ZEISS

Carl Zeiss
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West Germany

Accesories for transmitted light polarizing microscopy

Operating Instructions

ZEISS

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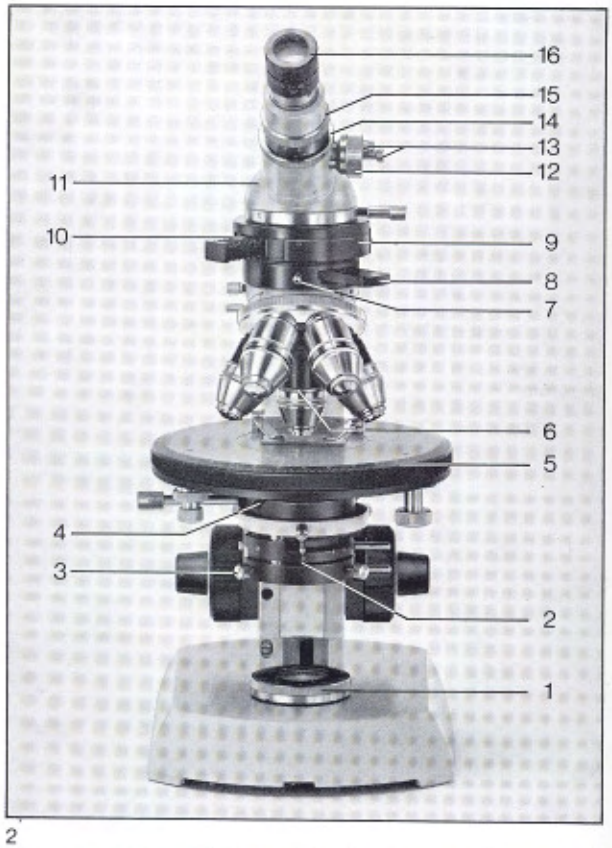
STANDARD 18 and UNIVERSAL

1



1 Knurled ring for luminous field iris diaphragm (for higher power light sources a heat absorbing filter should be placed on the light exit opening)
2 Rotating polarizer
3 Centering screw for auxiliary lens
4 Condenser with swing-out front lens Z "POL"
5 Rotary polarizing stage
6 POL objectives with knurled centering rings
7 Lever to open and close the slot for retardation plates
8 λ plate
9 Intermediate tube
10 Fixed analyzer on slide
11 Monocular polarizing tube with Bertrand lens
12 Knob for Amici-Bertrand lens
13 Centering screws for tube iris diaphragm
14 Knurled ring for iris diaphragm to select special specimen areas
15 Knurled ring for focusing the objective exit opening for conoscopic observation
16 Kpl POL crosshair eyepiece

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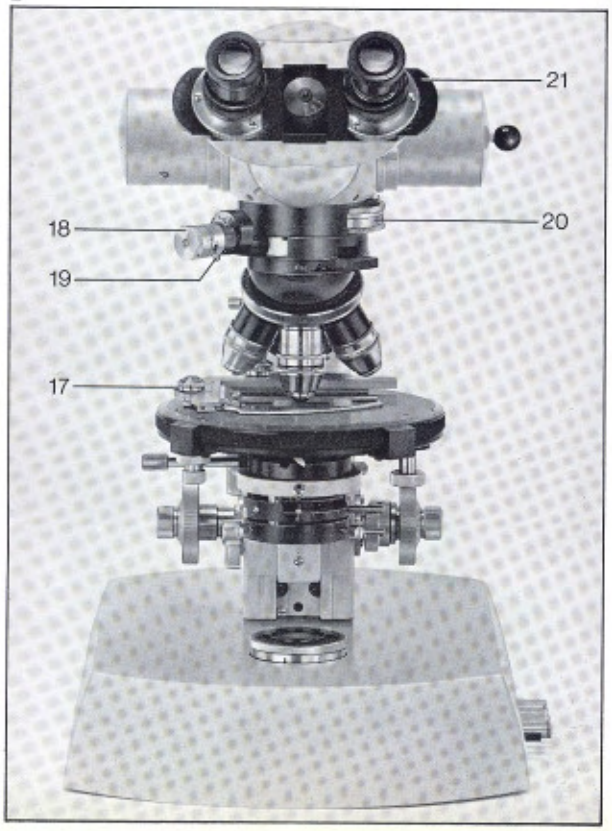

17 Attachable mechanical POL stage
18 Analyzer with POL filter rotating through 360°
19 Lever to fix the analyzer position
20 OPTOVAR magnification changer with Amici-Bertrand lens
21 Inclined binocular POL tube

