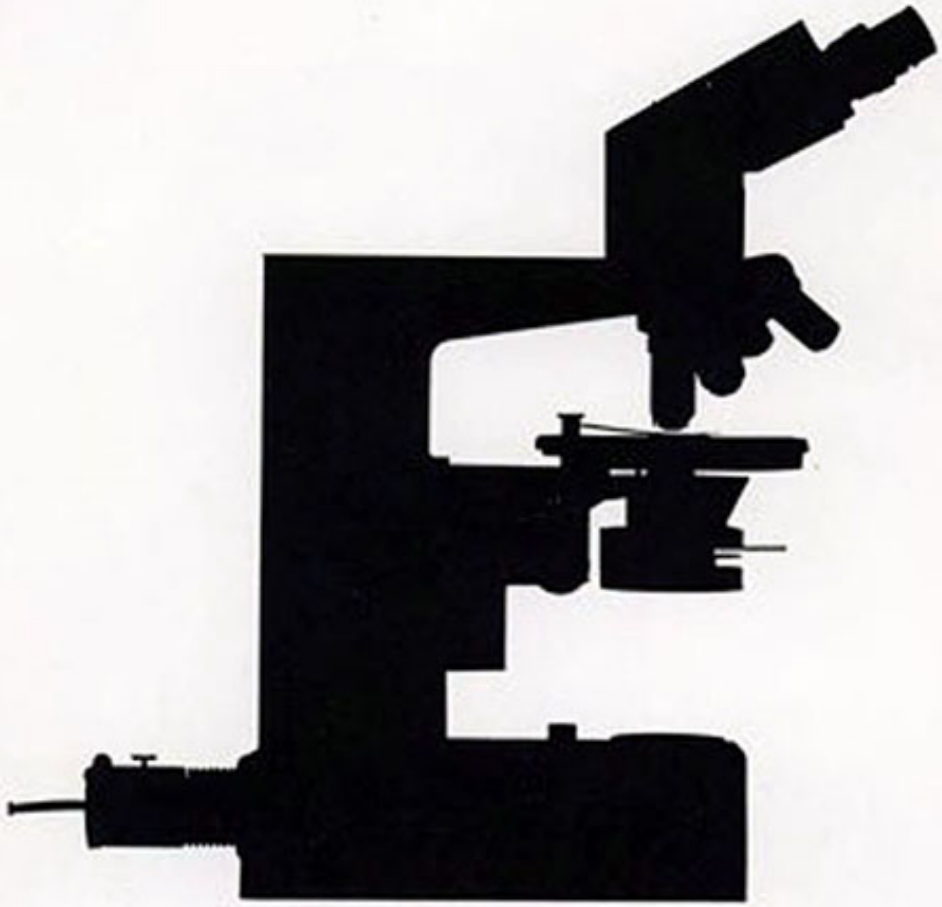
# SM-LUX-POL
# polarizing microscope

Leitz
WETZLAR

## Instructions



550 – 34 / Engl.

# 1 Introduction

The SM-LUX-POL stand is a microscope for the most important methods of investigation in polarized transmitted and incident light.
The unit-component principle permits the following microscopic methods to be carried out with the appropiate accessories:
brightfield (in normal and polarized light)
darkground
phase contrast
fluorescence
high-temperature microscopy
(up to 350 °C)
microphotometry
microprojection
photomicrography

# 2 Setting up the microscope

High-quality optical instruments must be set up in a suitable work place. The work-room must be free from oil- or chemical fumes. Vibrations from neighbouring machines and passing vehicles as well as direct sunlight and appreciable temperature fluctuations are disturbing factors during measurement and photomicrography. A robust work bench of suitable height (about 75cm/30in) with drawers for accessories as well as a comfortable chair considerably facilitate work. Work benches of the LEITZ programme have been specially developed for microscopy, meeting these requirements in the best possible way (details see list 513–71). The installation of a multiple socket for easy connection of microscope illuminators and accessories is recommended.
It is essential to compare the mains voltage with the setting of the transformers and power units supplied.
Carefully check the equipment with the packing note during unpacking and ensure that no small components are left in the packing material.
Mechanical and optical components are cleaned before dispatch and packed in dust-proof containers.
To protect the microscope against dust, it should be covered after use with the special dust cover or kept in a cabinet.
The accessories should always be kept in the drawer of the work bench or in the accessory case.

