coolpix 990 performs adequately for these types of applications (see Figure 18).

The Nikon MC-EU1 remote control that attaches to the Coolpix camera is highly recommended. For accurate focus, the image sensor of the camera is parfocal with a photo mask inside one of the two oculars.

We rarely obtain acceptable results with the automatic white balance adjust of the Coolpix cameras and hence compensate with a blue filter when using a halogen lamp.

Last but not least, an IR blocking filter is recommended to increase sharpness. Preferably, this filter is added into the filter-slot of the lamp housing.

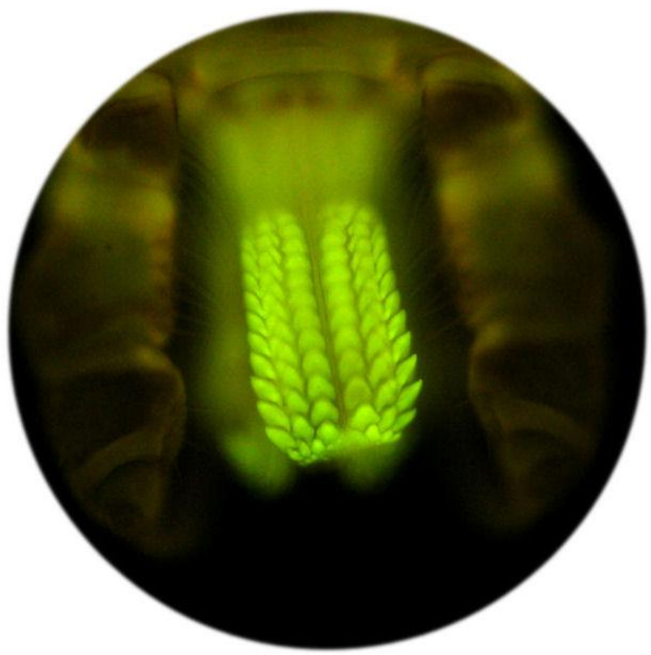


Figure 18 - Mouth of Dermacentor variabilis (American dog tick). Used Ortholux II with Ploemopak 2.2. The fluorescence response has been recorded with a Nikon Coolpix 990 using filter cube I2.

The **Wild Leitz MPS 46/52 Photoautomat** is a dedicated camera for photomicrography, which uses 35mm film (see Figure 20). It supports a wide range of exposures (1/100 sec to 30 min) and film speeds (12 to 37 DIN). The MPS 52 camera unit uses an electromagnetic shutter assembly that virtually eliminates all vibrations due to shutter motion. Integral and spot metering is supported. The viewing telescope with photo mask is very bright and conveniently located. Of course, the viewing telescope is only used to ensure that the film plane and the photo mask inside one of the two oculars of the FSA viewing head are parfocal. The MPS 46 control unit provides a sync terminal for a speedlight, which allows flash photography through the microscope. Multi-exposure control is possible through a simple push button. The user interface of the MPS 46 is functional and intuitive (see Figure 19). It has a special button to adjust for brightfield or dark field illumination.

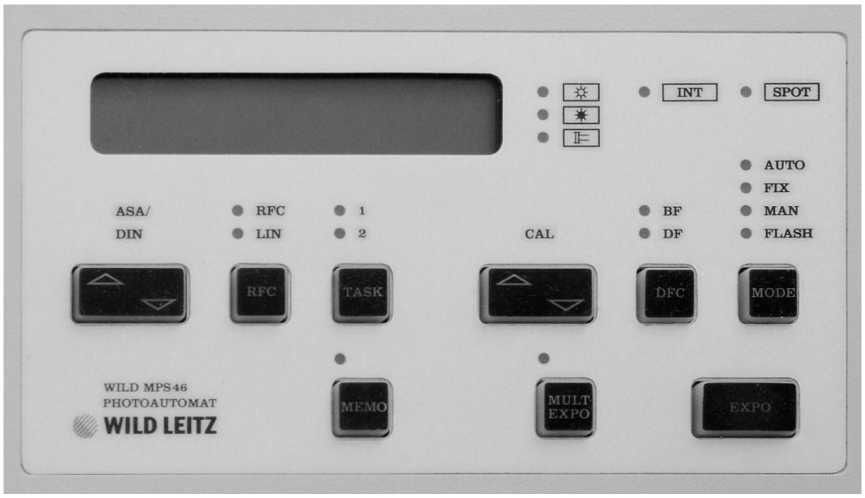


Figure 19 – User interface panel for Wild Leitz MPS 46.