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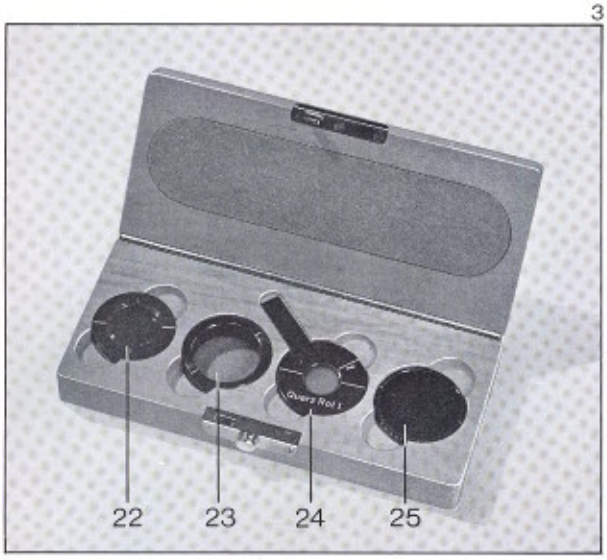
The dimensions of retardation plates and compensators correspond to German standard DIN 58 880. The orientation of polarizer and analyzer and the calibration direction of angles of rotation correspond to German standard DIN 58 879, i.e. polarizer in 0 position (East-West), analyzer in crossed position "+90°" (North-South).
As in mathematics all angles of rotation are **positive** in case of **counterclockwise** rotation.
For specimen rotation around the microscope axis the user's viewing direction is assumed to be towards the light source.

Simple polarizing equipment

3



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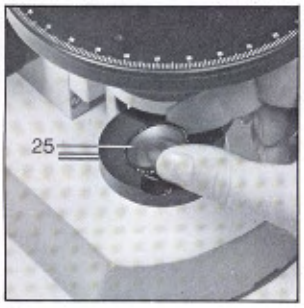

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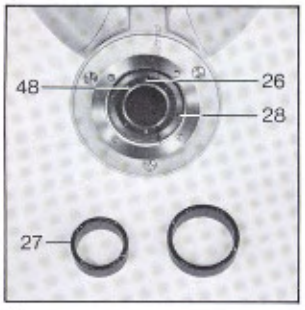

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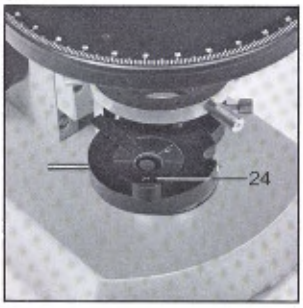

POL equipment (49 36 00) on STANDARD microscopes is for simple polarized light observations of birefringent specimens and for qualitative work, such as determination of the optical character.
The equipment comprises:
22 Analyzer (47 36 51)
23 Spanner for analyzer
24 λ plate (47 37 01)
25 Polarizing filter (47 36 00)
A rotary stage is recommended.

Place the **polarizing filter** (47 36 00) as polarizer in the swing-out filter holder of the condenser carrier or in the opening in the microscope base above the luminous field stop. The two white index lines on the edge of the mount indicate the oscillation direction and should lie in East-West direction.

With the spanner (27) screw the **analyzer** (47 36 51) (26) from below into the tube. For tubes (47 30 11/13) the adapter ring M 24/M 30 (47 36 95) (28) is required with the second spanner included in the equipment. Two white index lines indicate the oscillation direction of the analyzer. With attached tube it should be North-South, i.e. at right angles to that of the polarizer. Fix the oriented analyzer with screw (48).

For exact cross position turn tube or polarizer slightly until the field of view background shows maximum extinction. Upon rotation of the stage only birefringent details will light up.

Place the λ **plate** (47 37 01) (24) on the polarizer so that the white index line is parallel with the index lines of the polarizer. This plate has two oscillation directions at right angles to one another, through which the light passes at different speeds. Both are at an angle of 45° to the oscillation direction of polarizer and analyzer. The direction marked γ on the mount is the oscillation plane of the light passing at lower speed.

In "addition position" the specimen shows an interference color which is by 550 nm (λ plate) higher, e.g. blue. The oscillation direction of the slower wave train in the specimen will be parallel to the direction γ of the retardation plate.
In "subtraction position" the interference color is correspondingly lower, e.g. yellow (oscillation direction of the faster wave train parallel to the direction γ).

Polarizers

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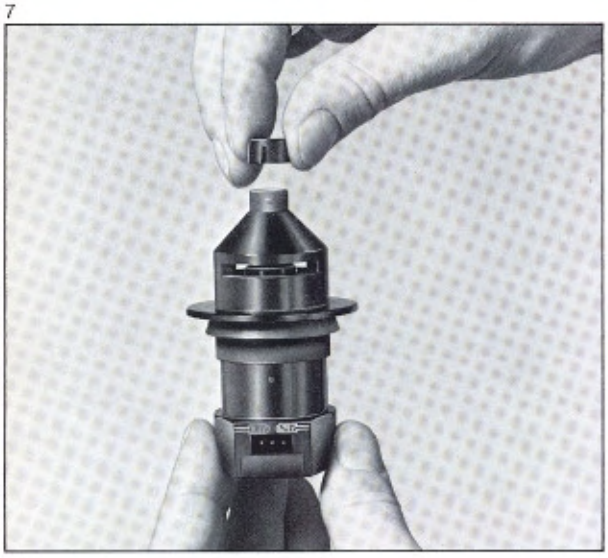

