

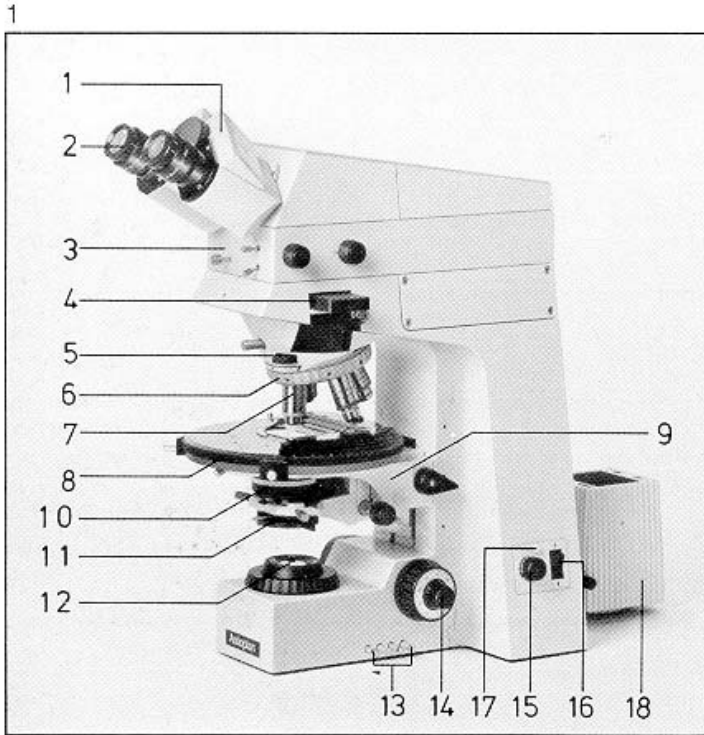
**OPTON**

Opton Feintechnik GmbH  
D-7082 Oberkochen

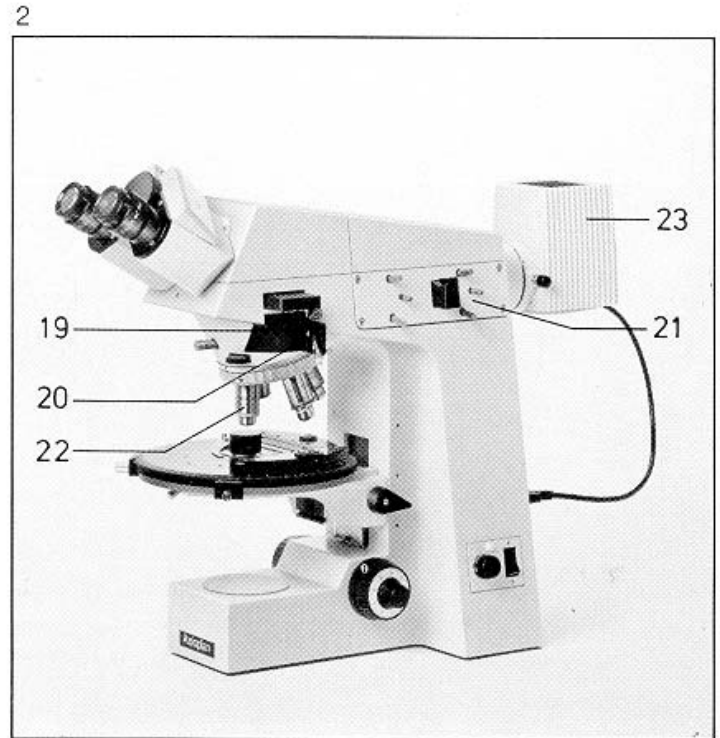
Axioplan Pol  
Universal microscope

Transmitted and Reflected light

Operating instructions



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- 2 Pol eyepieces
- 3 Intermediate Pol tube
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- 5 Slot for auxiliary objects
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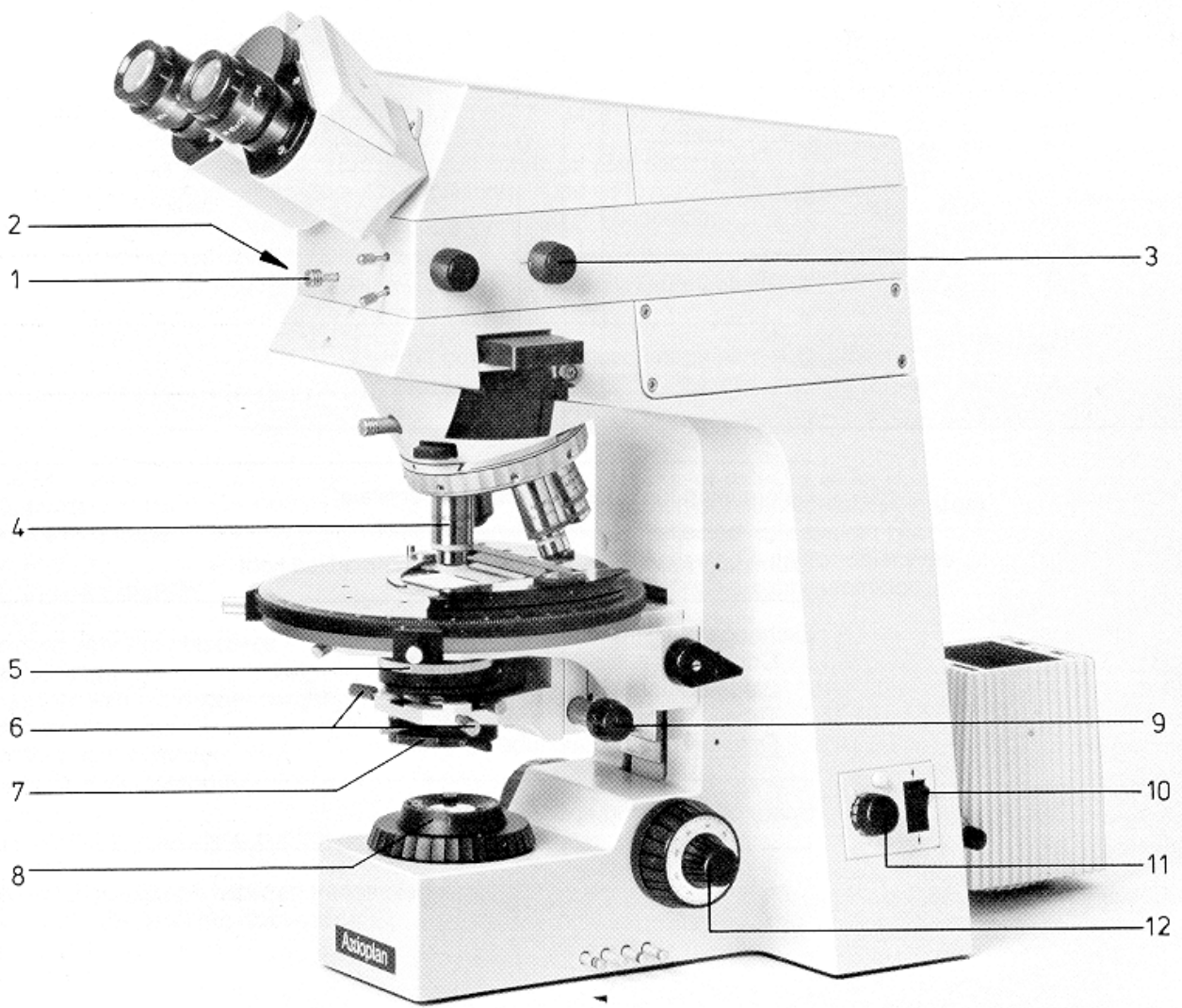


- 19 Slot for reflector slider H
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**Special notes**

- The 6- to 10-digit numbers, e.g. 451827, are ordering numbers of instruments or instrument components.
- Caution  
The instruments shall not be used in explosion-hazardous locations.
- The instruments shall be changed and/or repaired only by the manufacturer or his authorized representative.
- Specifications subject to change.



# Microscope adjustment in brief (Transmitted-light brightfield)

Note: Framed numbers like **1.1** refer to the description of the instrument starting on page 6.

- Check data on nameplate (instrument back) and local line data for coincidence. Plug in microscope power cable. Select lower (or only) illuminator with switch (10). Switch on with (11) and set to 3–4 V.
- Load a high-contrast specimen (coverglass face up!).
- Turn in 10× objective (yellow ring) (4) on nosepiece, check 0-positions on the eyepiece scale. With (9) move condenser to topmost position (front lens not swung out).
- Close the condenser diaphragm about half with (5).
- Pull out pushrod (1) of intermediate Pol tube, set knob (3) to diaphragm 2.0, and flick lever (2) back (symbol ⊕).
- Swing out polarizer (7) beneath the condenser.

You should now see light spots (the exit pupils) behind the eyepieces. The pushrod of a binocular phototube Pol must be pulled out.

When you look into the tube you will see a bright circle (the eyepiece stop) with each eye. Turning the two eyepiece tubes to your PD will merge the two circles into one.

Further steps of Köhler illumination adjustment:

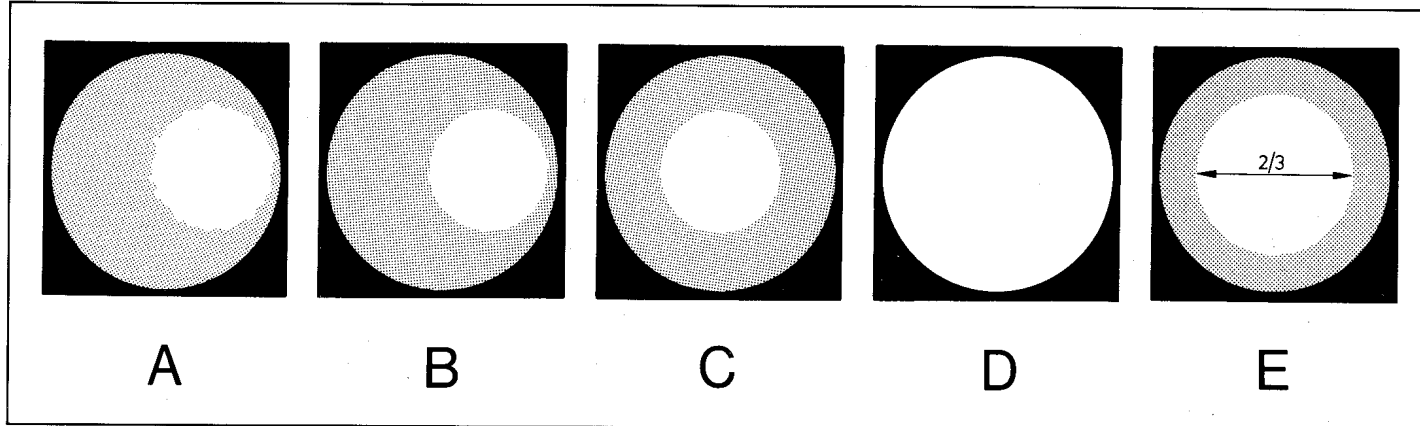
- Focus the specimen with coarse/fine focusing control (12). (If your eyes have different powers and for work without eyeglasses → **6.5**.)
- Close luminous field diaphragm (8) moderately; it will become unsharp (A).
- Focus the diaphragm image by lowering the condenser with (9) (B).
- Move the diaphragm image to the center of the field of view with screws (6) (C), and
- open luminous field diaphragm (8) until it just disappears from the field of view (D).

With the condenser diaphragm (5) adjust the contrast for each specimen. If you are not certain how far to stop down: ca. 2/3 of the rear element of the objective (visible at the tube bottom without eyepiece in the tube) should be illuminated if a specimen is of moderate contrast (E). Field of view and objective aperture change, of course, with each objective exchange, so that the last-mentioned steps must be repeated.

As soon as a low-power objective images more than the condenser can illuminate, swing out the condenser front lens, either automatically by lowering the condenser, or by a lever. For a full description of the procedure see pages 11 and 12.

You will need the above brightfield adjustment only for preliminary examinations, because most observations will be made in polarized light. The corresponding accessories will be described later.

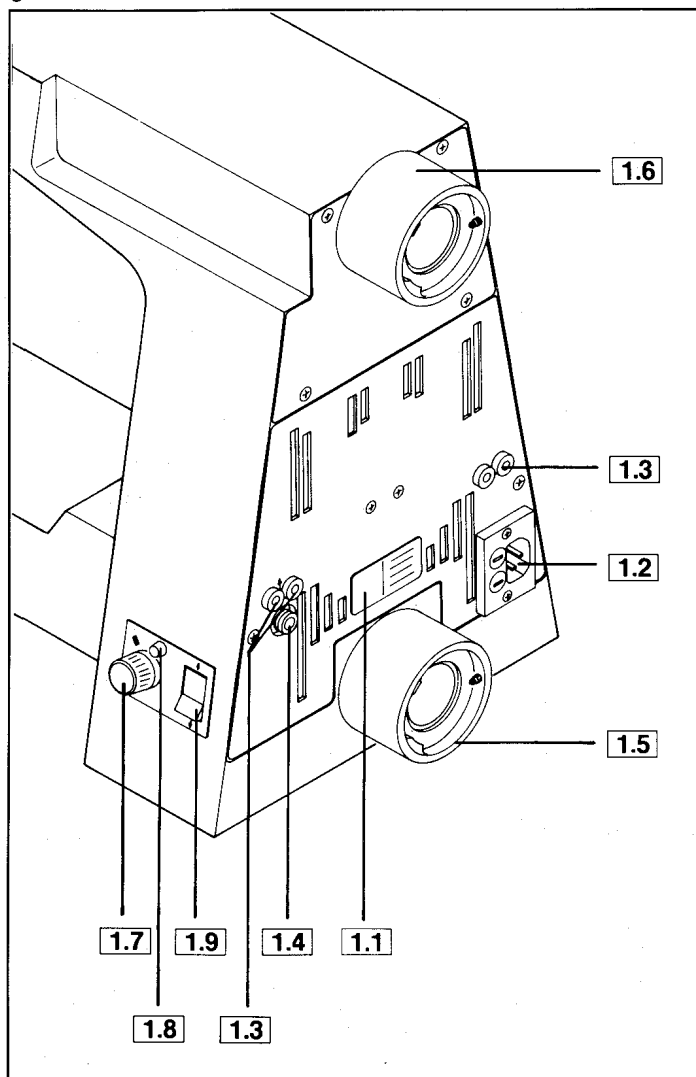
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Special note

Almost all screws you need are 3 mm (M 3) or 1.5 mm (M 1.5) socket-head screws for which the hex socket wrenches with the red handles are supplied.

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**1.0 Lamp power supply**

**1.1** 12V 100W lamp power supply integrated in stand.

Data on nameplate:

220 ... 240 V or 100 ... 127 V AC,

50 ... 60 Hz input voltage;  $\pm 10\%$  voltage tolerance.

Stabilized output voltage: 0 ... 12 V AC.

Power consumption max. 170 VA.

The instrument is radio-screened and complies with VDE and UL regulations.