This sophisticated camera system is still an excellent choice for amateur microscopists. Using a slide scanner, photomicrographs can be scanned into a computer system for further processing, sharing and archiving. Of course, the convenience of digital photomicrography is perfectly obvious. But even today, the Wild Leitz MPS 46/52 Photoautomat is still very competitive when the utmost quality is expected. – We are using the following 35mm films with this system:

- Fujichrome Velvia 50
- Kodak Professional BW 400CN
- Ilford HP5 Plus 400

A Leitz Periplan ocular (6.3× to 10×) is used to complete the optical correction. The fully corrected image is projected with a 0.32× relay lens onto the film. This optical "multi-stage" approach is recommended by Leitz [13].

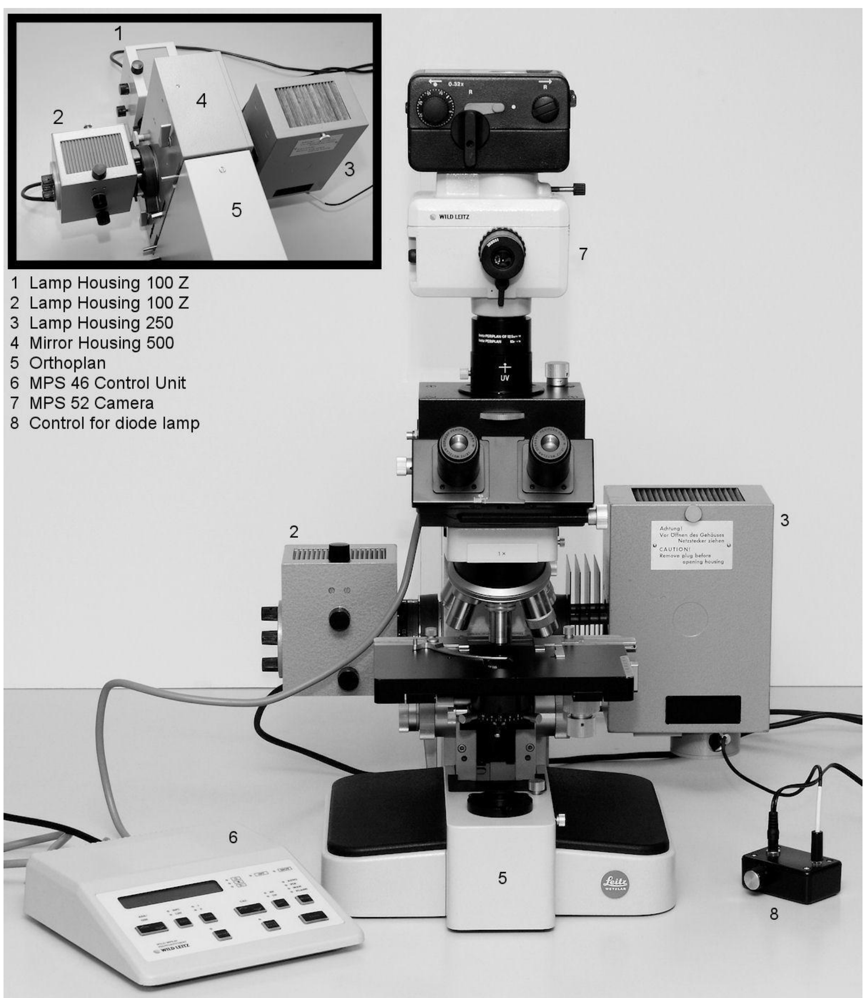


Figure 20 – Leitz Orthoplan with Wild Leitz MPS 46/52 Photoautomat and Mirror Housing 500.

The Focusing Block of the Leitz Orthoplan and Ortholux II

(The following text and figures are from [4]. We only made small changes to improve clarity.)

The focusing block provides backlash-free precision stage movement (Figure 21). The drive mechanism for the coarse and fine adjustment is of an ingenious design with a fine focusing range over the entire travelling distance of 40mm. On both high-end stands, the coarse and fine adjustments are actuated with coaxial 2-knob controls using a planetary gear for the drive mechanism (see Figure 22).