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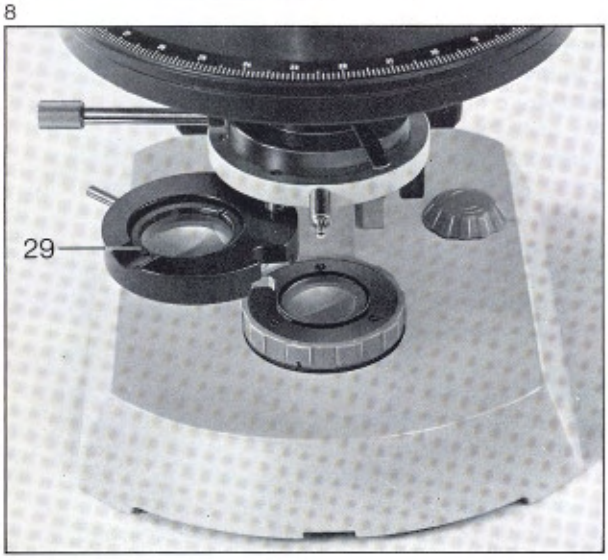


On STANDARD microscopes with **LUCIGEN** illuminator plug the **polarizer (47 36 15)** over the LUCIGEN opal glass so that the guide pin of the LUCIGEN engages the recess.

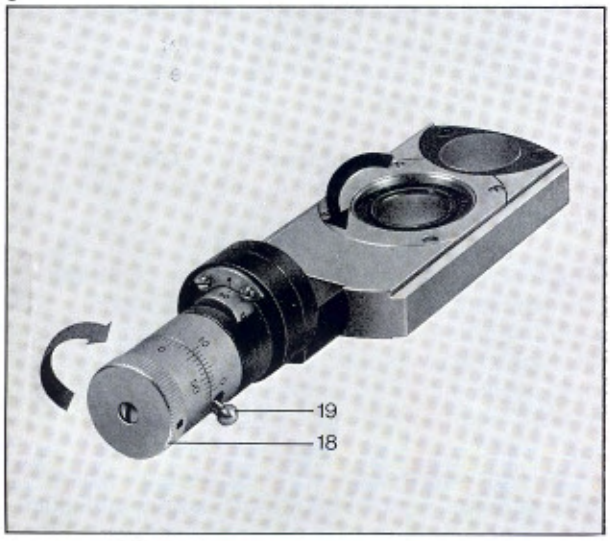
The **fixed polarizer with carrier (47 08 66)** (Fig. 8) is mounted on the condenser and can be swung out of the beam path.

The **rotating polarizer with carrier and centering auxiliary lens (47 08 65)** (2 Fig. 1) has a mount with 15° graduation. The polarizer is rotating through 210°, with click stops at 0° and 90°. In click stop position 0° the oscillation direction is East-West. The rotary knob gives the readout.

For higher power light sources a heat absorbing filter is recommended between polarizer and illuminator (e.g. above the luminous field stop (1 Fig. 1) or at the illuminator).

Analyzers

9



STANDARD microscopes with monocular POL tube I (47 30 30): swing the analyzer in the tube (31 Fig. 10) into the beam path; the oscillation direction is North-South.

STANDARD microscopes with OPTOVAR magnification changer (47 30 52): switch analyzer into beam path and cross polarizer by turning. The oscillation direction of the analyzer is North-South.

LUMINAR head (low-power photomacrography) on UNIVERSAL, Photomicroscope and ULTRAPHOT: insert polarizing filter (47 36 00) as analyzer in the rear opening of the LUMINAR holder in North-South direction (indices on the polarizer mount).

STANDARD microscopes with monocular polarizing tube with Bertrand lens (47 30 31) or binocular inclined tube POL (47 30 35) require intermediate tube (47 30 59) for the analyzer slide. On UNIVERSAL, Photomicroscope and ULTRAPHOT the analyzer slide is inserted in the tube head.

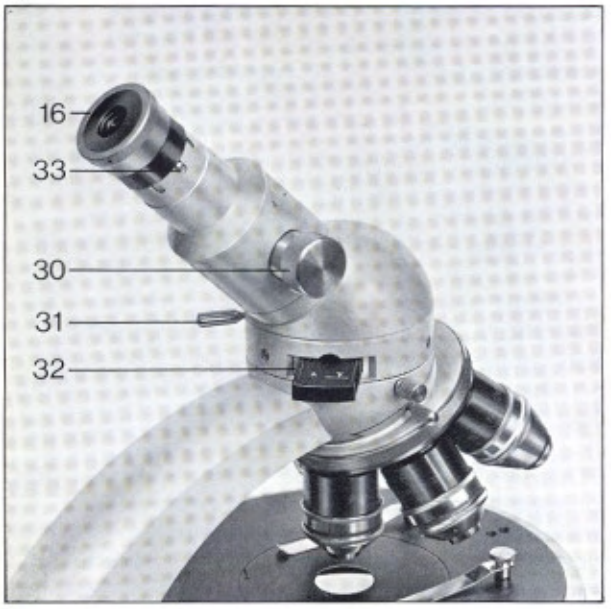
There are two versions of the analyzer slide:
Simple analyzer slide (47 36 63) (10 Fig.1) with fixed POL filter (oscillation direction North-South).