**1.2** Power switch and, next to it, the fuses.

They are easily exchangeable after removal of the inserts with a screwdriver.

Spare fuses:

220 ... 240 V: 3.15 A SB; ordering no. 127.026

100 ... 127 V: 6.3 A SB; ordering no. 127.029

**1.3** Sockets for 12V 100W halogen lamp:

arrows indicate transmitted and reflected light.

**1.4** Socket for control line to set the lamp to 3200 K independent of the position of switch **1.7**, which facilitates color temperature setting for photography (see also page 22).

**1.5** Transilluminator port.

It contains a tube with heat-reflecting filter and diffusion disk for homogeneous illumination. This tube can be removed to observe the lamp coil in the pupil for lamp centration.

If the microscope is equipped for reflected light only you will find here a mounting plate.

**1.6** Adapter for reflected-light illuminator containing holder with heat-reflecting filter.

**1.6** is omitted in the transmitted-light microscope.

**1.7** Power switch with lamp voltage setting potentiometer supplies 12 V AC in stop position. The adjusted voltage can be read on the index.

**1.8** Power signal lamp.

**1.9** Toggle switch to change between transmitted and reflected-light illumination according to the arrows. (The change is possible with instrument power-on.)

## 2.0 Illuminator 100

The standard equipment includes a 12V 100W halogen filament lamp with socket and collector, which connects to sockets [1.3] according to the arrow.

**2.1** Light exit with dovetail ring to mount the illuminator on the microscope:

1. Loosen screw [1.5] or [1.6] sufficiently.
2. Insert dovetail ring of inclined illuminator in recess opposite the clamping screw, lower the illuminator on to the seating surface and secure it by tightening the screw.

**2.2** Knob for collector adjustment. The collector can be removed if this knob is pulled out (the pin of the knob engages a notch of the collector). The collector contains in front a holder for a 42 mm dia. heat-reflecting filter. To protect the polarizer this filter must be fitted with its reflecting surface facing the light source.

**2.3** Clamping screw of lamp socket (concealed, at the bottom of the housing).

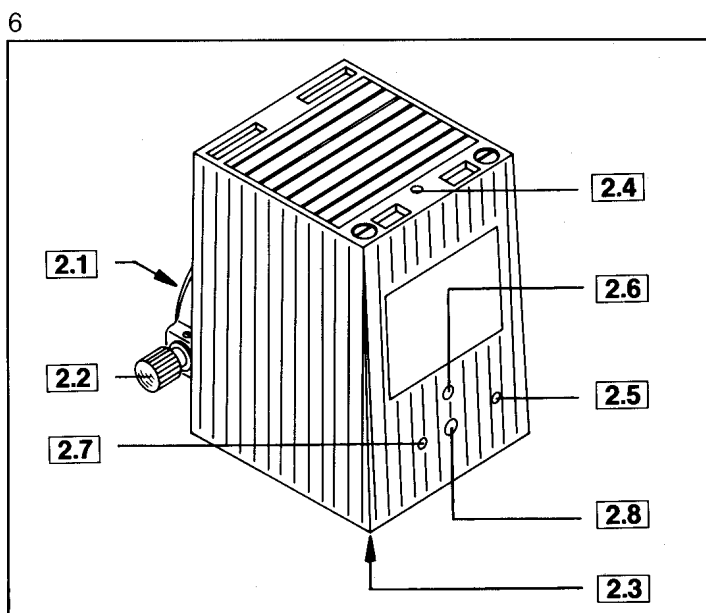
**2.4** Vertical lamp adjustment

**2.5** Lateral lamp adjustment

**2.6** Vertical adjustment of mirror image

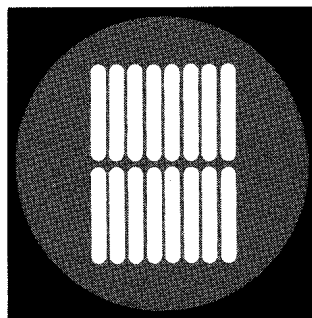
**2.7** Lateral adjustment of mirror image

**2.8** Focusing of mirror image



The lamp is factory-centered. Should re-centering be necessary, proceed as follows:

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1. Detach illuminator from microscope, switch on lamp and project image of coil on suitable surface (e.g. a wall at 1 m distance) by adjusting [2.2].

2. If image and mirror image are other than in the above Fig. 7, correct with the adjusting elements [2.4] and [2.8].
3. The further steps of lamp centration which are different for transmitted and reflected light, are described below.

### Transmitted light

Take tube out of [1.5], swing out all filters of magazine [3.2], mount illuminator, and adjust specimen (see page 5) with condenser 0.9 (front lens swung in) and 40× or similar transmitted-light objective.

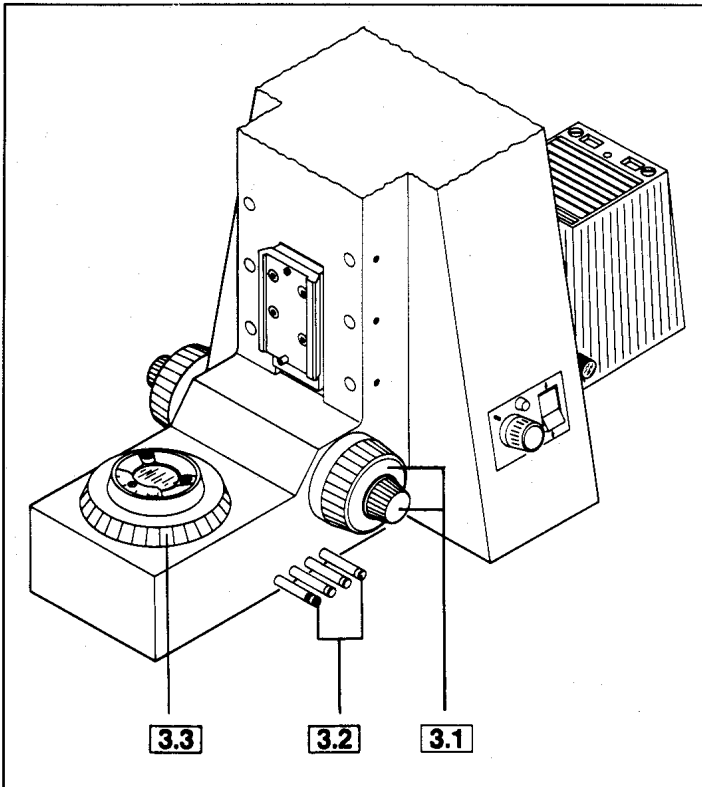
Without eyepiece (or with Bertrand optics, pushrod [7.9] pushed in) you will now see at the bottom of the tube the pupil and the coil image which should evenly cover the pupil. Make corrections as said above. Insert tube in [1.5], check pupil image again and optimize adjustment by adjusting the collector with [2.2].

### Reflected light

Mount the illuminator, turn in a 50× or 20× reflected-light objective, use a specular surface as object and brightfield illumination. Loosen 4 screws of reflected-light system HD [8.1], take it off, and unscrew the diffusion disk at its back. Re-mount reflected-light system HD.

Without eyepiece you will now see at the bottom of the tube the pupil and the coil images which should evenly cover the pupil. Make corrections as said above. To achieve uniform pupil illumination adjust the collector with [2.2]. Mount diffusion disk again in reflected-light system HD.

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### 3.0 Stand base

Fig. 8 shows the stand base equipped for transmitted, Fig. 9 for reflected light.

**3.1** Coaxial coarse/fine focusing control. It acts on a plate with dovetails which carries the stage carrier (or the condenser carrier on a transmitted-light microscope). Turning the outer part of the control anticlockwise lowers the stage. Total travel range (including fine focusing control): 25 mm. One revolution of the coarse focusing control corresponds to ca. 2 mm travel; gear ratio of fine focusing control 1:10. Index line on coarse focusing control can be used to roughly measure the object thickness: 1 scale division corresponds to ca. 2  $\mu\text{m}$ .

**3.2** Filter magazine in the illuminating beam path with 4 pushbuttons, from front to back:

- Dark-gray ring: neutral density filter 0.06; 32 mm dia.
- Light-gray ring: neutral density filter 0.25
- Green ring: green filter VG 9
- Blue ring: conversion filter 3200/5500 K

The brightness can be graded by the neutral density filters used singly or in sets. The transmittance of a filter set is determined by multiplication (e.g.  $0.06 \times 0.25 = 0.015$ , i.e. 1.5% transmittance).

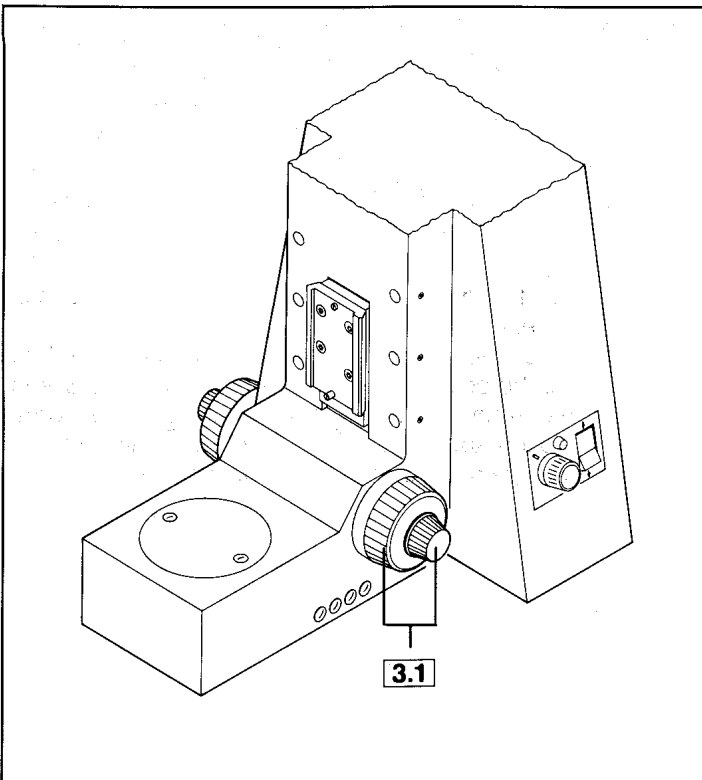
The green filter increases the contrast in B/W photography. The conversion filter converts artificial light of 3200 K into daylight of 5500 K.

If several filters are to be used at a time, the corresponding pushbuttons must be pressed simultaneously. Pressing the foremost button removes a swung-in filter from the beam path.

Exchange of filters in the magazine should be made by the maintenance service. (The bottom plate is removed, and a filter, secured by a retaining ring, is accessible if all others are swung in.)

**3.3** Luminous field diaphragm. It is adjusted by the knurled ring. The (removable) dust cover glass accepts a 32 mm dia. filter. This plane is not imaged.

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#### 4.0 Specimen stage

The standard equipment includes

**4.1** a rotary centrable stage with

**4.2** attachable mechanical stage with a  $45 \times 25$  mm motion range in x and y. With the aid of graduations and verniers object coordinates can be determined accurate to 0.1 mm.

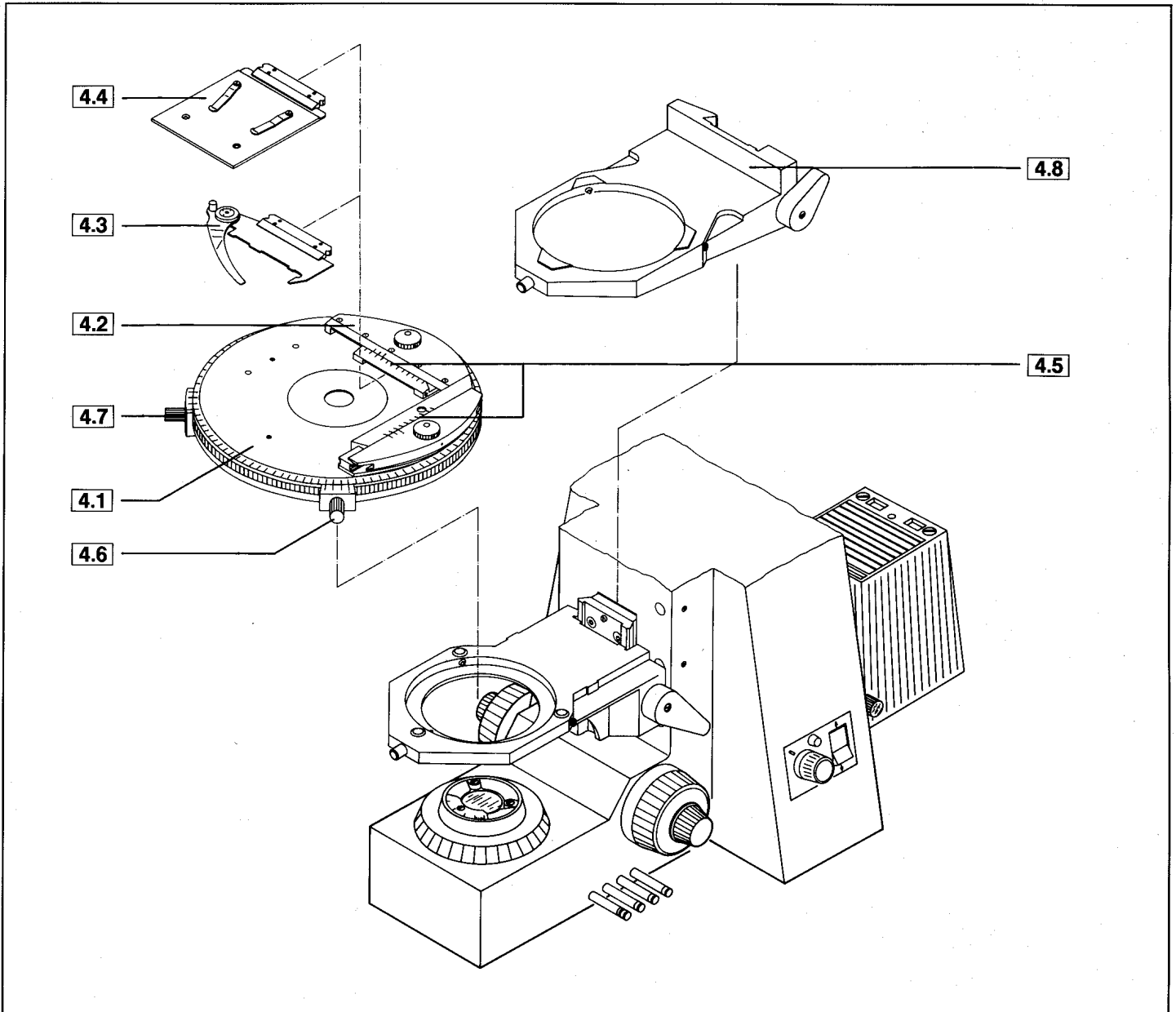
**4.3** Specimen holder D Pol (with spring clip to hold the specimen), attached to the attachable mechanical stage, is exchangeable for specimen holder A Pol **4.4** for reflected-light specimens.