# 4 Technical description and assembly of the components

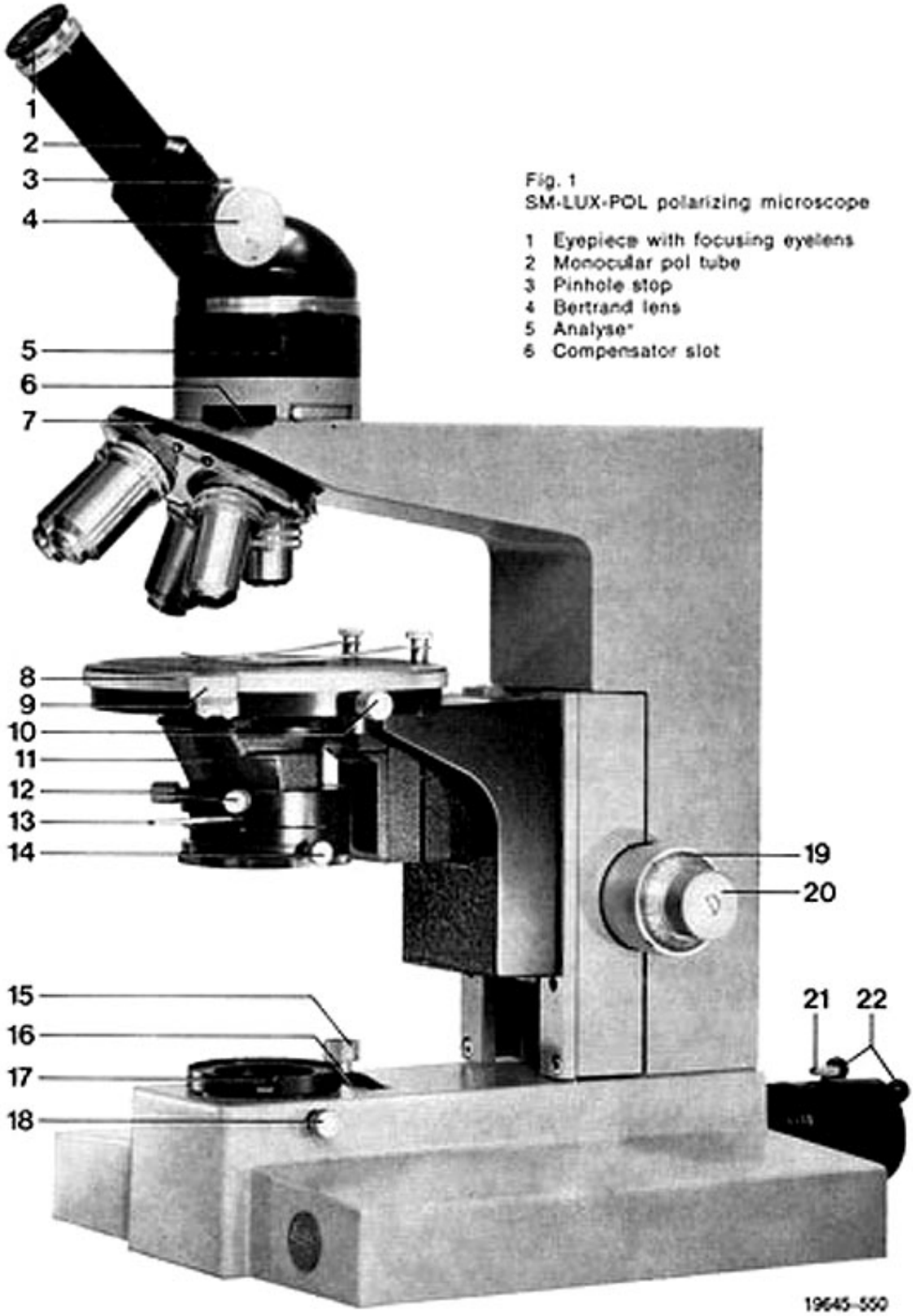



Fig. 1
SM-LUX-POL polarizing microscope

1 Eyepiece with focusing eyelens
2 Monocular pol tube
3 Pinhole stop
4 Bertrand lens
5 Analyser
6 Compensator slot

7 Centring revolving nosepiece
8 Rotating object stage
9 Verniers for the graduation
10 Clamping screw for the object stage
11 Pol condenser
12 Knurled screws for centring the condenser
13 Aperture diaphragm
14 Clamping screw for the polarizer
15 Illuminating lens
16 Field diaphragm
17 Dust glass with filter support
18 Clamping screw for accessories
19 Coarse adjustment
20 Fine adjustment
21 Clamping screw for lamp mount
22 Centring screws

## Stand

The stand supports all other components of the microscope. Owing to the unit component system light sources, condenser systems, optical systems for observation, tubes, and other accessories can be interchanged simply and without loss of time.