Analyzer with POL filter rotating through 360°
(47 36 62) (Fig. 9). In crossed position with the polarizer (oscillation direction North-South) the angular position of the analyzer is 90°. The angle of rotation can be read to within 0.1°; when turning knurled knob (18) it is positive with increasing graduation (analyzer rotates counterclockwise). Each position can be fixed with lever (19).

Depending on the equipment, crossed position of polarizer and analyzer is achieved by turning the polarizer, turning the analyzer or turning the tube (with fixed analyzer at the tube).

Polarizing tubes

10



To ensure exactly parallel orientation of eyepiece crosslines and oscillation direction of polarizer and analyzer, the tube must be mounted on the microscope in oriented position. To achieve this, let the spring bolt of the tube set screw engage one of the two guide slots of the tube dovetails; the guide pin of the eyepiece must engage the central notch at the upper tube edge.

Monocular polarizing tube I (47 30 30) (Fig.10), for STANDARD microscopes only. With lever (31) the non-rotating analyzer can be swung in or out. The Amici-Bertrand lens is operated with knob (30); it is combined with a pinhole diaphragm so that only a small surface detail in the center of the object field is used for the observation of interference figures, e.g. of small crystals. This ensures uniform sharpness of the interference image with all objectives. Opening (32) is for retardation plates or compensators.

Monocular polarizing tube with Bertrand lens (47 30 31) (11 Fig.1) is mounted on STANDARD microscopes via intermediate tube (47 30 59) (9 Fig.1) and on UNIVERSAL, Photomicroscope and ULTRAPHOT directly on the tube head.

Intermediate tube with monocular polarizing tube with Bertrand lens. Opening (10 Fig.1) for the analyzer slide (47 36 62) with analyzer rotating through 360° or for simple analyzer slide with non-rotating analyzer (47 36 63). Opening (8) for retardation plates (tilting compensators can be operated up to 30° tilt).

Knob (12) for Amici-Bertrand lens. In the beam path it converts the eyepiece into a centering telescope for the observation of enlarged interference figures or to supervise the illumination of the objective aperture.

Interference figure or objective aperture are focused by turning knurled ring (15). The mechanical tube length (indicated in cm by the graduation) is altered.

With the tube iris diaphragm (Bertrand iris) (14) small areas in the center of the image field can be isolated for the observation of the interference figures of small crystals.

With the two knobs (13) the interference figure can be centered relative to the crosslines, e.g. for axial angle measurements.

The interference figure can be observed with a pinhole diaphragm (diopter 46 48 89) which is inserted in the tube instead of the eyepiece. The Amici-Bertrand lens is then removed from the beam path.

Monocular inverting tube (43 30 18)
The prisms in the tube of UNIVERSAL, Photomicroscope and ULTRAPHOT invert the image so that birefringent crystals and interference figures appear with inverted optical character (see Table on p. 23 below). The above tube compensates this inversion and offers the optical character as in a conventional microscope. The inverting tube has a magnification factor of 1.25.

Binocular inclined POL tube (47 30 35) (21 Fig. 2). Mount this tube on STANDARD microscopes via intermediate tube (47 30 59) and on UNIVERSAL, Photomicroscope and ULTRAPHOT directly on the tube head. For conoscopic observation one eyepiece can be replaced either by the pinhole diaphragm (diopter 46 48 89), a centering telescope (46 48 22) or the centering telescope with built-in micrometer disk (46 48 23). With the other eyepiece in the tube, simultaneous orthoscopic observation is possible.

Conoscopic observation with both eyes with UNIVERSAL, Photomicroscope and ULTRAPHOT requires OPTOVAR position Ph. If crystals are smaller than the field of view, close the luminous field stop so that its edge lies within the crystal. The interference figure cannot be centered relative to the crosslines, though.

Binocular inverting POL tube (43 30 19). Like tube (43 30 18) it rotates the image through 90° to compensate image inversion in UNIVERSAL, Photomicroscope and ULTRAPHOT; magnification factor 1.25.

The **straight POL tube (47 30 21)** and the **binocular phototube POL with sliding prism (43 30 03)** are for work with a photomicrographic camera.

POL eyepieces

All POL eyepieces (16 Fig.10) feature centered crosslines. If the guide pin (33 Fig.10) of the eyepiece engages the central notch of the tube edge, the horizontal bar of the crosslines is parallel with the oscillation direction of the polarizer (0 position), the vertical bar parallel with that of the analyzer. The crosslines are in diagonal position relative to these oscillation directions if the pin engages one of the notches which are 45° displaced.

Focusing with the eyepiece on the crosslines: remove eyepiece, hold it against a bright surface and with the knurled ring turn the eyelens in until the crosslines are in focus.

POL Z objectives

(6 Fig. 1)
The centering objectives feature strain-free lenses, which is indicated by the red "POL" symbol. Unless they are exhibited to extreme temperature fluctuations or mechanical pressure they will remain strain-free. If the aperture stop is opened with high-power objectives, the field of view is brightened between crossed polarizer and analyzer. In conoscopic observation this will give the impression of an interference image of an optically uniaxial, positively birefringent crystal, viewed parallel to its axis.
The reason for this phenomenon is the unavoidable rotation of the oscillation plane of light in case of impinging on strongly bent lens surfaces.