With the eyepiece reticle the rotary stage of the polarizing microscope forms an angle measuring instrument, for which purpose it has a  $360^\circ$  graduation and

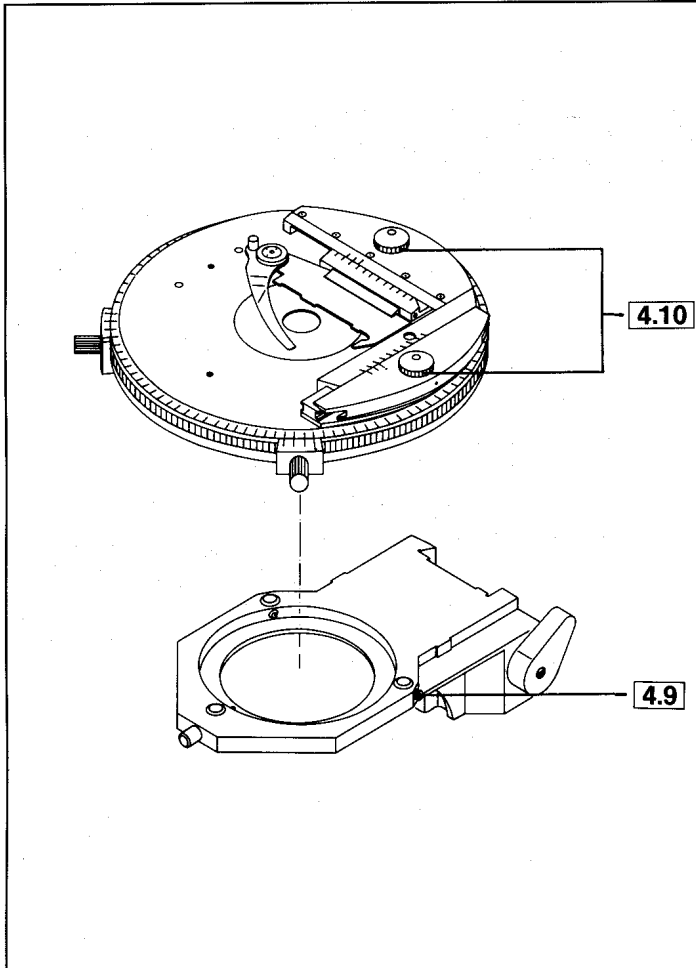
**4.5** one vernier each to read off  $1/10^\circ$ . The stage movement can be locked by the right screw **4.6**. Tightening the left screw **4.7** provides every  $45^\circ$  a click stop of the stage rotation.

**4.8** Stage carrier ZA for specimens max. 72 mm high.

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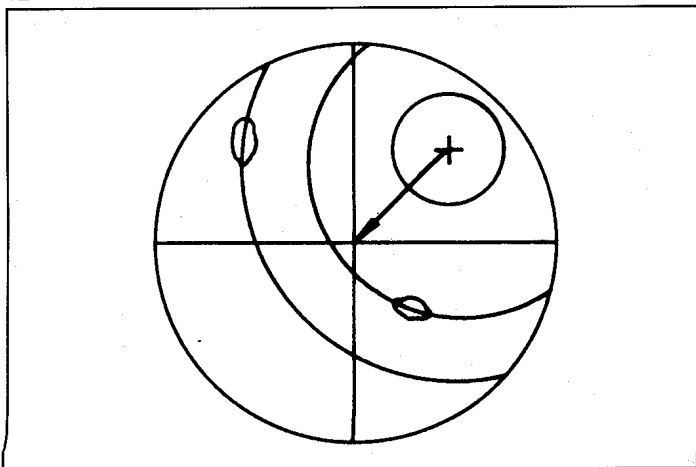


The stage must be centered to make sure that an object feature in the center of the field of view does not migrate when the stage is turned. Before each examination the user of a polarizing microscope controls the centration as follows:

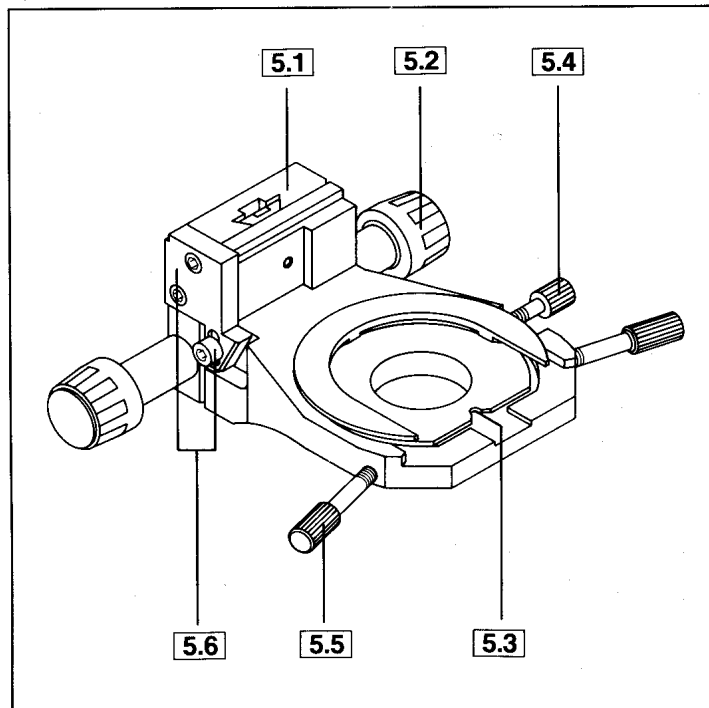
1. The microscope nosepiece [6.3] features 3 centrable thread mounts for the objectives and one fixed mount which generally contains a 10× objective; turn in this objective and focus on a high-contrast specimen.
2. Turn the stage. You will notice that almost all object features move on circles; the center of all circles is the center of rotation of the stage (see Fig. 12 below).
3. With the (small) screwdrivers plugged into [4.9] bring this object to the point of intersection of the eyepiece cross-hairs and thus the optical axis of the 10× objective. Repeat this procedure if the object still migrates from the cross-hair center when the stage is turned. – The stage is centered.

The pointcounter on the controls [4.10] of the attachable mechanical stage provides for a click stop after every 0.5 mm specimen movement. The pointcounter facilitates systematic screening of a specimen and can also be used for volume and quantitative analyses. The click stops are set with the supplied Allen wrench on the controls; they are overridden if the wrench is unscrewed.

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### 5.0 Transmitted-light condensers

The designation of optic-containing condenser parts in red instead of white indicates that the optical elements are strainfree and do not interfere with polarized light.

The condenser is mounted in

**5.1** condenser carrier with

**5.2** coaxial controls for max. 34 mm vertical adjustment, whose stiffness is factory-adjusted and should be changed only by a service technician.

**5.3** Orientation notch for condenser.

**5.4** Clamping screw of condenser (required only for condenser exchange).

**5.5** Two condenser centering screws. With these screws the luminous field diaphragm image is centered for illumination adjustment (see page 5).

To prevent a specimen from being pressed out by the condenser the vertical condenser movement is limited by stop screw

**5.6** which is adjusted as follows:

1. Adjust specimen (use a thick specimen slide).
  2. Image the luminous field diaphragm (see page 5).
  3. Move the condenser up by a small amount (diaphragm image becomes unsharp).
  4. Loosen stop screw **5.6** with red-handle wrench – the stop pin will fall down – tighten it again.
- The specimen is secured.

The available condenser systems meet the high demands on the versatility of a large research microscope.

Standard condenser is

**5.7** Condenser system (445325) with brightfield insert.

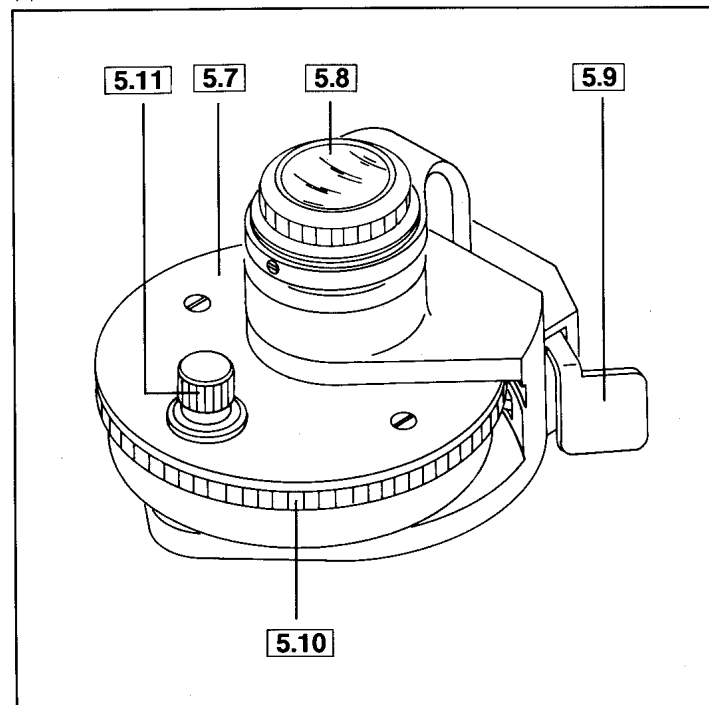
**5.8** Front lens, aperture 0.6 or 0.9.

**5.9** Lever to swing the front lens in or out (for 2.5X or 5X objective).

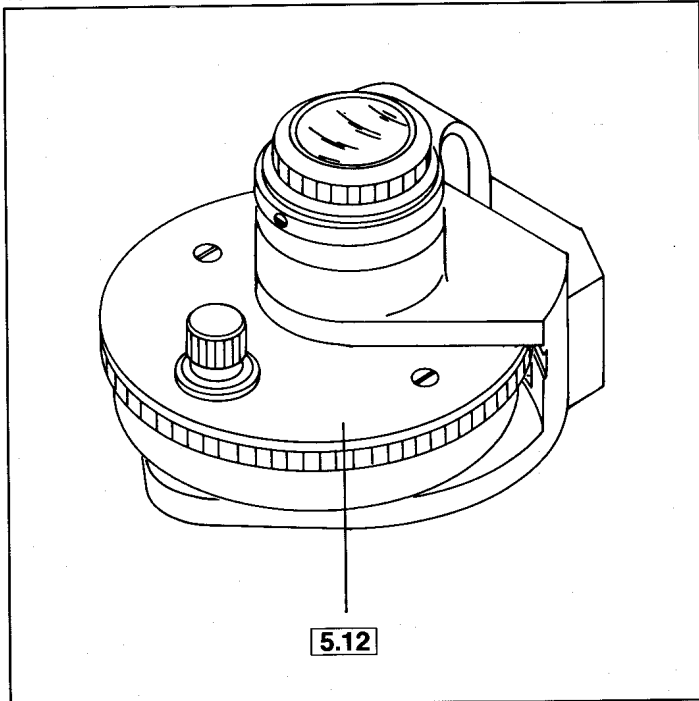
**5.10** Knurled ring for aperture iris diaphragm with aperture scale on top.

**5.11** Fixing screw: when loosened and lifted the insert can be taken out.

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**5.12** Condenser system (445326) corresponds to **5.7**, except that the front lens is automatically swung out when the condenser is lowered. Lowering it further swings the front lens in again, and it remains in its place while the condenser is turned up.

**5.13** Condenser system (445328 + 445332) for maximum illuminating aperture (1.4). There must always be oil between its front lens and the bottom of the specimen slide. The front lens cannot be swung out but can be unscrewed to illuminate the fields of 2.5 $\times$ , 5 $\times$  and 10 $\times$  objectives (the aperture will be 0.24).

#### Optical condenser data

Without front lens (swung out or unscrewed) all condensers for objectives 2.5 $\times$  ... 10 $\times$  have a

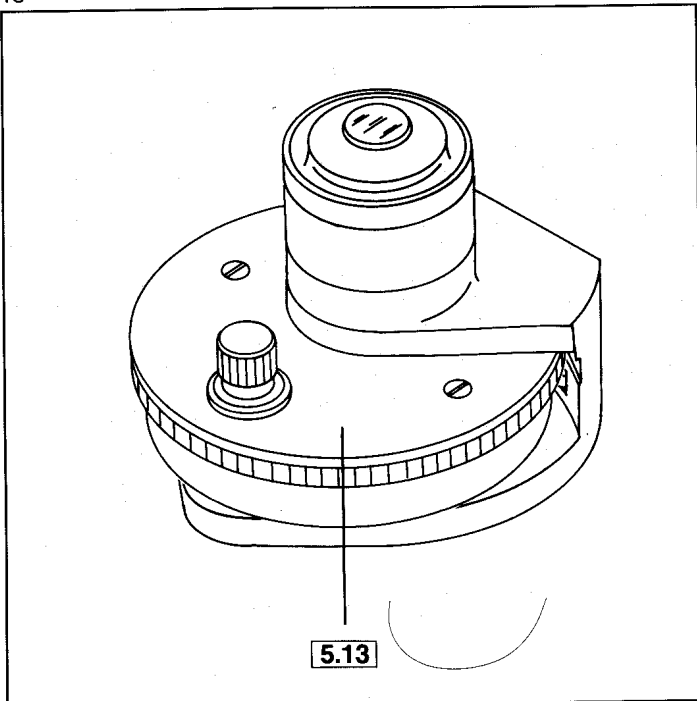
- numerical aperture (NA) of 0.24
- working distance (WD) of 23 mm
- luminous field dia. of max. 11 mm

The values in the table below apply to condensers with front lens:

	NA	WD	Luminous field dia.	for objectives
0.6	0.6	6.8 mm	4 mm	10 ... 100 $\times$
0.9	0.9	0.8 mm	2.8 mm	10 ... 100 $\times$
1.4	oil 1.4 air 0.9	0.4 mm	1.9 mm	20 ... 100 $\times$

With a 10 $\times$  objective in critical illumination work without front lens.

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## 6.0 Image-forming components

As said for transmitted-light condensers, the optics between polarizer and analyzer in the polarizing microscope are made of strainfree glass and mounted strainfree; they are engraved in red and the objectives designated Pol.

**6.1** Objectives, the most important elements of a microscope, must be kept meticulously clean, especially their front lens surfaces. (For cleaning breathe on the surface and wipe over it with a cotton wad. For thorough cleaning see brochure 41-100 "Microscopy from the very beginning".)

The numbers and symbols engraved on the objectives, e.g. Plan-Neofluar 20×/0.50 Pol; ∞ /0.17 signify: 20× = (individual) magnification, 0.50 = NA, ∞ = image distance, 0.17 = coverglass thickness in mm, for which the objective is computed.

For the reflected-light objective Epiplan-Neofluar 20×/0.50 Pol, ∞ /0.0 the engraving signifies that it is computed for a coverglass thickness of 0, i.e. uncovered specimens.