The backlash-free precision stage movement is a combination of ball and steel-needle guides in prismatic basic arrangement (see Figure 21). The balls (labeled '**5**') with the hardened steel needle races '**6**' are visible. The rear guide track '**1**' is prismatic and the front guide track '**2**' is flat. Both of these guide tracks are rigid. The prismatic guide determines the movement and the plane guide the lateral fixation. The movable guide track '**3**' is pressed against the fixed guides '**1**' and '**2**' by means of a spring bar '**4**' via the metal balls. This construction ensures constant pressure and the spring arrangement eliminates any backlash.

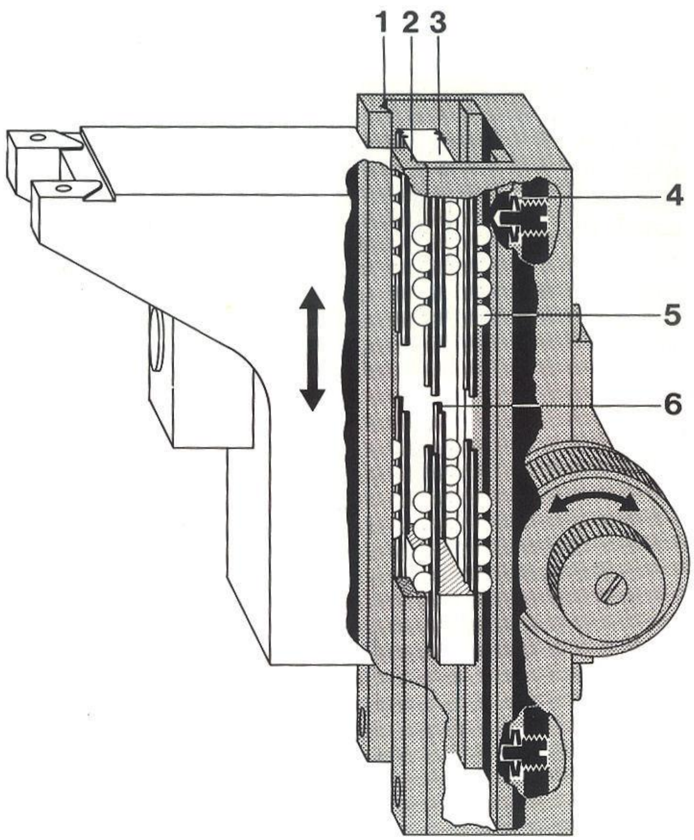


Figure 21 – Backlash-free precision stage movement for the Ortholux II and Orthoplan. For a description, please see text. © 1977 by Ernst Leitz GmbH, Wetzlar.

Figure 22 shows the planetary gear for the coarse and fine adjustment. The yellow elements are part of the coarse adjustment (see right diagram in Figure 22) and the cyan ones of the fine adjustment (see middle diagram in Figure 22). In the diagram on the left side of Figure 22, we can recognize the fine adjustment knob ‘**1**’, the coarse adjustment knob ‘**2**’, the terminal gear wheel ‘**3**’, the large worm wheel ‘**4**’, the pairs of obliquely toothed wheels (‘**5**’ and ‘**6**’), and the casing ‘**7**’.

In the right diagram of Figure 22, the planetary wheels are shown in yellow, which now act as pure transmission links (similar to the transmission of a lathe). This motion provides the coarse adjustment. In short, the worm ‘**12**’ drives the worm wheel ‘**9**’, which in turn drives the terminal gear wheel ‘**3**’ via the four gear wheels ‘**10**’, ‘**11**’, ‘**13**’, and ‘**14**’.