Centering the objectives:
Bring a punctiform detail of the specimen at the spot around which the specimen moves upon stage rotation. This item marks the stage axis of rotation. Turn the two knurled screws of the objective alternately until stage axis of rotation and microscope axis (center of crosslines) coincide.

POL condensers

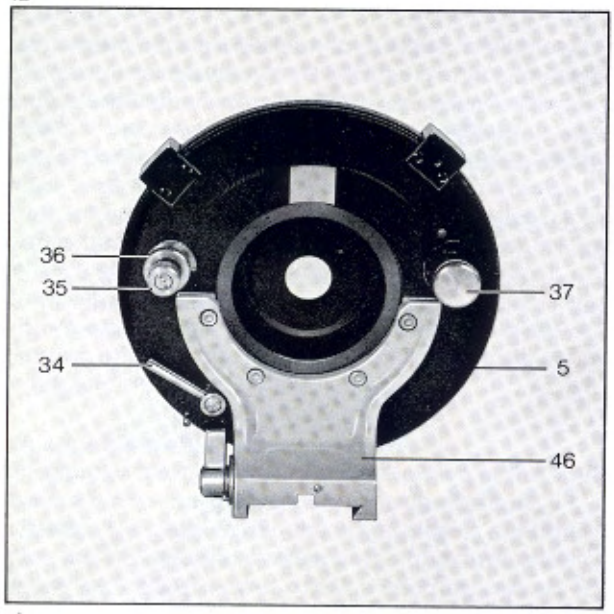
(4 Fig. 1)
The optics of the POL condensers is also strain-free (the same is true of the POL spectacle lens condensers which are used for low-power photomacrography with LUMINAR objectives on UNIVERSAL, Photomicroscope or ULTRAPHOT).

POL condensers bear the red symbol "POL".
On STANDARD microscopes with built-in 6 V 10 W halogen source screw the auxiliary lens POL (46 51 44) from below into the POL condenser.

11

Rotary polarizing stages

12



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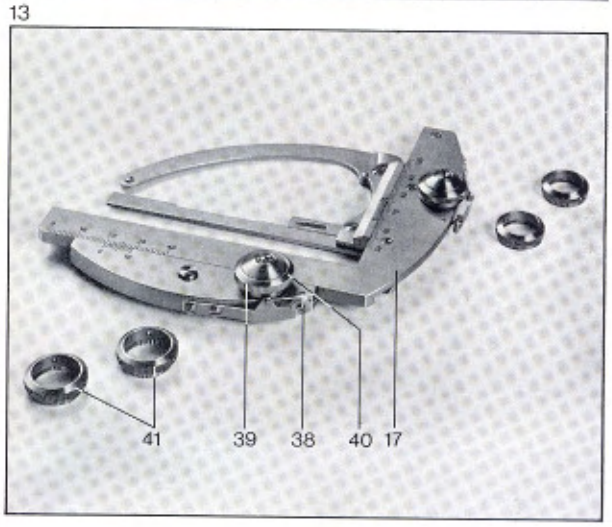


The stage is rigidly mounted on STANDARD microscopes, whereas on stage carrier (47 15 40) (46) it is exchangeable on dovetails on WL microscope, UNIVERSAL, Photomicroscope and ULTRAPHOT. The stage position of the **simple rotary POL stage (47 34 64)** can be read to within 0.1° and fixed. The same is true of the **rotary polarizing stage (47 34 66)** (Fig. 12). This stage features the following additional operating elements:

34 = locking lever for stage rotation
35 = fine drive for stage rotation
36 = knurled screw to activate the fine drive
37 = 45° click stop mechanism for quick changeover from parallel to diagonal specimen position for work with retardation plates, compensators, etc. Coupling (tightening of knurled ring) is possible in any position, decoupling only in click stop position.

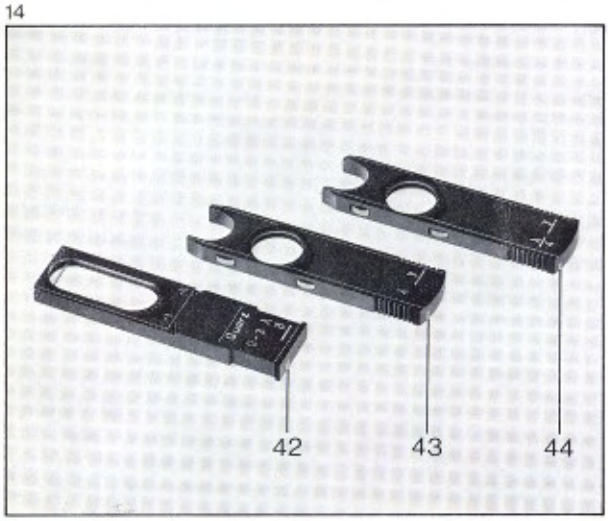
The attachable mechanical POL stage is mounted on both stages with the aid of a threaded borehole and two holes in the stage plate.

Attachable mechanical POL stage (47 33 25-9903) (17) on stage plate with two guide pins and one screw is shown mounted in Fig. 2.