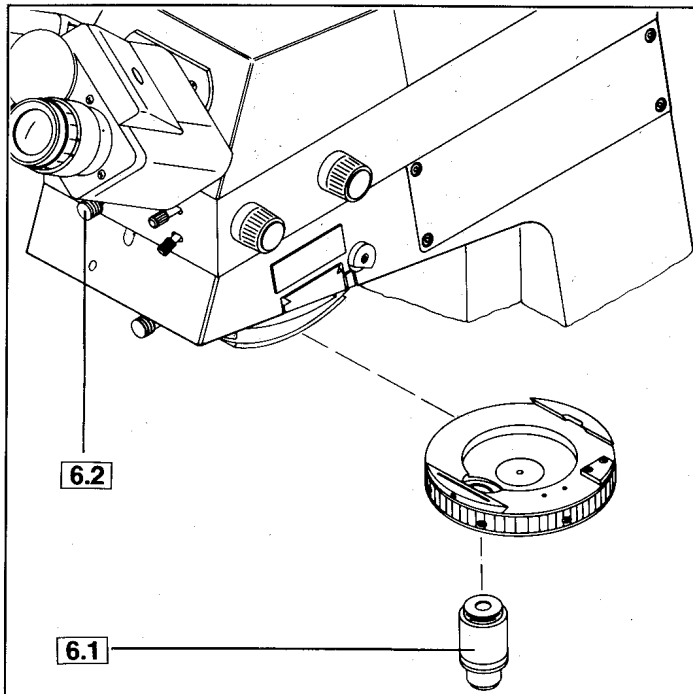
(Individual) magnification multiplied by the eyepiece magnification (generally 10×) results in the microscope magnification.

$\frac{NA}{\lambda} \times 1000$  (500 in the above example) is the highest useful magnification; no more details will be revealed above this value.

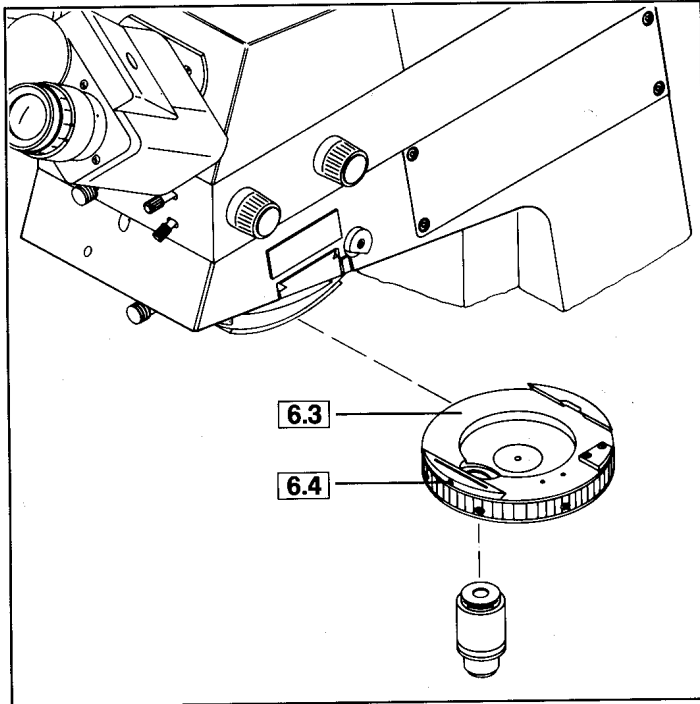
∞ is a reminder that these objectives cannot be used on microscopes with objectives bearing the number 160. The coverglass thickness of 0.17 mm must be the more observed for transmitted-light specimens the higher the NA of the objective. Certain objectives can be adjusted to different coverglass thicknesses (correction mounts): Find out, by means of a high-contrast specimen feature, in which position of the correction mount optimum sharpness is achieved (re-focusing will always be necessary). Immersion objectives are insensitive to differences in the coverglass thickness. Because of their short working distances 20× and higher-power objectives have spring mounts to protect the specimen. To prevent specimens from being contaminated by oil if the nosepiece with immersion objectives is turned, these can be locked in the upper position of the spring mount (don't forget to disengage them from "lock-in" position!).

The air between the coverglass and an immersion objective is replaced by a liquid, generally a special oil. Some training is needed to achieve a bubble-free layer. Some microscopists prefer to turn the objective from the side into the oil drop on the coverglass or specimen, others recommend to always control the exit pupil, preferably with the Bertrand lens [6.2](#) or by taking out one eyepiece, as described on page 5, a procedure which instantly reveals any bubbles. If the bubbles have not disappeared even if the objective has been turned in several times, clean the specimen and repeat the procedure.

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**6.3** Nosepiece with 4 thread mounts. Three can be moved horizontally by screws for objective centration which is the second, important step in polarizing microscopy besides stage centering ( **4.0** ). Once the stage is centered turn in successively the objectives in centering mounts and focus on a high-contrast specimen.

Now turn the stage. Almost all specimen features will move on circles. The center of all circles is the optical axis of the objective.

Plug on the two (small) screwdrivers and move the specimen feature to the point of intersection of the eyepiece crosshairs and thus to the center of rotation of the specimen stage (see Fig. below). To maintain this centration, turn the nosepiece by holding the knurled ring but not an objective.

To take off the nosepiece, e.g. to check the front lens for cleanliness, loosen screw **6.4** and pull the nosepiece out to the right.

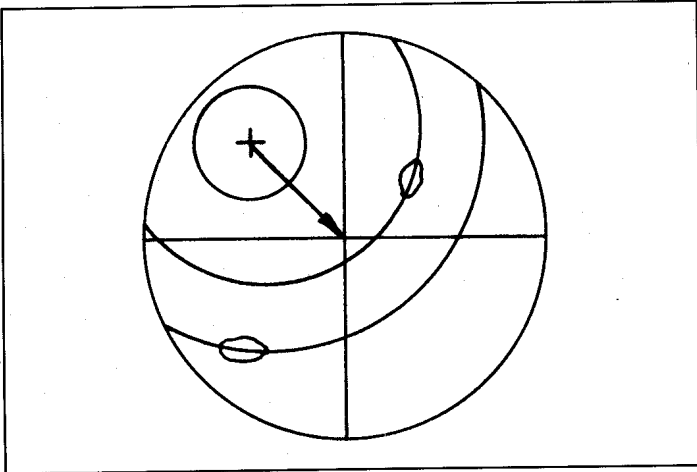
**6.5** Eyepieces with 10× magnification and field-of-view number 25 produce an angular field of 54°, are equally well suited for eyeglass wearers (Br) and carry an exchangeable rubber ring to protect eyeglasses (folding eyecups are available under ordering number 44 48 01). Both eyepieces are focusing eyepieces (foc).

The Pol eyepiece contains fixed, exactly aligned crosshairs. If the screw on the eyepiece side engages the upper notch of the eyepiece tube (pointing to 9 o'clock to the left and to 3 o'clock to the right) the two bars of the crosshairs will indicate the orientation of polarizer (West-East) or analyzer (North-South). If the setscrew engages the second notch the crosshairs will be oriented diagonally.

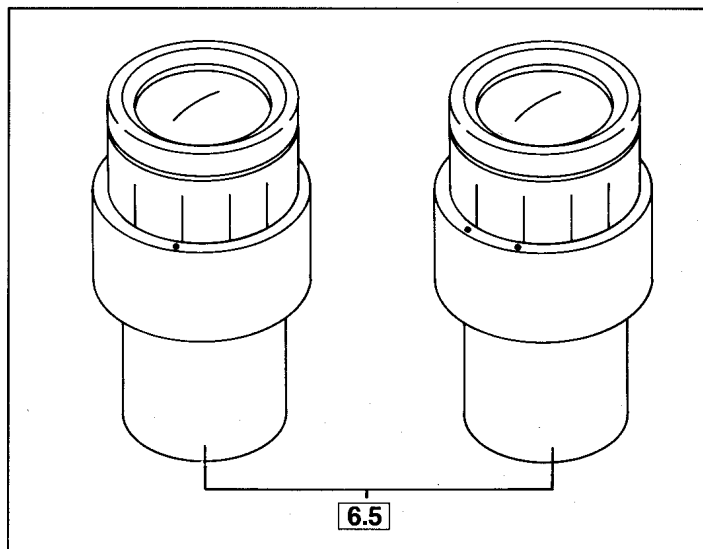
The diopter scale of the eyelens is set to 0 (white index) for emmetropic users and eyeglass wearers. If your eyes have different powers or you want to work without eyeglasses, proceed as follows:

- Take Pol eyepiece out of the tube and point it towards a bright surface, turn eyelens out and slowly in again while looking through the eyepiece, until the crosshairs are in focus. Plug eyepiece into tube.
- Focus the specimen through the Pol eyepiece. Leave the focusing control unchanged, and with the focusing eyelens of the second eyepiece focus the specimen for the second eye.

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6.5

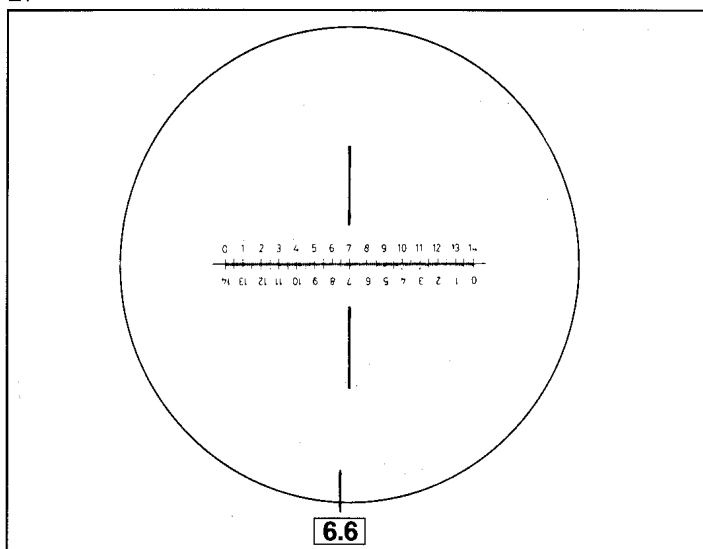
If you have a “cylinder” in your eyeglasses you should always wear them for microscopic work.

The focusing eyepiece without crosshairs accepts any type of reticle, e.g. a crossline micrometer **6.6** (14 mm, 1/10 graduation), used mainly to measure the conoscopic image. The slight displacement of the image the reticle causes is considered by the zero position on the diopter scale indicated by the red index. All Pol eyepieces have reticles and are provided with a white index which considers the displacement of the image.

Only one focusing eyepiece can be equipped with a reticle. Exchange of reticles should be left to specialists because of the high demands on cleanliness and exact alignment. (The lower part of the eyepiece can be unscrewed; the scale-bearing surface of the reticle must face down!)

An Axioplan Pol microscope can be equipped with either of these tubes:

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6.6

**6.7** Binocular Pol tube 25, or

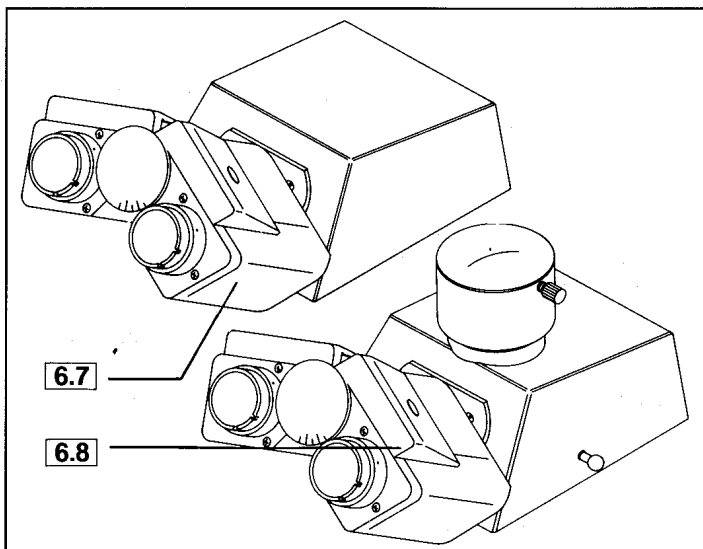
**6.8** binocular phototube 25 Pol.

Both have a viewing angle of  $30^\circ$  and PDs between 55 and 75 mm adjusted by moving the tube halves in and out. Changing the PD does not change the orientation of a reticle in an eyepiece, which is secured by two notches on the eyepiece tube.

The pushrod of the binocular phototube 25 has two positions which can be adjusted with the pushrod: either 100% of the light upwards to the camera (pushrod all the way in) or 20% of the light for observation and 80% to the camera (pushrod pulled out).

The upper tube port is for mounting a photomicrographic camera, TV or special camera. (The adapter for photomicrographic camera and a photo eyepiece S-PL  $10\times$  or S-PL  $12.5\times$  are required for the MC 63 S photomicrographic camera. Cine and TV cameras with C mounts are mounted with standard C adapter (45 2995), without eyepiece. The adapters are parfocalized with the integral reticle.)

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6.7

6.8

In a reflected-light microscope without Pol intermediate tube the additional magnification factors  $1.25\times$ ,  $1.6\times$  and  $2\times$  are achieved with the Optovar intermediate tube. For a description of this tube see page 30.

## 7.0 Accessories for transmitted-light polarizing microscopy

Many parts of a polarizing microscope are equal or similar to normal microscope components. The elements which are exclusively used on a polarizing microscope are described below as they are arranged in the beam path.

**7.1** Swing-in mount with rotary polarizer beneath the condenser. The small control generally points to  $0^\circ$ , the West-East oscillation direction of the emerging light according to standardization. Between  $0^\circ$  and  $90^\circ$  there are click stops every  $15^\circ$  on the rotary mount. (The angles of rotation will only be correct if the mount was swung in completely.)

Rotary stage **7.2** and nosepiece **7.3** and their centration have been described above.

**7.4** Slot for (standard) auxiliary objects and compensators.

Compensators are birefringent optical elements which are brought into the beam path in addition to the birefringent object. They are aligned so that the plane of the higher refractive index  $n_y'$  marked by a line and  $\lambda$  is North-East to South-West.

Auxiliary objects are qualitative or fixed compensators to also determine the direction of  $n_y'$  in an object (for a full description of the measurement see page 21).

Available auxiliary objects are:  $\lambda$  (473704),  $\lambda/4$  (473714) and quartz wedge  $0-3\lambda$  (473724).

Quantitative compensators produce variable path differences to measure the path difference of birefringent objects (see page 23). The birefringence of an object can be determined from its thickness and orientation. It is an important material constant for identification and to get information about certain properties.

The following compensators with different path difference ranges are available:

1. Tilting compensator E up to ca.  $20\lambda$  (413741)
2. Tilting compensator B up to  $5\lambda$  (413740)
3. Rotary Brace-Köhler compensator  $\lambda/10$  (413731)
4. Sénarmont compensator  $546/4$ ;  $6 \times 20$  mm (473718)

**7.5** Slot for reflector slider behind cover plate; it is necessary for conversion of a transmitted-light polarizing microscope into an instrument for reflected-light examinations of opaque objects.