## Object stage

The rotating object stage No. 32 has a diameter of 130mm, runs on ball bearings, and has verniers with a friction clamp.

The vertical adjustment of the condenser is situated below the object stage. After it has been lowered, the polarizing condenser can be replaced by other condensers (darkground, phase contrast).

The bushes in the top of the stage serve for the attachment of accessories such as the attachable mechanical stage or the heating stage 350.

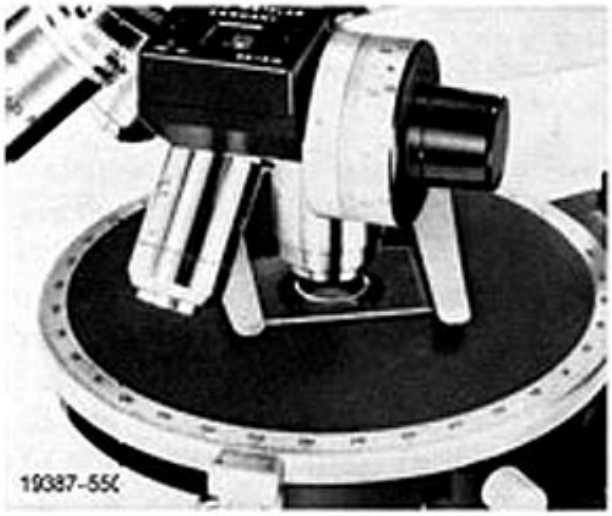



Fig. 2 Rotating object stage, graduated in degrees, and running on ball bearings. (A tilting compensator is introduced into the top of the stand.)

## Revolving nosepiece and tube lens system

The revolving nosepiece accepts 5 objectives, which are individually centred. The compensator slot (20x6mm) has been arranged so that the compensators it accepts are in the parallel beam of the tube lens system. This preserves the focusing of the microscopic image when the compensator is inserted. In addition no correction factor need be allowed for when tilting compensators are used. To avoid collection of dust on the optical system, the compensator slot must always be covered.

## Other object stages

a) Instead of the standard SM-LUX-POL outfit with non-interchangeable rotating stage No. 32 an outfit with the interchangeable object stage No. 832 (Code No. 522241) is available. This permits the attachment of universal rotating stages.

**Mounting the universal rotating stage (2a. 27).**

Unscrew the objectives from the revolving nosepiece. Lift the stage plate from the object stage, unscrew the front lens of the condenser, raise the condenser as far as it will go, lower the stage by means of the control (20.19) or, after unscrewing the clamping screw 2a.26), in the object stage changing guide. Attach the universal rotating stage to the stage with the two screws supplied. Screw the condenser top for the universal stage for orthoscopy, Code No. 553139 or the auxiliary condenser A0.60 for conoscopy, Code No. 533140 in position. Screw only two UM or UMK objectives into the revolving nosepiece so that the tilting movement of the stage is not obstructed. Close empty nosepiece apertures with screw caps.

**Mounting the quartz glass plate, segments, and specimen**

See List 55–9 "Scheme of Investigation with the Universal Rotating Stage".

b) For special investigations such as microscopy of large polished sections, stages of the ORTHOLUX® II and ORTHOPLAN® outfits can also be used on the SM-LUX-POL.