Specimen slides of all common formats can be moved within an area of 30 x 38 mm, and the specimen coordinates accurately determined to within 0.1 mm. With the **pointcounter attachment (47 40 35-9901)** 0.2 or 0.3 mm intervals of specimen movement can be marked. Unscrewing knob (38) overrides the click stop. To mount the click stop ring loosen the three screws (39), pull off ring (40) and fix the click stop ring (41).

Retardation plates and compensators

14



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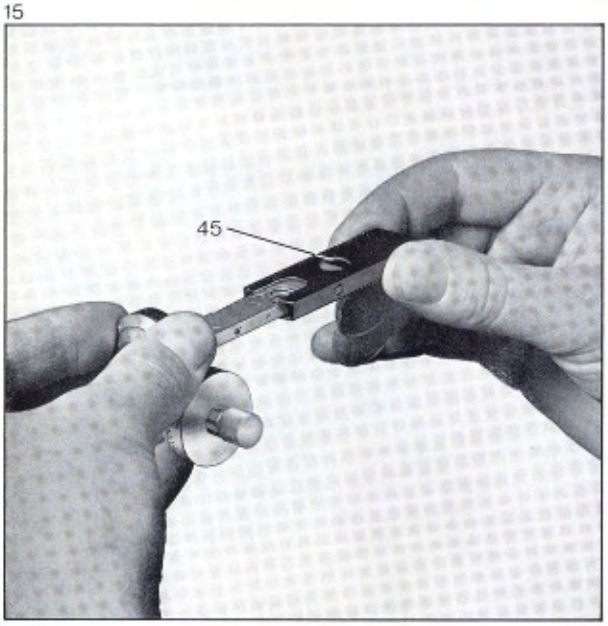


In orthoscopic observation retardation plates are used to determine the relative refractive index, and in conoscopic observation to determine the optical character of the interference figure (positive or negative); i.e. for qualitative work.
The following retardation plates are used for polarizing microscopy:
λ/4 plate, 6 x 20 mm (47 37 14) (44)
λ plate, 6 x 20 mm (47 37 04) (43)
Quartz wedge 0—3 λ, 6 x 20 mm (47 37 24) (42)
The items are inserted in the opening in the intermediate tube (8 Fig. 1) or in the tube head beneath the analyzer.
The more slowly propagating wave oscillates in the direction marked γ of the retardation plates and compensators.

Compensators are used to measure path differences in birefringent specimens. For such measurements the principal oscillation directions of the specimen must be diagonal to the crossed polarizers.

Compensator	Type	For path differences of max.
Quartz tilting compensator	Ehringhaus	2nd orders
Calcite tilting compensator		36.5th orders
Mica λ/4	Sénarmont	1st order
Rotary compensator λ/4	Brace-Köhler	$^1/_4$th order
Rotary compensator λ/10		$^1/_{10}$th order
Rotary compensator λ/20		$^1/_{20}$th order
Rotary compensator λ/30		$^1/_{30}$th order

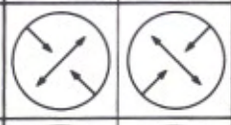
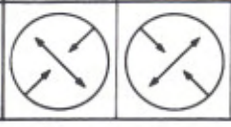
Tilting and rotary compensators are provided with reducing piece (Fig.15). 4 x 12 mm compensators are inserted in the wider tube slots with the aid of the reducing piece 6 x 20/4 x 12 (47 16 50) (45).

Adjusting the microscope

Adjust the orthoscopic image in brightfield according to the Operating Instructions of the microscope. For small convergence of the illuminating light bundles, close the aperture stop more than usual according to Köhler's rules. This applies, for instance, to the determination of the extinction direction of anisotropic crystals, to the observation of a high-contrast Becke line or to an increase in black-and-white or color contrast between crossed polarizer and analyzer.

Adjusting the conoscopic image (interference figures)
Move the specimen to the crossline center and open luminous field stop and condenser (aperture) stop completely.
Swing in Amici-Bertrand lens, and with monocular polarizing tube with Bertrand lens (473031) (11 Fig. 1) center the interference figure in the field of view with the two centering screws (13 Fig.1). Focus the interference figure by changing the tube length with knurled ring (15 Fig.1). Because of the natural unsharpness of the interference figure use the sharp image of the objective aperture as focusing criterion. For better reproducibility of focusing, write down the tube length of each objective. To avoid that the interference figure of a small crystal in the center of the field of view is superimposed by that of neighboring crystals, close the Bertrand iris diaphragm. Binocular observation of interference figures with UNIVERSAL, Photomicroscope and ULTRAPHOT is possible with Bertrand lens and OPTOVAR in position Ph.
Set the tube length again to 160 mm when changing over to orthoscopic observation to ensure parfocalization of the objectives.

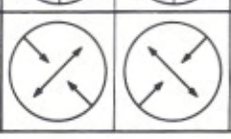
Tables on page 23
The tables show the oscillation directions in the orthoscopic and the character of birefringence in the conoscopic interference image.