**7.6** Analyzer slot on top of it, with

**7.7** Analyzer slider with fixed analyzer in N-S orientation. To remove it from the beam path pull it out of the slot as far as it will go. For Sénarmont compensation (see page 23) exchange this analyzer slider for the rotary analyzer. Its angle scale set to  $90^\circ$  indicates normal N-S orientation; it can be rotated from  $0^\circ$  to  $180^\circ$  and the rotation read to within  $1/10^\circ$  on a vernier.

A quartz depolarizer is firmly mounted at the stand head port.

The observation of a magnified object, e.g. a thin section in polarized light is referred to as orthoscopy (from the Greek orthos = straight and skopein = to see) because of illumination by "straight" light beams which run parallel to the microscope axis if the condenser diaphragm is almost completely closed.

To classify (and thus identify) crystalline matter more information can be derived from the investigation of an interference image in the objective pupil than from the observation of the object itself. A Bertrand lens (focusable and centrable supplementary optical system) brought into the beam path makes the interference image visible in the eyepiece. This phenomenon is known as conoscopy, because of illumination by a wide-open cone. In practice the condenser front lens 0.9 or 1.4 must be swung in, the condenser diaphragm fully open, and a high-aperture objective used.

To prevent surrounding features from interfering with the conoscopic image of a feature in the crosshair center, the center of the field of view can be masked out: fields of 6, 20 or 40 scale intervals of the eyepiece micrometer are covered by 3 pinhole diaphragms, which corresponds to the following diameters in the object plane:

Pinhole diaphragm dia. (mm)	0.3	1.0	2.0	
20×objective	30	100	200	} (measuring-field dia. μm)
40×objective	15	50	100	
100×objective	6	20	40	

**7.8** Intermediate Pol tube for conoscopic microscopy.

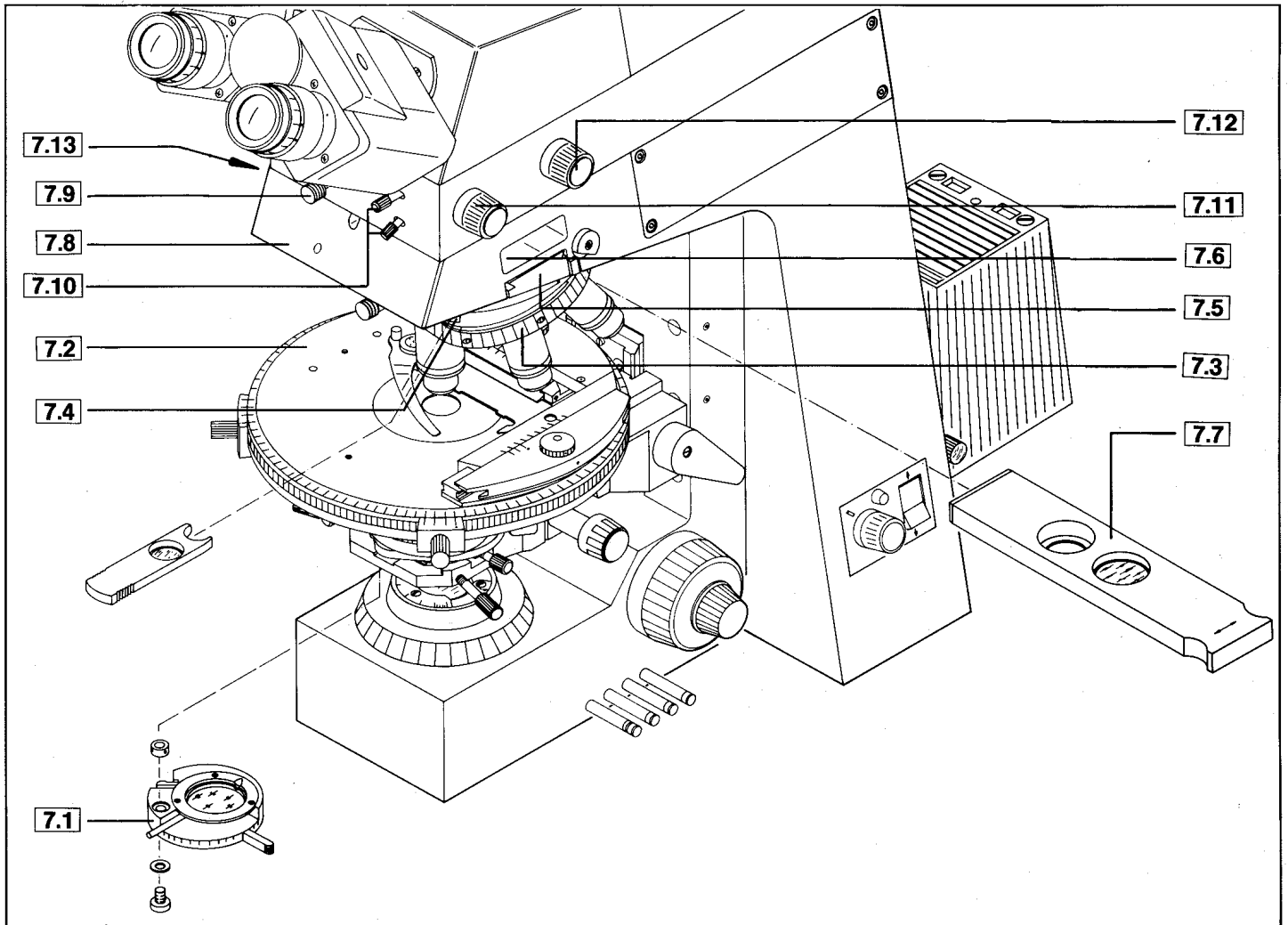
**7.9** Pushrod on intermediate Pol tube engraved C for conoscopy (pushed in) and O for orthoscopy (pulled out).

**7.10** Centering screws for Bertrand lens to the right of the pushrod on top of each other. With these screws the pupil image can be exactly aligned to the crosshairs, e.g. to facilitate measurement.

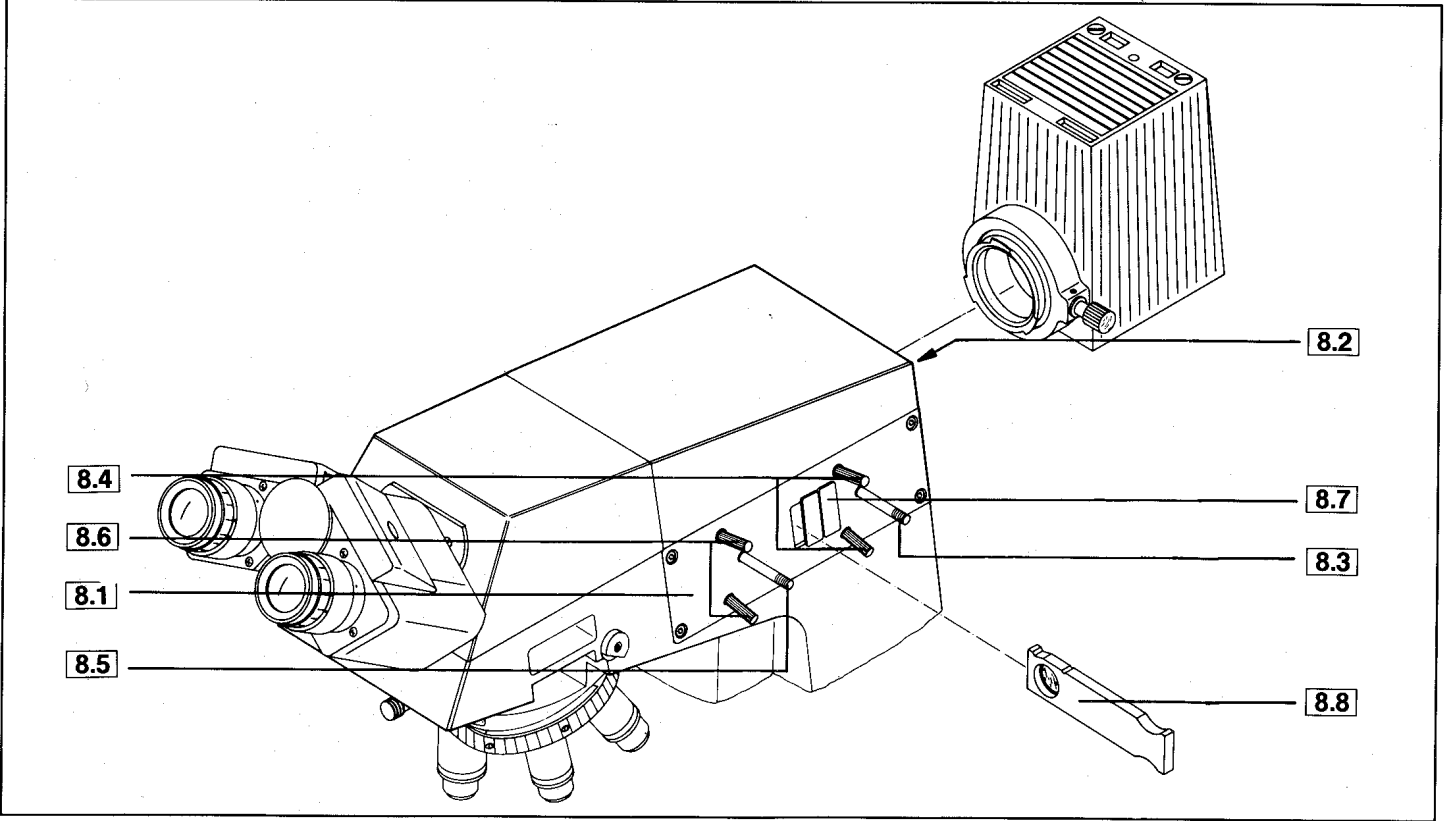
**7.11** Knob FOC on the right side to focus Bertrand lens and pupil image. Behind it a similar knob **7.12** DIAPHRAGM with index and the numbers 0.3; 1.0 and 2.0 for the 3 pinhole diaphragms.

**7.13** Lever on the left side to change in conoscopic observation (**7.9** to C) between observation of the pupil image alone (lever to the front, symbol  $\oplus$ ) and observation of pupil image plus orthoscopic image of the surrounding field (lever to the back, symbol  $\ominus$ ). In orthoscopic observation (**7.9** to O) this lever should be flicked back; only then will the full size of the field of view be visible.

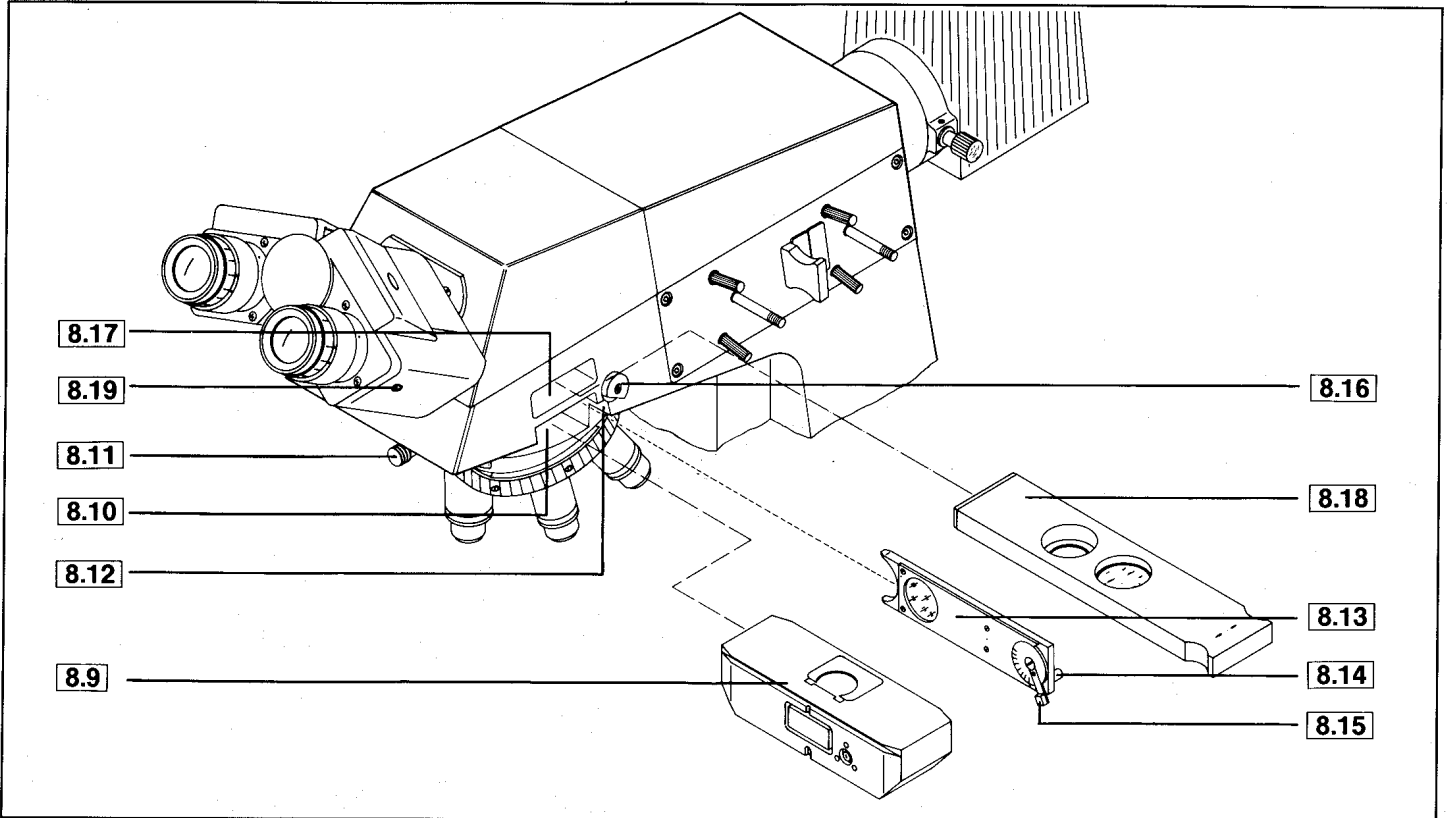
23



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## **8.0 Accessories and illumination system for reflected-light polarizing microscopy**

Besides the illuminator the illumination system includes:

- 8.1** Reflected-light system HD.
- 8.2** Heat-reflecting filter inserted directly behind the seating surface of illuminator **1.6** to protect further filters in the beam path. The next items in the beam path:
- 8.3** Pushrod with index rings for aperture diaphragm: pushed in – diaphragm open; pulled out – diaphragm closed.
- 8.4** Centering screws for aperture diaphragm.
- 8.5** Pushrod for luminous field diaphragm acts like **8.3**, with wide index ring for open diaphragm and narrow black ring for closed diaphragm.
- 8.6** Centering screws for luminous field diaphragm correspond to **8.4**.
- 8.7** Three slots between the above-mentioned diaphragms for:
- 8.8** Filter slider A:  
pushed in – filter in beam path;  
pulled out – free light path.  
The slider accepts the following 18 mm dia. filters:
  - Neutral density filter 0.25 (25% transmittance)
  - Neutral density filter 0.06 ( 6% transmittance)
  - Conversion filter 3200/5500 K
  - Green filter VG 9

Brightness control by neutral density filters (graded by a factor of 4):

Filters 0.25 and 0.06 used in combination yield  $0.015 = 1.5\%$ .