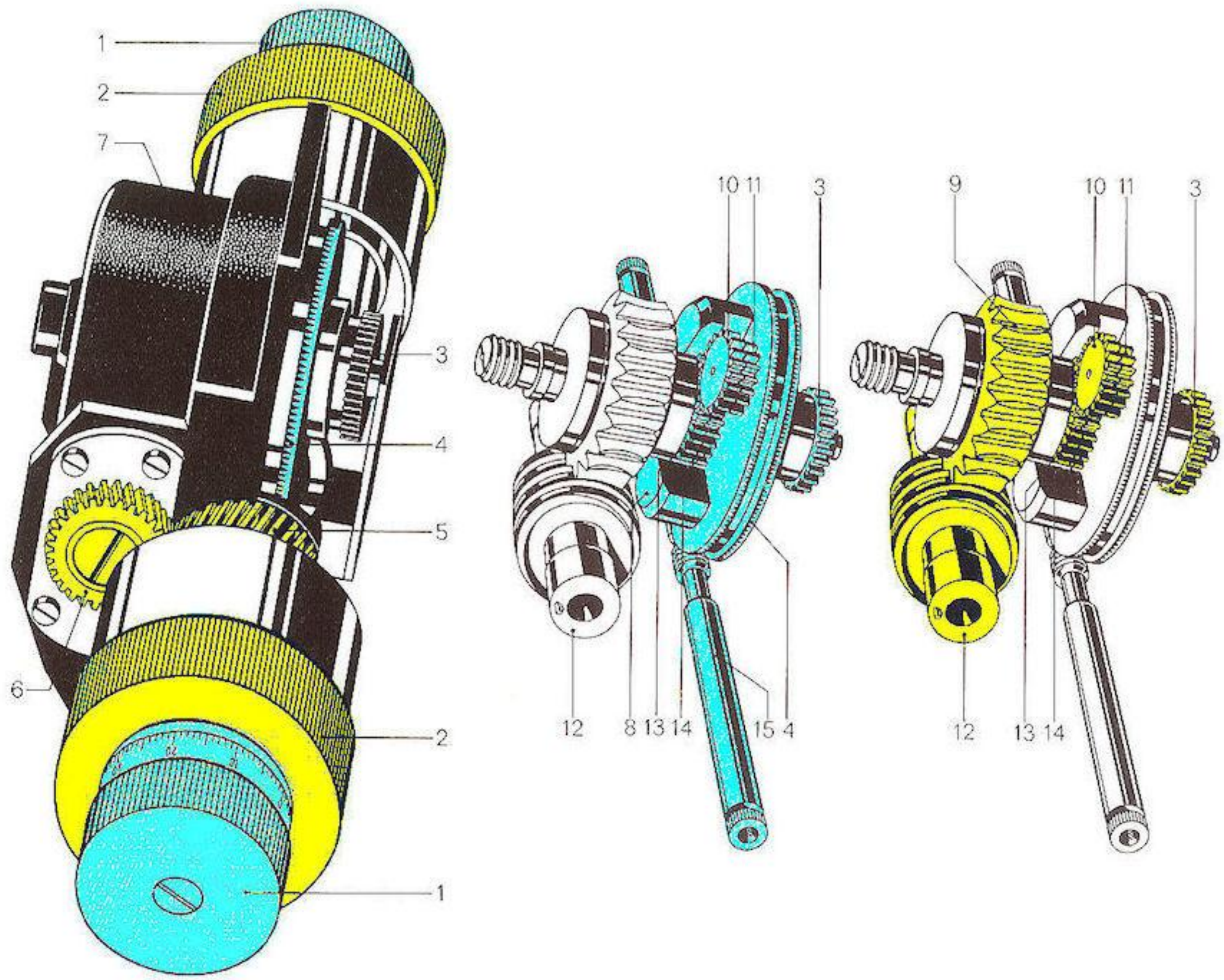


Figure 22 – Complete drive mechanism for coarse and fine adjustment used on the Ortholux II and Orthoplan microscopes (left). The illustrations in the middle and on right side show the planetary gear only. The functions for fine adjustment (middle in cyan) and the functions for coarse adjustment (right in yellow) are shown. For a more detailed explanation, please see text. © 1977 by Ernst Leitz GmbH with small modifications.

In the middle diagram of Figure 22, the planetary wheels are shown in cyan, which now act as a pure planetary gear motion. This motion provides the fine adjustment. In short, the cyan worm ‘**15**’ drives the large worm wheel ‘**4**’, and this in turn drives the terminal gear wheel ‘**3**’ via the planetary wheels ‘**10**’, ‘**11**’, ‘**13**’, and ‘**14**’. The two gear wheels ‘**10**’ and ‘**11**’ move round the internal gear wheel ‘**13**’ and ‘**14**’, like two planets.