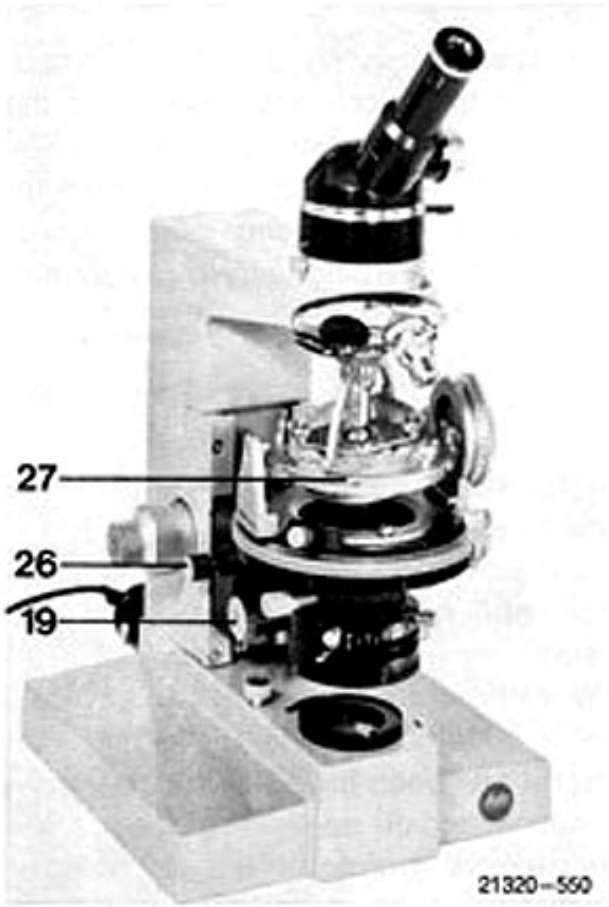



Fig. 2a SM-LUX-POL with universal rotating stage
**19** Coarse adjustment
**26** Clamping screw for stage change
**27** Universal rotating stage

# 5 Objectives and eyepieces

**Objectives**

The objectives in strainfree mounts for polarized-light microscopy have the additional letter P engraved. To remain strainfree, they must be protected against violent shocks and temperature fluctuations.

The strainfree achromats are used for orthoscopy. For conoscopy the Fl 63/0.85 P objective is recommended. Only in very special cases (e.g. with very small granules or large axial angles) the P Oil 100/1.30 objective in combination with the condenser top No. 004 Oil 1.30 P is used for conoscopy.

The table below contains the technical data of the objective.

**Strainfree achromats for transmitted light** (further objectives on request)

| Designation of the objectives Reproduction scale/aperture | | Free working distance (mm) | Coverglass correction * | Adjustment length (mm) |
|---|---|---|---|---|
| Achromats | 4/0.12 P | 24.08 | DO | 45 |
| | 10/0.25 P | 7.6 | DO | 45 |
| | 40/0.65 P | 0.28 | D | 45 |
| | Fl 63/0.85 P | 0.15 | D | 45 |
| | Oil 100/1.30 P | 0.11 | D | 45 |

**Strainfree plan-achromats for incident light** (further objectives on request)

| Designation of the objectives Reproduction scale/aperture | | | Free working distance (mm) | Coverglass correction * | Adjustment length (mm) |
|---|---|---|---|---|---|
| Plan-achromats NPI | NPI | 5x/0.09 P | 12.5 | DO | 40 |
| | NPI | 10x/0.20 P | 14.2 | DO | 40 |
| | NPI | 20x/0.40 P | 0.86 | DO | 30 |
| | NPI | 50x/0.85 P | 0.38 | O | 30 |
| | NPI Oil | 125x/1.30 P | 0.28 | O | 30 |

* D: to be used with coverglass d = 0.17mm (maintain coverglass thickness to within ± 0.05mm)
O: to be used without coverglass, DO: to be used with or without coverglass

Strainfree plan-achromats NPI are free from curvature of field across the entire field of view and therefore eminently suitable for photomicrography.

**Eyepieces**

In connection with almost all objectives and for the majority of applications GF 10x PERIPLAN widefield eyepieces are used. A pair of eyepieces serves for binocular observation, with only the right-hand eyepiece equipped with crossline graticule and focusing eyelens. For monocular observation only the eyepiece with crosslines is used.

The GF 10xM PERIPLAN® eyepiece with graticule 10mm = 100 intervals supplied is used for microscopic linear measurements after calibration by means of the stage micrometer supplied. Other special eyepieces with various graticules, e.g. for point counting methods, can be found in our sales literature.