The conversion filter converts artificial light into daylight for observation and color photomicrography on daylight film.

A green filter improves the image quality of uncolored specimens and increases the contrast of colored objects, especially in B/W photomicrography.

A built-in diffusion disk which homogenizes the light source image can be unscrewed.

Illuminating and observation beam paths are combined in

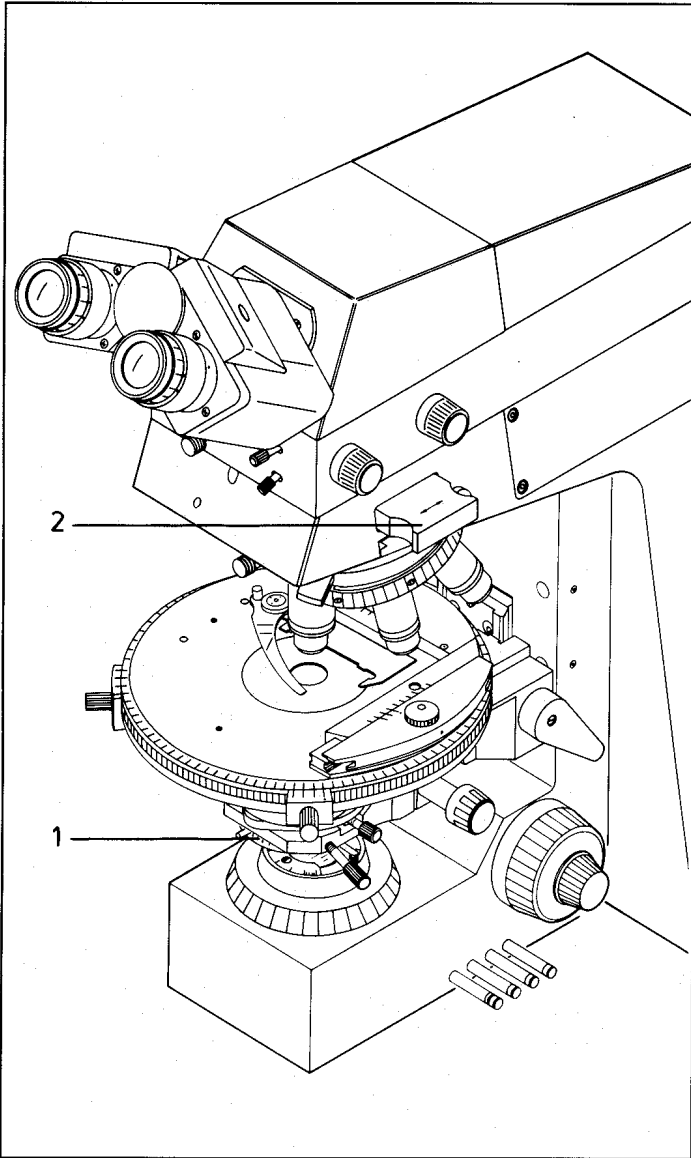
- 8.9** reflector slider H which fits into
- 8.10** slot for reflector slider after pulling out
- 8.11** spring pin.
- 8.12** Slot for
- 8.13** rotary polarizer A; held on **8.14** it can be moved between two stops in and out of the beam path. With lever **8.15** it is turned between  $0^\circ$  (click stop; normal position W-E orientation) and  $90^\circ$ .

The Pol filter is in the beam path when the slider is pushed in; the light path is free when it is pulled out.

- 8.16** Loosen socket head screw and turn the disk underneath: the slider can be taken out.
- 8.17** Slot for
- 8.18** fixed analyzer slider:  
pushed in – effective (N-S orientation);  
pulled out – free light path.
- 8.19** Socket head screw. Loosen it for exchange; tightened it acts as stop.

A quartz depolarizer is firmly mounted at the stand head port.

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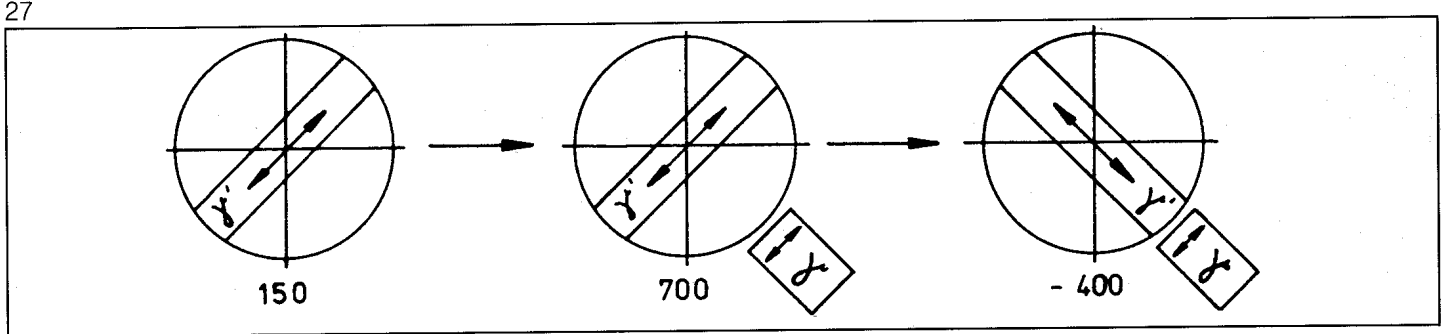
Birefringence or anisotropy (from the Greek an = non –; isos = equal; tropos = rotation) is the property of transparent matter of different refractive indices for different directions of the transmitted light.

Birefringence can be recognized with crossed polarizer and analyzer: when the specimen stage is turned through full 360° the dark field of view is brightened four times by the object from just visible gray (e.g. of biological specimens) via white and strong to weak interference colors to higher-order white.

- Adjust the microscope for normal brightfield microscopy (see page 5).
- Center stage (see page 10) and objective (see page 14).
- Turn in polarizer (1) beneath the condenser, and set it to 0°.
- Slide in analyzer (2); without object the field of view is dark.

Bring the object into the field of view. The above-mentioned colorless or colored brightening indicates birefringence. Turn the specimen stage with the object.

Only if the isotropic axes (optically uniaxial or biaxial matter) are parallel with the direction of observation will a birefringent object cause no brightening.



Required is the auxiliary object  $\lambda$ .

The position of the two directions with the higher ( $n_y'$ ) or lower ( $n_x'$ ) refractive index in proportion to morphological directions (crystal surfaces, longitudinal fiber directions, etc.) is an important criterion for recognition, and, for the synthetic fiber of the example, can be determined as follows:

- Adjust the microscope and cross polarizers. The fiber lights up in the field of view. Turn the stage until maximum extinction of the object is achieved.
- Provide the stage with the click stops and turn it to the next (45°) click stop. The object – in diagonal position – lights up strongest, let's say in gray-white.
- According to the Michel-Lévy color chart this "color" has a path difference of ca. 150 nm.
- With auxiliary object  $\lambda$  the color of the fiber changes to yellow-orange (ca. 400 nm according to the color chart).
- When the stage is turned through 90° the color of the fiber changes to green-blue (ca. 700 nm).

**Conclusions:**

The orientation of the auxiliary object is NE-SW with  $n_y$  and yields a path difference of  $\lambda$  ca. 550 nm. The higher interference color (700 nm) can only be created by an addition of the path differences of object (ca. 150 nm) and auxiliary object (ca. 550 nm), the lower (ca. 400 nm) by subtraction (150-550 = -400; color match with +400).

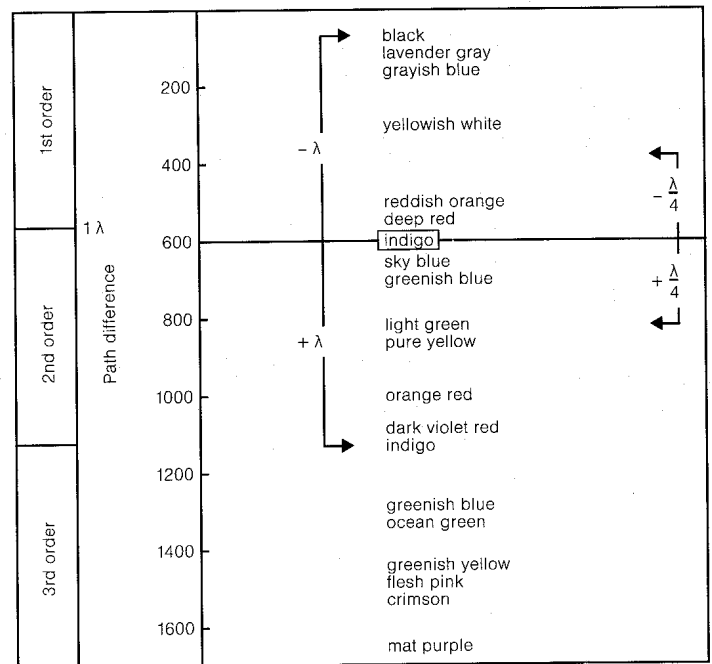
For an addition of the path differences,  $n_y'$  of the auxiliary object and  $n_y'$  of the object must be parallel. With a higher interference color,  $n_y'$  of the object will also be in NE-SW direction (in the above example it will coincide with the longitudinal direction of the fiber, a fact the specialist terms "optically positive").

Consequently,

it follows from a comparison of interference colors/path differences in both diagonal positions that the higher path difference results if both  $n_y'$  directions are parallel, which defines the  $n_y'$  direction of the object.

Another example: color changes of a birefringent object (indigo 2) due to addition and subtraction of auxiliary objects  $\lambda$  and  $\lambda/4$ .

Object color	[nm]	Addition		Subtraction	
		$\lambda$	$\frac{\lambda}{4}$	$\lambda$	$\frac{\lambda}{4}$
indigo 2	600	indigo 3	greenish blue 2	lavender gray 1	red-orange 1



Schematic representation of Michel-Lévy color chart see leaflet S 41-500.0.

1st order	1 λ	Path difference	200	black lavender gray grayish blue
			400	yellowish white
2nd order			600	reddish orange deep red indigo sky blue greenish blue
			800	light green pure yellow
3rd order			1000	orange red dark violet red indigo
			1200	greenish blue ocean green
			1400	greenish yellow flesh pink crimson
			1600	mat purple

With the color chart path differences can only be roughly estimated. A compensator is needed to exactly measure them. With a compensator the path difference entered by the object is reduced to 0 (1st order black).

The addition position is important to determine the  $n\gamma'$  direction. With compensators,  $n\gamma'$  of the object must be perpendicular to  $n\gamma$  of the compensator (subtraction position, i.e.  $n\gamma'$  of the object must run NW-SE).

Which compensator is used depends on the path difference of the specimen; it may be extremely small ( $1/50 \lambda \cong 10 \text{ nm}$ ) or great ( $20 \lambda \cong 11,000 \text{ nm}$ ).

To find the right compensator

bring the specimen in the dark field of view between crossed polarizer and analyzer. Turn the stage and you will see

**A:** more or less strong interference colors: the path difference lies between  $1/2 \lambda$  and  $5 \lambda$  (beyond this value the colors will "fade" to 1st order white).

Use tilting compensator B (up to  $5 \lambda$ ).

**B:** no colors but white:

● with auxiliary object  $\lambda$  colors are generated, an indication of 1st order white with a path difference of ca.  $1/2 \lambda \cong 270 \text{ nm}$ .

Use tilting compensator B (up to  $5 \lambda$ ) or

Sénarmont compensator up to  $1 \lambda$  (see below).

● with auxiliary object  $\lambda$  white is maintained, an indication of higher-order white ( $15 \lambda - 1 \lambda$ , for example, is still far beyond  $5 \lambda$  where higher-order white begins).

Use tilting compensator E (up to  $20 \lambda$ ).

**C:** dark gray; the color chart shows a very small path difference of  $\leq 1/10 \lambda \cong 50 \text{ nm}$ .

Use rotary Brace-Köhler compensator up to  $1/10 \lambda$  (standardized for this wavelength)  $1/20 \lambda$  or  $1/30 \lambda$  optional.

The right compensator is chosen, the procedure as follows:

- The specimen is adjusted.
- The polarizers are crossed.
- The specimen is turned to extinction or normal position, the stage is provided with click stops, and set to diagonal position ( $45^\circ$  click stop) with strongest brightening.

Slide in the chosen compensator and move it from zero position:

● The path difference will be reduced, the interference colors become stronger,  $n_y$  compensator and  $n_y'$  object are perpendicular to each other (subtraction position), the right specimen position for compensation.

● The path difference will be increased, the colors become paler (addition position), no 1st order black will appear. Turn the specimen through further  $90^\circ$ .

Adjust the compensator until complete extinction of the object is achieved, note the value(s) and in the table read the path difference in nm. For details see the compensator instructions.

Brace-Köhler compensation is possible in any diagonal position of the object. If no extinction is achieved by turning the compensator to  $45^\circ$  in the one direction, turn it into the other.

Sénarmont compensation is possible up to a path difference of  $1 \lambda$ . It differs from the above description in that:

- a Sénarmont compensator 546/4 is used, i.e. a  $1/4 \lambda$  plate with  $n_y$  in E-W orientation, and
- for measurement the fixed analyzer is exchanged for the rotary analyzer.

The optical character of crystals must often be determined to identify materials. The determination is made in conoscopic observation:

The specimen is adjusted in brightfield (see page 5), the polarizers are crossed, the condenser diaphragm is completely open and the condenser front lens swung in (high illuminating aperture!).

Conoscopic images can best be observed if the objective magnification (and aperture) are the highest.