Successors of the Leitz Orthoplan and Ortholux II

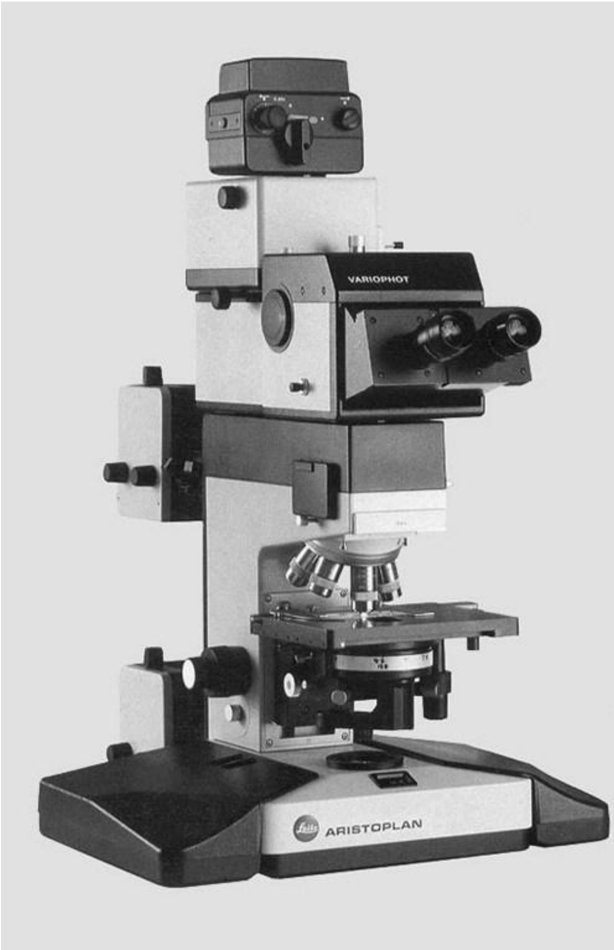


Figure 23 – Leitz Aristoplan. It uses a 160 mm mechanical tube length. © Ernst Leitz GmbH, Wetzlar.

In 1985, Leitz introduced its new workhorse research microscopes, the Leitz Diaplan and the Leitz Aristoplan (see Figure 23). During the eighties, the Leitz Diaplan gradually replaced the Ortholux II, and the Aristoplan became the top research microscope. The last Leitz Orthoplan microscopes were sold in the nineties. It is interesting to note that before coining the name Aristoplan, Leitz sold this new research stand under the name Orthoplan 2. The designation Orthoplan 2 did not last for long.

A very well written article about the Leitz Diaplan microscope is written by David Walker and published in the Micscape Magazine [14].

Around the same time the company moved away from the 170mm mechanical tube length design, it underwent several stages of reorganization. Before long, even the famous name of *Ernst Leitz GmbH* became part of history.

In 1986, the Leitz family sold the remaining shares to Wild-Heerbrugg AG, Switzerland. See Table 3 for some important dates in the history of Leitz.[16] – More information about the history of Leitz can be found in [15] and [16].

Table 3 – Important events in the history of Leitz

Event	Year
Carl Kellner founds the "Optical Institute"	1849
Ernst Leitz joins the Optical Institute	1864
Leitz becomes sole owner and manages company under his own name	1869
Introduction of legendary *Ortholux* research microscope	1937
Introduction of *Orthoplan* (largefield research microscope)	**1965**
Introduction of *Ortholux II* (second generation of Ortholux)	**1972**
Co-operation with Wild-Heerbrugg AG	1972
Wild AG gains majority of Leitz	1974
Accepting the 160mm mechanical TL standard	1976
Introduction of NPL-FLUOTAR objectives	1976
Leitz family sells remaining shares to Wild	1986
Name change to Wild Leitz GmbH	1988
Name change to LEICA Mikroskopie und Systeme GmbH	1990
Danaher Corporation acquires LEICA Microsystems Inc.	2005

[16] We only focus on events relevant to the development of microscopes.

Appendix A – The Mechanical Tube Length

How can we measure the "mechanical tube length" of a microscope? – Without difficulty, this can be measured for a monocular microscope, such as the Leitz LL from 1950, because the mechanical tube length is just the distance between the flange of the objective lens and the seating surface on which the eyepiece rests (see Figure 24). But in case of a research microscope outfitted with a nose piece containing a tube lens, this seemingly plain task becomes rather difficult.

Figure 24 – Shows mechanical tube length of 170 mm for a Leitz LL student microscope.