# 6 Polarizing tubes

The following four tubes can be used on the SM-LUX-POL microscope:

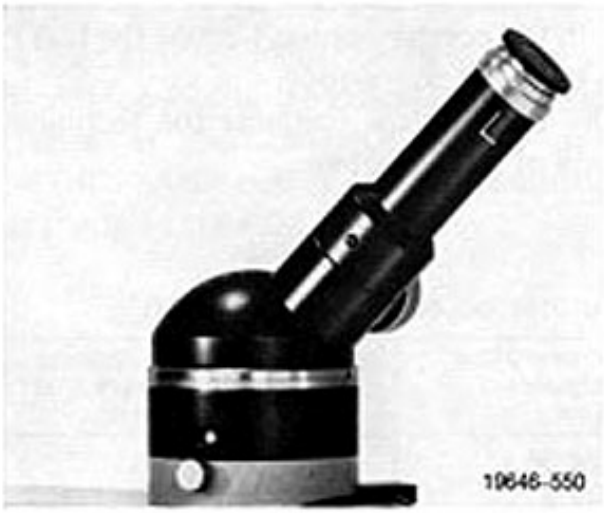



Fig. 3 Inclined monocular pol tube P 12
Standard equipment for monocular observation, fitted with disengageable Bertrand lens. Disengageable pinhole stop for conoscopy of small grains.


Fig. 4 Straight pol tube O 15
With disengageable Bertrand lens. Disengageable pinhole stop for conoscopy of small grains. Application: Wright eyepiece and micro-attachment for the LEICA®.

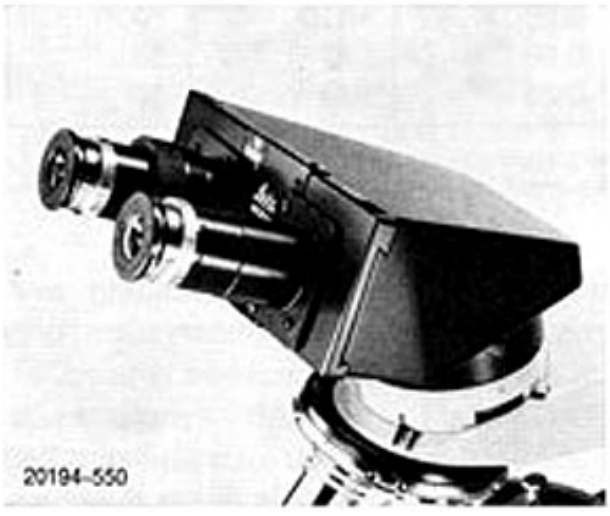



Fig. 5 Inclined binocular pol tube S 20
For orthoscopic observation. Conoscopy possible only with the pinhole stop, which is inserted in the eyepiece tube instead of the eyepiece.


Fig. 6 Binocular phototube FSA 52
As binocular pol tube S, but with additional straight tube for photomicrography and for the use of the Wright eyepiece.

# 7 Adjustment

**Mounting the tubes:**

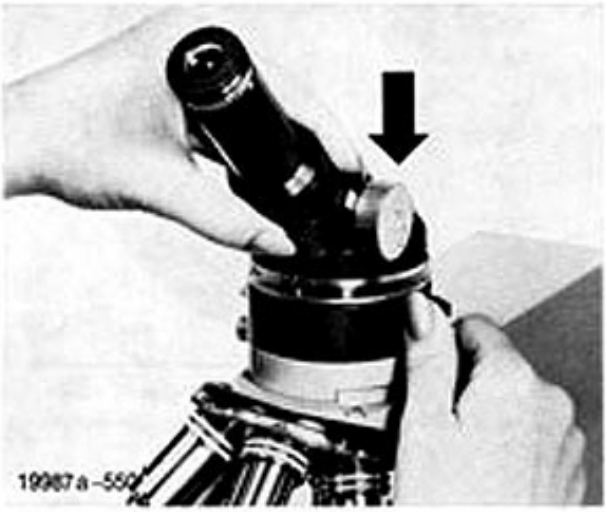



Fig. 7 Mounting the tube

Push the tube lock back. Carefully lower the tube onto the stand, so that the locating pin on top of the stand engages in the groove of the tube provided for it. Release the tube lock and slightly tighten it.

**Condenser and image-forming optical system**

Place the object on the object stage and clamp it in position.

Swing the hinged lens of the condenser into the beam and fully raise the condenser.

Choose an objective of medium power – preferably 10/0.25 P – for observation.

Open the aperture- (1.13) and the field (1.16) diaphragm. Swing the illuminating lens (1.15) into the beam.

When a binocular tube is used set the interpupillary distance with both hands (by pulling or pushing) until the two part-images in the microscope coincide (only one circular image is seen).