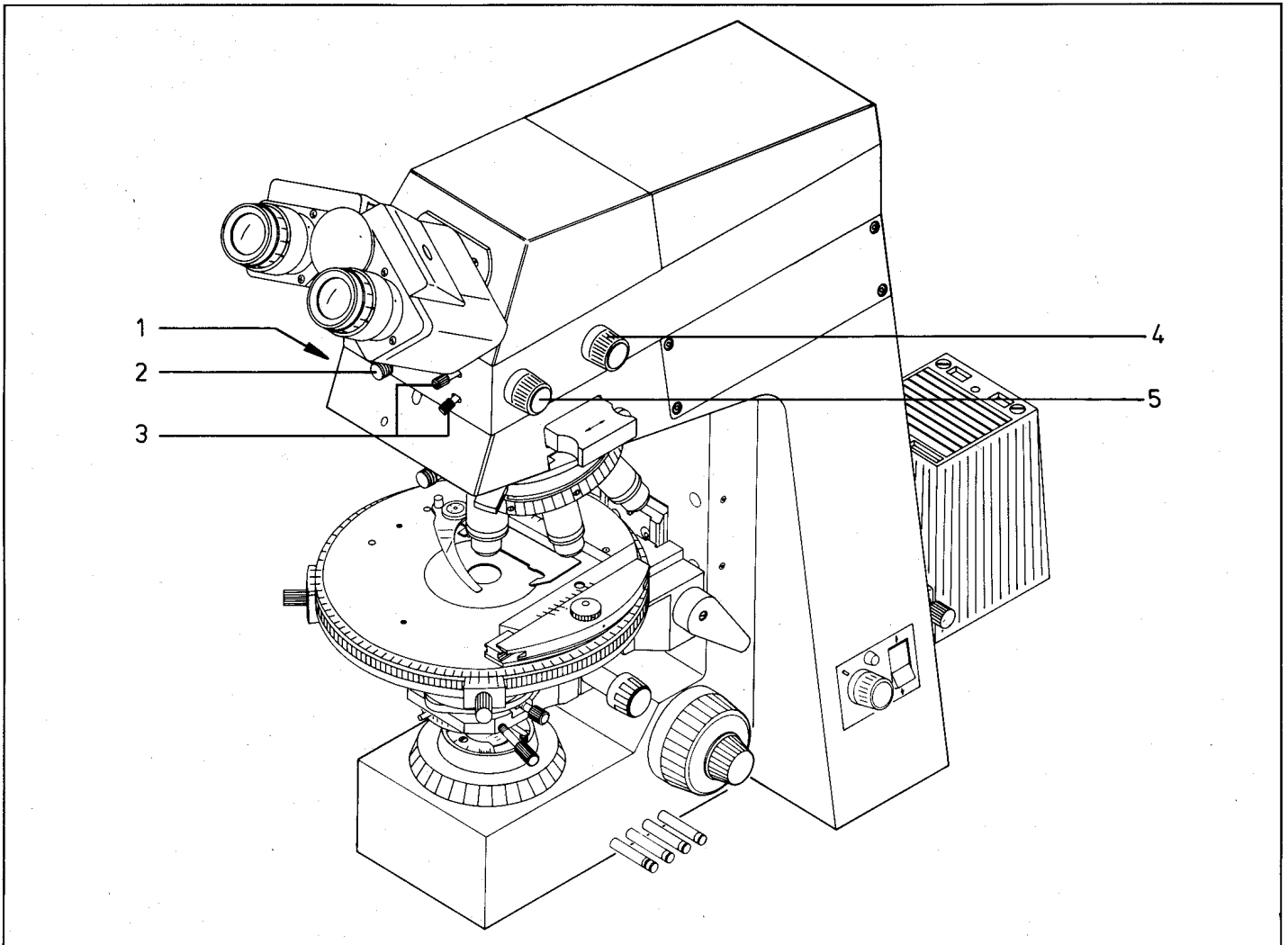
In conoscopic observation of uniaxial crystals those details (e.g. of a thin section) are optimally oriented which in orthoscopic observation alter the brightness least during stage rotation, because direction of observation and optical axis of the crystal are then  $\pm$  parallel. The same is true if biaxial crystals are observed along or at least approximately along either of the two optical axes.

Move a corresponding detail to the crosshair center. Slide in the pushrod (2) of the intermediate Poi tube, which swings in the Bertrand optics. With knob (5) focus the Bertrand lens, which also focusses the pupil image (interference figure).

Select a suitable pinhole diaphragm (0.3; 1.0 or 2.0) with knob (4) to prevent the interference figure of a small crystal in the center of the field of view from being superimposed by interference figures of neighboring crystals. If you flick lever (1) forward you will see the pupil image alone, if you flick it back, the pupil image plus the orthoscopic image of the surrounding field. With the centering screws (3) of the Bertrand lens the pupil image can be exactly aligned to the crosshairs, if necessary. Required are auxiliary object lambda or (better) quartz wedge  $0 \dots 3 \lambda$ ; a variable compensator will also do.

Most crystals are uni- or biaxial, each optically positive and optically negative.

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The conoscopic image of a uniaxial crystal (optical axis parallel to the observation direction) will show a dark cross surrounded by concentric interference fringes or isochromats (from the Greek isos = equal; chroma = color). The cross is maintained when the stage is turned. Observe the NE quadrant of the cross (1st quadrant counted anticlockwise):

In the corner next to the intersection 1st order white will change to

- yellow . . . optically negative
  - blue . . . optically positive
- with auxiliary object lambda.

With  $\lambda/4$  auxiliary object a dark spot will appear in the corners next to the intersection

- in the 1st and opposite 3rd quadrant . . . optically negative
- in the 2nd and opposite 4th quadrant . . . optically positive.

If a variable compensator is moved from 0-position (or a quartz wedge 0...3 slid in) the isochromats in the 1st (and opposite 3rd) quadrant will move

- outward . . . optically negative
- inward . . . optically positive.

If the stage is turned the cross in the conoscopic image of a biaxial crystal is "resolved" into two hyperbola legs which you move into the 1st and 3rd quadrant. There will be a fringe of 1st order white on either side of the black hyperbola line (isogyre).

With auxiliary object lambda the white changes

- on the outer (concave) side of the dark line to yellow and on the inner (convex) side to blue . . . optically negative
- on the outer side to blue and on the inner to yellow . . . optically positive.

With  $\lambda/4$  auxiliary object a dark spot occurs

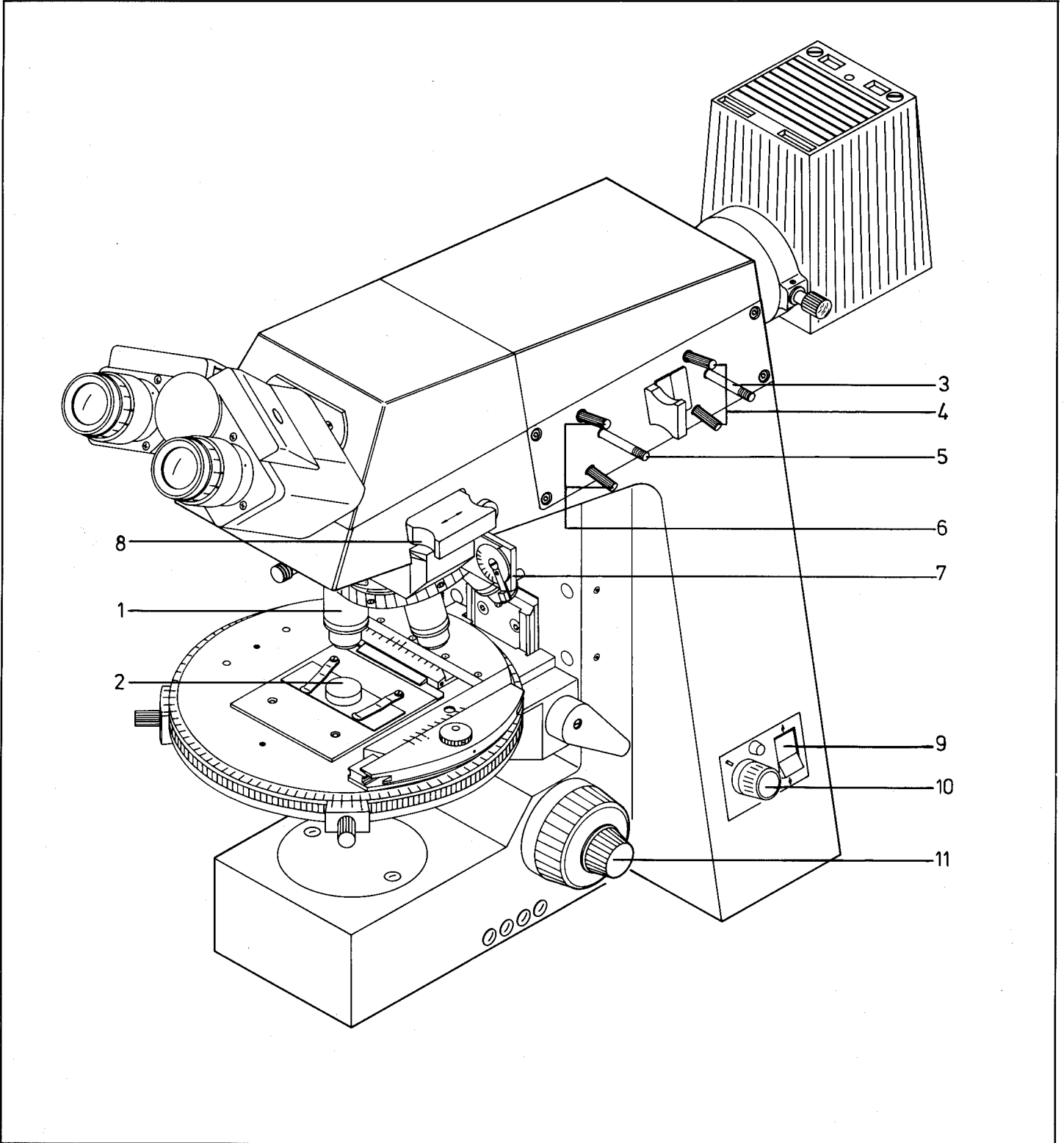
- outside the dark isogyre . . . optically negative
- inside the dark isogyre . . . optically positive.

If variable compensators (or quartz wedge 0...3) are moved from 0-position, the isochromats in the 1st and 3rd quadrants will move

- outward . . . optically negative
- inward . . . optically positive.

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	Optically uniaxial		Optically biaxial		
	positive	negative	positive	negative	
Lambda plate (white → blue → yellow)					+ = blue - = yellow
Quartz wedge (motion direction when slid in)					
$\lambda/4$ plate (position of black spots)					



The reflection properties of polished sections of ores, coals or ceramic products vary with their orientation in linearly polarized light, so that it can be applied as contrast-enhancement method. See item [8.0] on page 19 for the corresponding accessories.

Procedure

- Check data on nameplate (instrument back) and local line data for coincidence. Plug in microscope power cable. Select upper (or only) illuminator with (9); switch on with (10) and set to 3–4 V.
- Load a polished specimen (2) (top surface aligned parallel with seating surface, e.g. by a levelling press).
- Turn in 10× objective (1) (yellow ring) on nosepiece, check 0-positions on eyepiece scale. Remove polarizers (7, 8) from beam path.

You should now see light spots (the exit pupils) behind the eyepieces. The pushrod of a binocular phototube Pol must be pulled out.

When you look into the tube you will see a bright circle (the eyepiece stop) with each eye. Turning the two eyepiece tubes to your PD will merge the two circles into one.

Further steps of Köhler illumination:

- Close diaphragm (5) of the illumination system by pulling out the pushrod.
- Focus the specimen with (11). The image of the luminous field diaphragm (A) which lies exactly in the specimen plane, may be helpful. (If your eyes have different powers or for work without eyeglasses → [6.5].)
- Move the diaphragm image to the center of the field of view (B) with screws (6), and
- by moving pushrod (5) open the diaphragm so far that the field of view is just free (C).

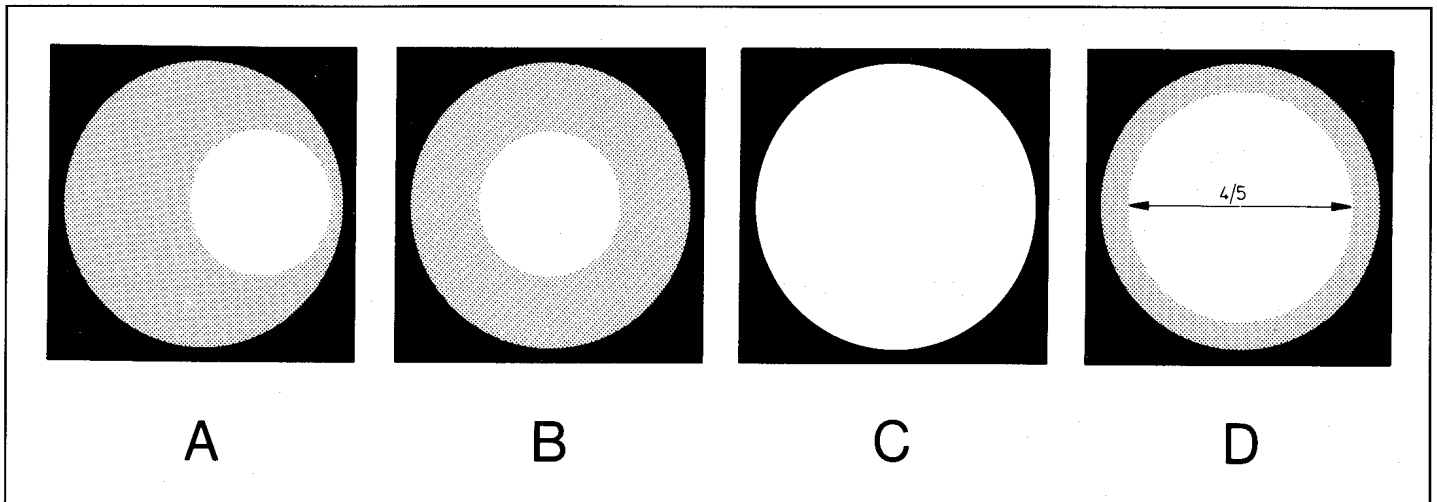
The contrast is adjusted with the aperture diaphragm (3), depending on the specimen. If you are not certain how far to stop down: ca. 4/5 of the rear element of the objective (visible at the tube bottom without eyepiece in the tube) should be illuminated (D). This diaphragm can also be brought to the center of the pupils with screws (4). Field of view and objective aperture change, of course, with each objective exchange, so that the last-mentioned steps must be repeated.

Slide in polarizer inserted in (7); set a variable polarizer to 0.

Pleochroism (color change with stage rotation) can be recognized in polarized light alone; the analyzer is swung out.

In case of bireflection (brightness and color changes with stage rotation due to anisotropism) analyzer (8) must be slid in.

If a polarizing microscope is equipped with intermediate Pol tube for the examination of reflected-light specimens, pull out pushrod [7.9], set knob [7.12] to diaphragm 2.0, and flick lever [7.13] back (see page 17).