The combination of tube lens and objective is responsible to generate an intermediate or primary image of the specimen at the fixed diaphragm of the eyepiece or photo relay lens. For an optical system that provides all necessary corrections inside the objective/tube lens combination, the intermediate image can directly be projected onto the image sensor without any loss of image quality.[17]

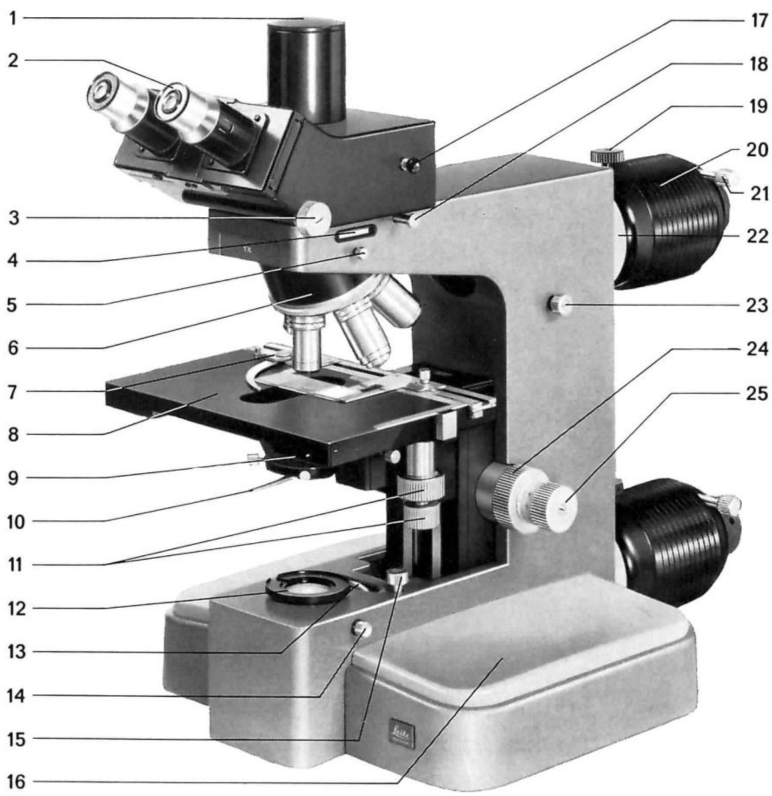
For many microscope designs (e.g. Orthoplan and Ortholux II) the ***optical tube length***,[18] which defines the exact location of the intermediate image below the shoulder of the ocular, is proprietary.

Provisions to add certain accessories force microscope makers to build microscopes with a longer finite tube length than the mechanical tube length required for correcting their optical system (e.g. longer than 170mm). As a result, for each such accessory in a finite system, optical elements must be added to bring the tube length ostensibly back to its proper value (e.g. 170mm).

[17] For instance, the Nikon CFI_{60} objectives are "fully" corrected, and therefore no additional image correction is necessary inside the tube lens and ocular to complete the correction of the objectives.

[18] The **optical tube length** is defined as the distance between the objective rear focal plane and the intermediate or primary image at the fixed diaphragm of the eyepiece. Since the position of the intermediate image is affected by any lens inserted below the intermediate or primary image, many eyepieces change the optical tube length (the field lens of the ocular lowers the image somewhat).

Appendix B – Parts of the Orthoplan Microscope



1 Removable cover in the photo tube
2 GW/GG eyepiece in the eyepiece tubes
3 Knob for adjusting the interpupillary distance
4 Filter slide
5 Screw for clamping the revolving nosepiece
6 Revolving nosepiece, horizontally interchangeable
7 Object guide; traversing range of the specimen 76x52mm
8 Large square mechanical stage No 660
9 Swing-out condenser No 602
10 Aperture iris lever
11 Coaxial drives for the mechanical stage adjustment
12 Filter space
13 Field iris
14 Clamping screw for accessories
15 Adjustment knob of the swing-out lens
16 Plastic hand rests
17 Lever for operating the beam splitter; fully pulled out: all the light in the eyepieces, fully pushed in: 20% light in the eyepieces, 80% in the photo tube
18 Locking lever for tube change
19 Knurled knob for adjusting the condenser of the low-voltage lamp
20 12v 60W low-voltage lamp for incident light (the lamps are identical for incident and transmitted light)
21 Lamp socket clamping screw
22 Knurled ring for securing the low-voltage lamp
23 Adjustment knob for the upper swing-out lens (incident light)
24 Coarse adjustment
25 Fine adjustment

Figure 25 – Parts of the Orthoplan microscope. © 1966 by Ernst Leitz GmbH, Wetzlar.