Leading reference direction in UNIVERSAL POL, Photomicroscope POL or ULTRAPHOT POL	Optically uniaxial Section at right angles to the optic axis		Optically biaxial Section at right angles to the acute bisectrix				Addition position	Subtraction position
			Cross position		Diagonal position			
	+	−	+	−	+	−		
λ plate								
Quartz wedge 0 - 3 λ while inserted and Ehringhaus calcite tilting compensator while tilted from zero position								
Retardation plate λ/4								
Ehringhaus quartz tilting compensator and Berek tilting compensator while tilted from zero position								

Motion direction of interference fringes in the orthoscopic image, noticeable at the wedges or edges of the specimen.

γ in the specimen

The indicated colors in the specimen in the orthoscopic image are examples; they prevail with 1st order white without retardation plate.

Leading reference direction in STANDARD POL or WL POL as well as UNIVERSAL POL, Photomicroscope POL or ULTRAPHOT POL with inverting tube.	Optically uniaxial Section at right angles to the optic axis		Optically biaxial Section at right angles to the acute bisectrix				Addition position	Subtraction position
			Cross position		Diagonal position			
	+	−	+	−	+	−		
λ plate								
Quartz wedge 0 - 3 λ while inserted and Ehringhaus calcite tilting compensator while tilted from zero position								
Retardation plate λ/4								
Ehringhaus quartz tilting compensator and Berek tilting compensator while tilted from zero position								

Motion direction of interference fringes in the orthoscopic image, noticeable at the wedges or edges of the specimen.

γ in the specimen

The indicated colors in the specimen in the orthoscopic image are examples; they prevail with 1st order white without retardation plate.

Addendum to operating instructions G 41-500/I-e "Accessories for transmitted light polarizing microscopy"

Tube head of Universal R Pol (47 16 92) with inclined binocular tube Pol (47 30 35)

1.1 Eyepiece with fixed eyelens

1.2 Pol eyepiece with reticle and focusing eyelens

1.3 Inclined binocular tube Pol (47 30 35)
Adjustment:
- Turn the eyelens of the Kpl Pol eyepiece out. View through the eyepiece against a bright surface and slowly turn in the eyelens until the reticle is in focus. Insert the Pol eyepiece in one of the tubes; screw (1.4) must engage the horizontal slot of the tube edge.

Fit an eyepiece of the same correction and the same magnification in the other tube.
Adjust the binocular tube to your pupillary distance by turning the two halves. The tube length which is important for the parfocalization of the objectives changes slightly.
- Read off the value on the small disk of the binocular inclined tube and adjust this value on both tubes. (Since the objectives are parfocalized, the image remains visible while changing the objective).
- With the microscope focusing control focus at first the image of the object in the crosshair eyepiece; then focus the image of the object in the fixed eyepiece by slowly turning in the tube end.

1.4 Screw to orient the crosshair eyepiece, fitted in horizontal slot of tube.

1.5 Slider with mirror
pushed in: position ← light to the front for observation
pulled out: position → light upwards for photomicrography, projection, TV

1.6 Housing with focusing and centering Bertrand lens and diaphragm (Bertrand optical system).

1.7 Slider with Bertrand diaphragm to occlude objects of various size in the center of the field of view
pushed in: maximum aperture
center position: medium aperture
pulled out: minimum aperture

1.8 Knob with scale to focus the conoscopic image. With the scale certain focusing positions can be marked.

1.9 Slider with pinhole diaphragm
pushed in: only the conoscopic image is visible
pulled out: conoscopic and orthoscopic images are visible simultanesously

Addendum to operating instructions G 41-500/I-e "Accessories for transmitted light polarizing microscopy"

Intermediate tube (47 30 56) with Bertrand lens and diaphragm with inclined binocular tube Pol (47 30 35) on Standard microscope

1.1 Eyepiece with fixed eyelens

1.2 Pol eyepiece with reticle and focusing eyelens

1.3 Screw to orient the crosshair eyepiece, fitted in horizontal slot of tube.

1.4 Inclined binocular tube Pol (47 30 35)
Adjustment:
- Turn the eyelens of the Kpl Pol eyepiece out. View through the eyepiece against a bright surface and slowly turn in the eyelens until the reticle is in focus. Insert the Pol eyepiece in one of the tubes; screw (1.3) must engage the horizontal slot of the tube edge.

Fit an eyepiece of the same correction and the same magnification in the other tube.
Adjust the binocular tube to your pupillary distance by turning the two halves. The tube length which is important for the parfocalization of the objectives changes slightly.
- Read off the value on the small disk of the binocular inclined Pol tube and adjust this value on both tubes. (Since the objectives are parfocalized, the image remains visible while changing the objective).
- With the microscope focusing control focus at first the image of the object in the crosshair eyepiece; then focus the image of the object in the fixed eyepiece by slowly turning in the tube end.