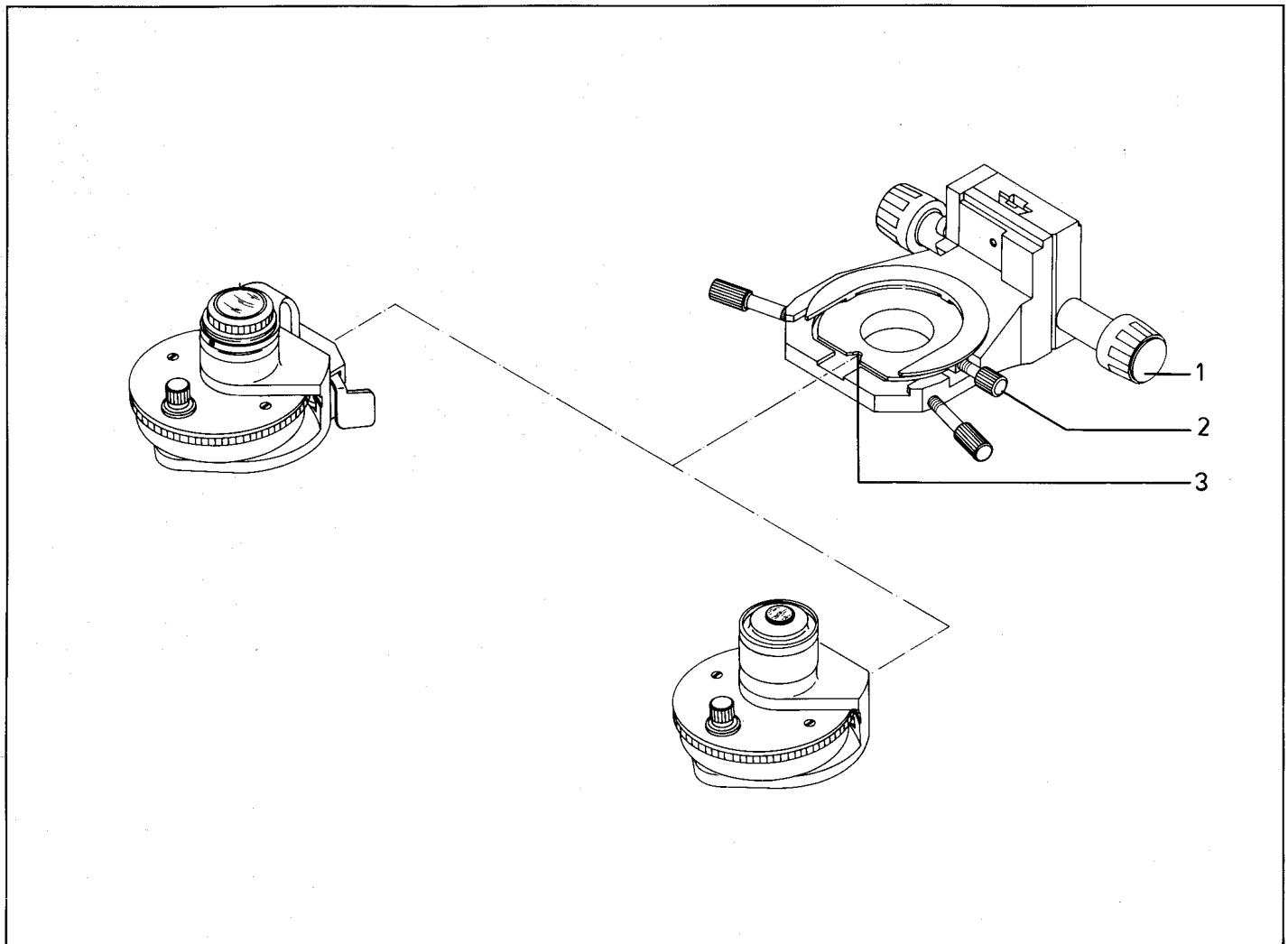


Should minor exchanges be necessary on your microscope and no service technician available, the following hints may be helpful.

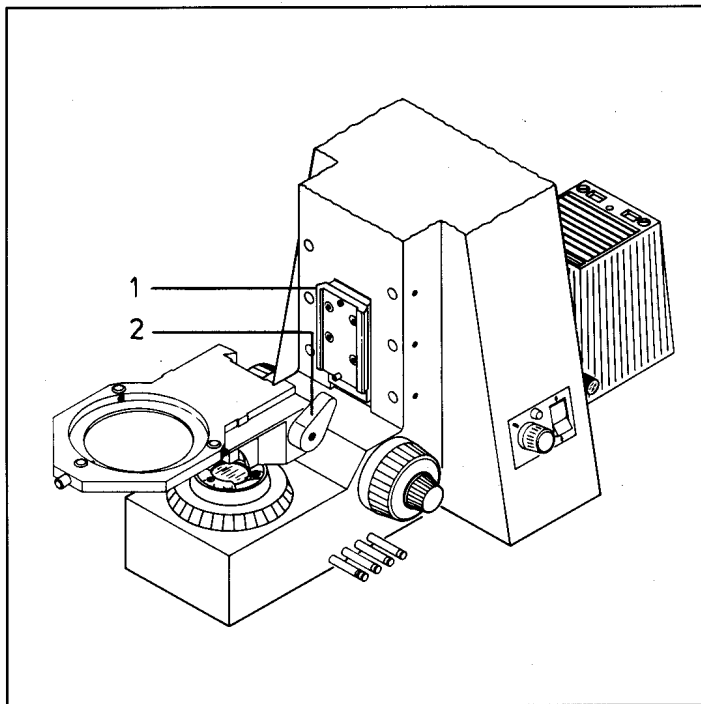
**Condenser exchange**

The normal condenser must be completely exchanged for the condenser system 1.4. Lower the condenser as far as possible with (1), loosen screw (2), and pull out the condenser forward. The exact insertion of the other condenser is ensured by notch (3).

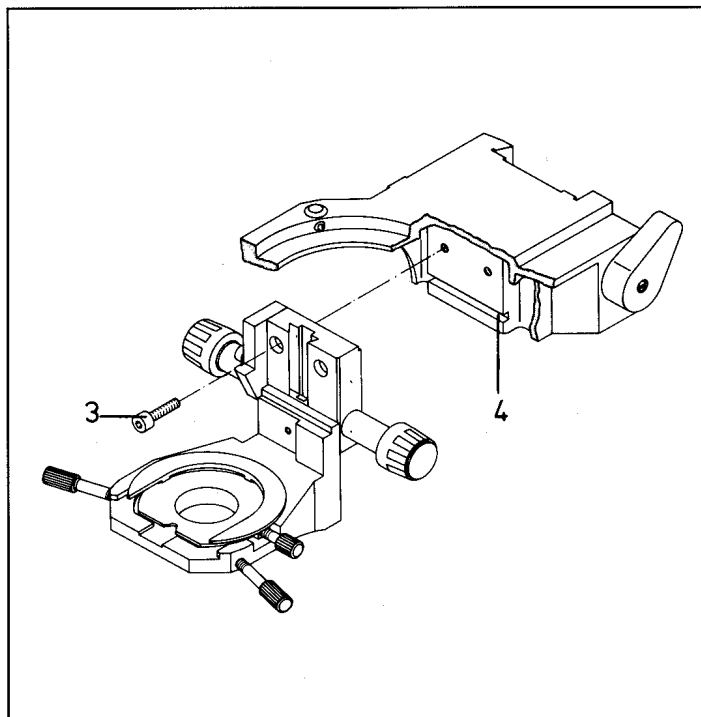
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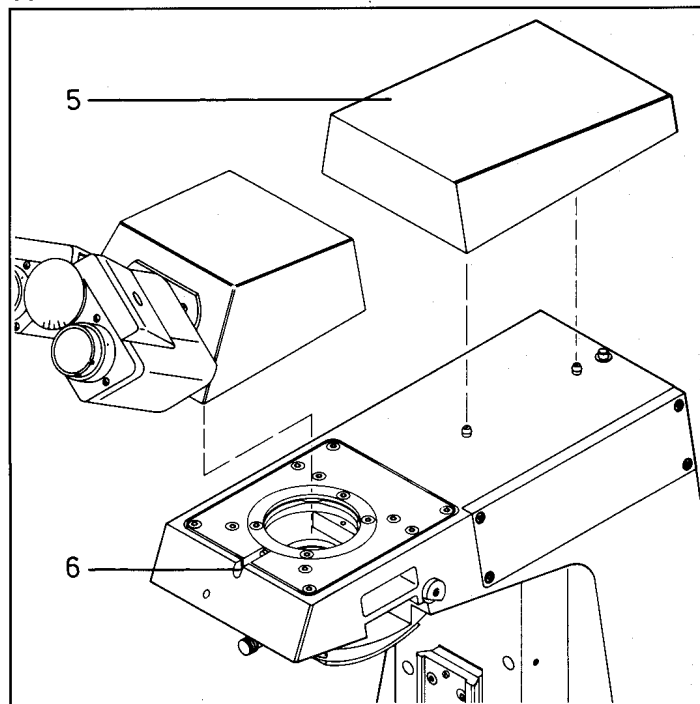
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### Stage components

Detachment from mounting plate: flick lever (2) (right) up, and turn off the entire unit about the left edge (1) of the plate. Attachment: put on left edge, then – lever up – press down right side; the spring pin is pressed down. Lever flicked down fixes the pin.

The condenser carrier (of transmitted-light equipment) can be removed after loosening 2 screws (3) on the front. When remounting the carrier the two orientation pins must engage notch (4); then tighten screws.

### Tube

For tube exchange pull off stand cover piece (5) upwards. Loosen socket head screw (6) and take off the tube. (Unscrew the socket head screw so far that it is no longer visible inside.) Insert new tube, secure it with screw and put on the stand cover piece.

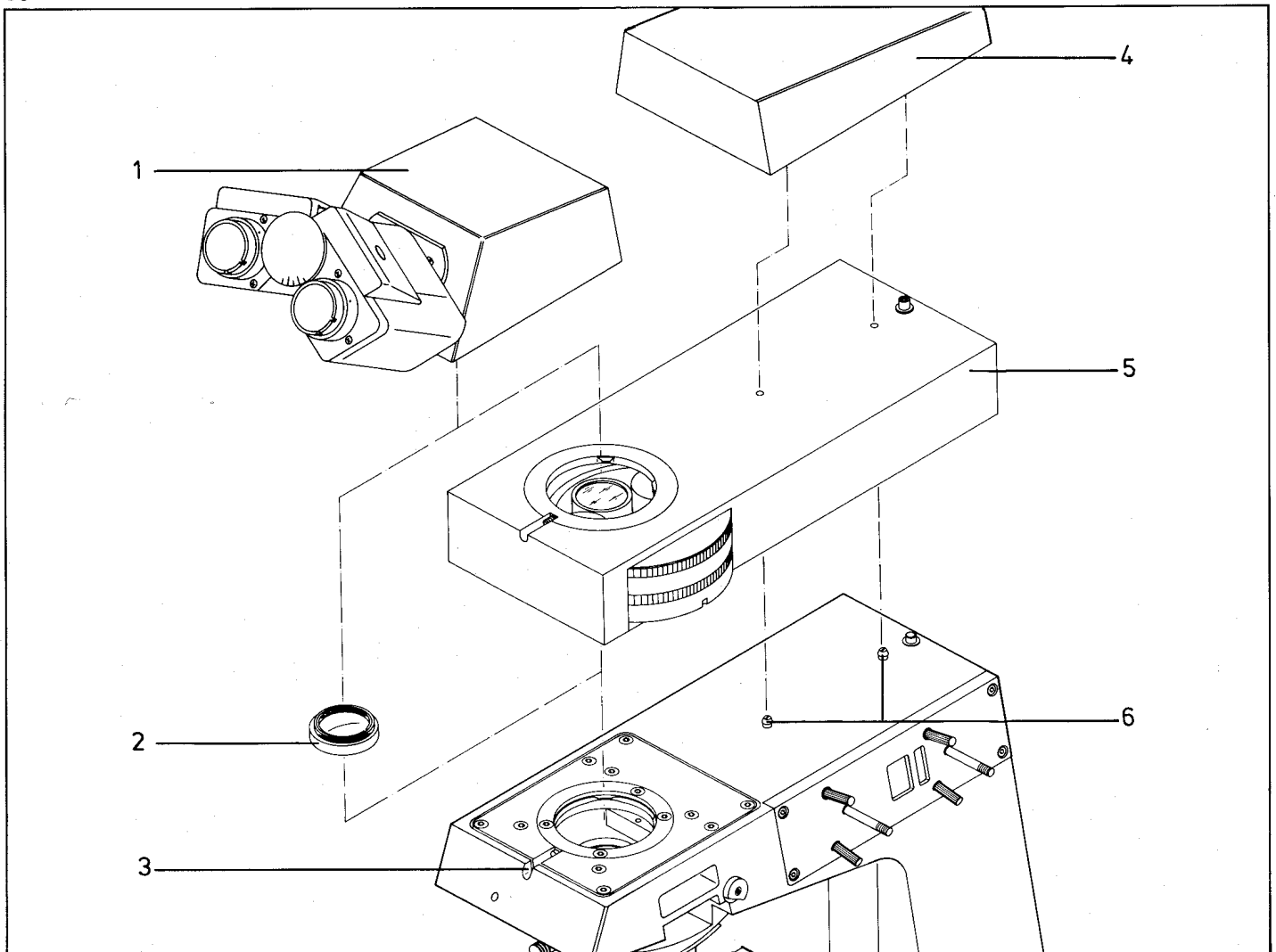
### Optovar intermediate tube

It can be mounted on a reflected-light Axioplan Pol microscope instead of the intermediate Pol tube. The additional magnification factors 1.25 $\times$ , 1.6 $\times$  and 2 $\times$  are indicated on the disk projecting on the right side. If you do not want 3 factors (objective, Optovar and eyepiece) to determine the microscope magnification, add the factors of Optovar and 10 $\times$  eyepiece, which yields the eyepiece values 12.5 $\times$ , 16 $\times$  and 20 $\times$ . The click-stop position marked Ph contains a Bertrand lens for convenient observation of the objective pupil. Focusing will then be made with the lower knurled ring (it is limited with low-power objectives).

To retrofit an Optovar intermediate tube on an Axioplan Pol microscope:

- Pull off stand cover piece (4) upwards and unscrew the two conical pins (6). Insert these pins in the top surface of the Optovar tube (5).
- Loosen socket head screw (3) and take off tube (1). (The screw must be unscrewed so far that it is no longer visible inside.)
- Unscrew the lens (2) at the bottom of the tube and screw it into the corresponding opening at the bottom of the intermediate tube.
- Mounting the intermediate tube: slightly lift the tube at the back (ca. 1/2 cm) and insert dovetails; lower the tube at the back, thereby sliding it backwards. The intermediate tube rests on the seating surface and can be secured with the socket head screw (3). Insert the tube (1), secure it and put on the stand cover piece.

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The spares are listed below as they appear in the instrument description starting on page 6.

**1.2** Fuses

1. 220 ... 240 V; 3.15 A SB; ordering no. 127.026
  2. 100 ... 127 V; 6.3 A SB; ordering no. 127.029.
- Both contain for the secondary circuit: 10 A SB; 128.167.

**1.5** **1.6** 42 mm dia. heat-reflecting filter, 467828; insert it so that the reflecting surface (marked L at the edge) faces the light source.  
Insertion of filter in illuminator 100 accordingly.

**1.5** 44 mm dia. diffusion disk, 451851-0003. (The retaining rings are loosened with small screwdriver; insertion accordingly.)

**2.0** 12V 100W halogen filament lamp, 380059-1660 (avoid fingerprints on the bulb!)

**8.18** 32 mm neutral density filter 0.03, 467842 fits into blank position of fixed analyzer.