Inserting the swing-out condenser No 602

1 Object stage clamping screw
2 Dovetail changer for the condenser
3 Knob for the vertical condenser adjustment
4 Rotating knob for swinging the condenser top in and out

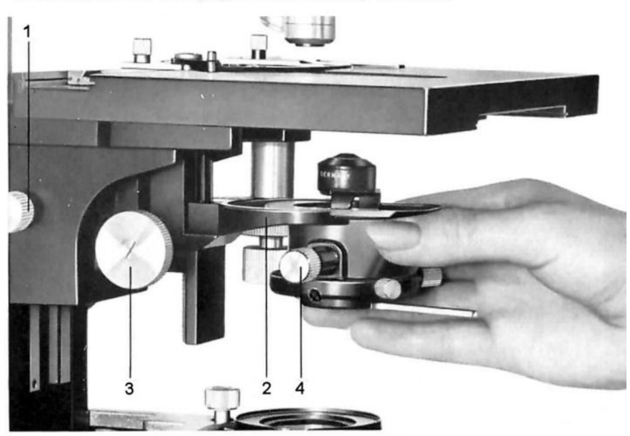


Figure 26 – Detail description of condenser mount of the Orthoplan. © 1966 by Ernst Leitz GmbH, Wetzlar.

References

[1] A. Hadley, Combine ZM and ZP for MS Windows, available at http://www.hadleyweb.pwp.blueyonder.co.uk with information at http://tech.groups.yahoo.com/group/combinez/.

[2] G. Overney and N. Overney, The Excellent Leitz Microscopes with Black Enamel Finish, 5th edition, Micscape Magazine, March 2008, available at http://www.microscopy-uk.org.uk/mag/artmar08/go-leitz.html.

[3] Leitz Inter-Office Memorandum (available at http://www.science-info.net/docs/leitz/Leitz-160mm-Memo.pdf) from September 30, 1976 entitled "160 mm Mechanical Tube Length".

[4] H. Determann and F. Lepusch, The Microscope and Its Application, 512-69c/Engl., Ernst Leitz Wetzlar GmbH, Wetzlar (1977).

[5] R. P. Loveland, p. 59, Figure 2-2 "Tolerance to tube length change versus objective NA." in Photomicrography – A Comprehensive Treatise, Volume 1, John Wiley & Sons, Inc. (1970).

[6] G. Couger, Science-Info.org, available at http://science-info.net/index.html.

[7] Manual for the Leitz Orthoplan, available at http://microscope.database.free.fr/Microscopes_manuals_files/512-83%20Instructions%20Orthoplan.pdf.

[8] Mike Andre, Leitz Orthoplan -- Universal Largefield Research Microscope, Micscape Magazine, May 2006, available at http://www.microscopy-uk.org.uk/mag/artmay06/ma-orthoplan.html.

[9] 1978 brochure for the Leitz Orthoplan at http://www.science-info.net/docs/leitz/orthoplan78.pdf.

[10] Manual for the Leitz Ortholux II at http://www.science-info.net/docs/leitz/Leitz_Ortholux_II.pdf.

[11] N. Overney and G. Overney, Digital Photomicrography with the APS-C Nikon Format Image Sensor, in preparation.

[12] R. P. Loveland, Photomicrography – A Comprehensive Treatise, Chapter 13, p. 604ff, John Wiley & Sons, Inc., 1970.

[13] Leitz advised against the use of negative oculars for photomicrography with plano objectives. See p. 57 in R. P. Loveland, Photomicrography – A Comprehensive Treatise, John Wiley & Sons, Inc., 1970.

[14] David Walker, A tour round a Leitz Diaplan microscope, Micscape Magazine, January 2009, available at http://www.microscopy-uk.org.uk/mag/artjan09/dw-diaplan.html.

[15] J. Grehn, Leitz Microscopes for 125 Years, English edition, E. Leitz, Inc. Rockleigh, N.J. 07647 (1977).

[16] Rolf Beck, Die Leitz-Werke in Wetzlar, Sutton Verlag, Erfurt, Germany (1999).