1.5 Intermediate tube (47 30 56) with focusing and centering Bertrand lens and diaphragm (Bertrand optical system).

1.6 Slider with pinhole diaphragm
pushed in: only the conoscopic image is visible
pulled out: conoscopic and orthoscopic images are visible simultaneously

1.7 Slider with Bertrand diaphragm to occlude objects of various size in the center of the field of view
pushed in: maximum aperture
center position: medium aperture
pulled out: minimum aperture

1.8 Knob with scale to focus the conoscopic image. With the scale certain focusing positions can be marked.

1.9 Opening (6x20 mm) for auxiliary objects and compensator; can be closed with a dummy slider.

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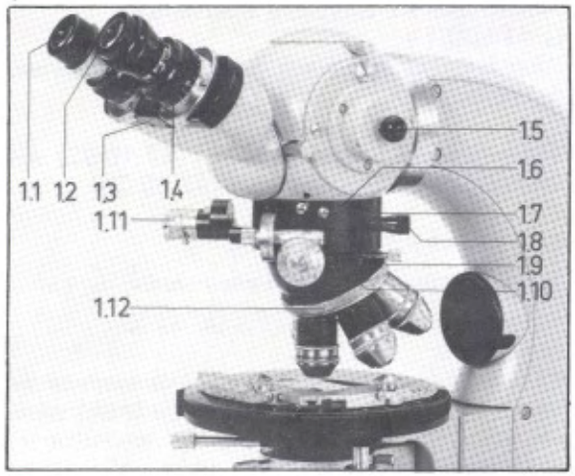

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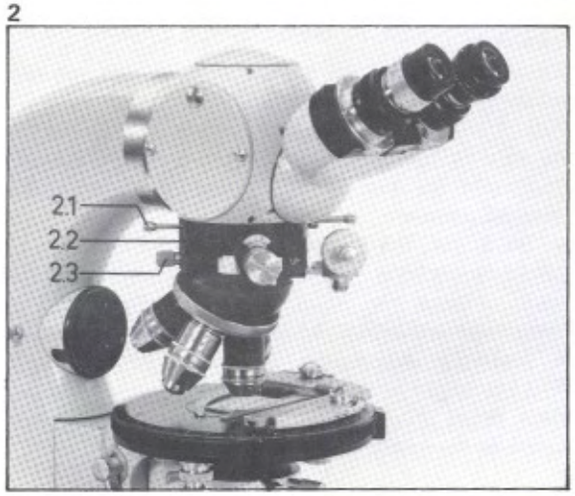

1.10 Opening (6x20 mm) for auxiliary objects and compensator; can be closed with a dummy slider.

1.11 Analyzer pushed in

1.12 Objective turret

2.1 Slider with double-faced mirror to bring the Bertrand optical system into the beam path
pushed in: Bertrand optical system in the beam path. For orthoscopic observation the slider with diaphragm (1.9) must be pulled out.

2.2 Two hexagonal socket screws to center the Bertrand optical system with the wrench supplied with the equipment.

2.3 Clamping screw for analyzer slider.

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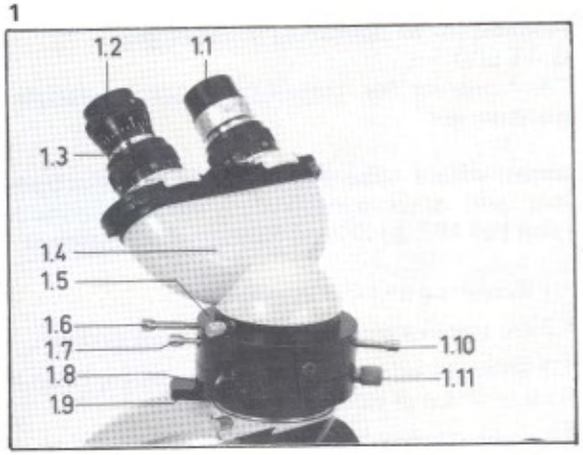

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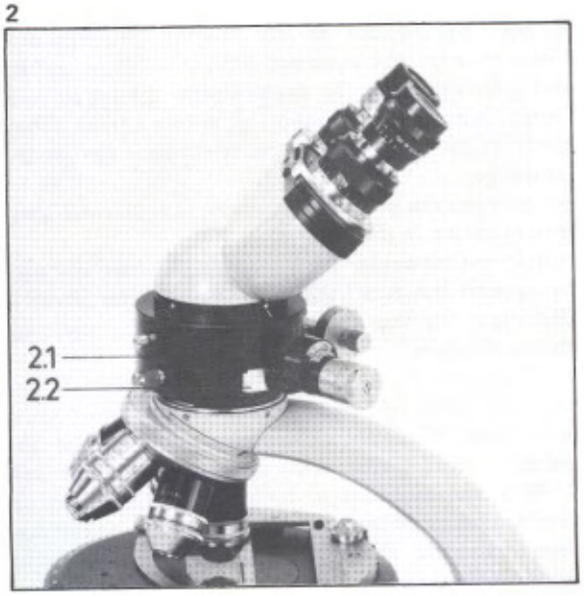

1.10 Slider with double-faced mirror to bring the Bertrand optical system into the beam path
pushed in: Bertrand optical system in the beam path. For orthoscopic observation the slider with diaphragm (1.6) must be pulled out.

1.11 Clamping screw for analyzer slider

2.1 Two hexagonal socket screws to center the Bertrand optical system with the wrench supplied with the equipment.

2.2 Analyzer pushed in