Look through the right-hand eyepiece with the right eye. Adjust the eyelens until the crosslines appear sharp, then focus the microscopic image with the coarse and fine adjustment. Now look at the same portion of the specimen with the left eye and rotate the left-hand eyepiece tube until a sharp image is produced of the same portion of the object; here the fine adjustment must not be operated.

Half close the field diaphragm and focus the image of the diaphragm now visible in the microscope by means of the vertical adjustment of the condenser. Move the image of the diaphragm into the centre of the field of view by rotating the two centring screws (1.12). Now open the field diaphragm far enough so that its image just disappears beyond the edge of the field of view (Fig. 9).

Close the aperture diaphragm (1.13) so that it transmits only two thirds of the objective aperture. This setting must be checked as follows:

Remove one eyepiece from the tube,

and look down the eyepiece tube. When the diaphragm is opened and closed, a bright circular area will be seen in the eyepiece which changes its size corresponding to the diameter of the diaphragm (cf. Fig. 8).

The following rules must be generally observed for the use of the diaphragms. The field diaphragm protects the specimen from unnecessary heat and prevents flare. It is therefore opened only far enough to transmit the field of view of the microscope. The aperture diaphragm – as long as it is smaller than the diaphragm of the objective – determines the resolving power and contrast of the microscopic image. With specimens of normal contrast range the aperture diaphragm is closed so that it transmits only $^2/_3$ of the objective aperture. When it is closed further the resolving power of the objective and therefore the performance of the microscope quickly fall off. With specimens of low contrast range the following procedure should be adopted:

Remove the eyepiece and open the aperture diaphragm so that it is just visible in the rear lens of the objective. The apertures of the condenser and of the objective are now identical. If all the details of the object are sufficiently clearly reproduced in the microscopic image the diaphragm of the condenser is gradually closed until the less contrasty structural elements too, become more prominent.

The aperture diaphragm does not serve for the regulation of image brightness; this should be regulated only by means of the transformer setting, or, with colour photography, by the insertion of neutral density filters (grey filters).

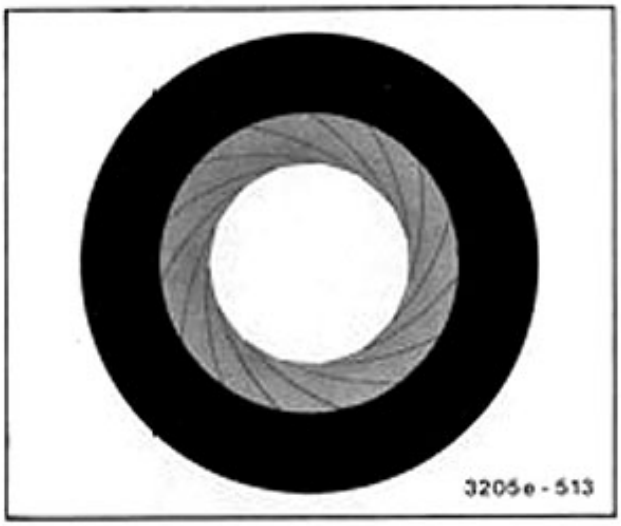



Fig. 8 Image of the aperture diaphragm
It is visible in the tube after removal of the eyepiece.

**Adjusting the index lines for the polarizer on the 702 fi condenser**

Carry out instructions according to paragraph "Crossing of Polarizer and Analyser".

The index lines on the front of the condenser should be accurately aligned. To achieve this, push the adjustment key onto the adjustment screw (8a, 28) on the back of the condenser from the left and rotate it until the two index lines are no longer displaced against each other (8a, 29).

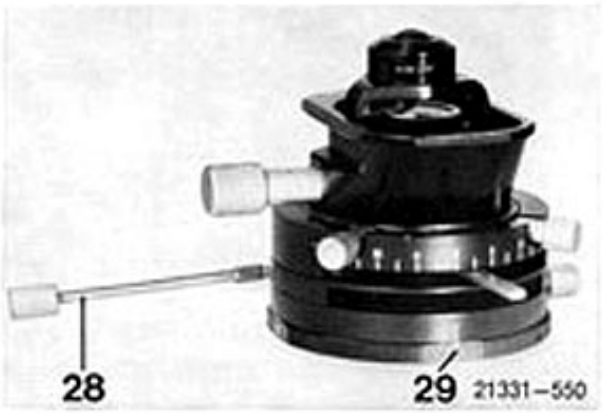



Fig. 8a Condenser 702 fi
**28** Adjustment key
**29** Index lines

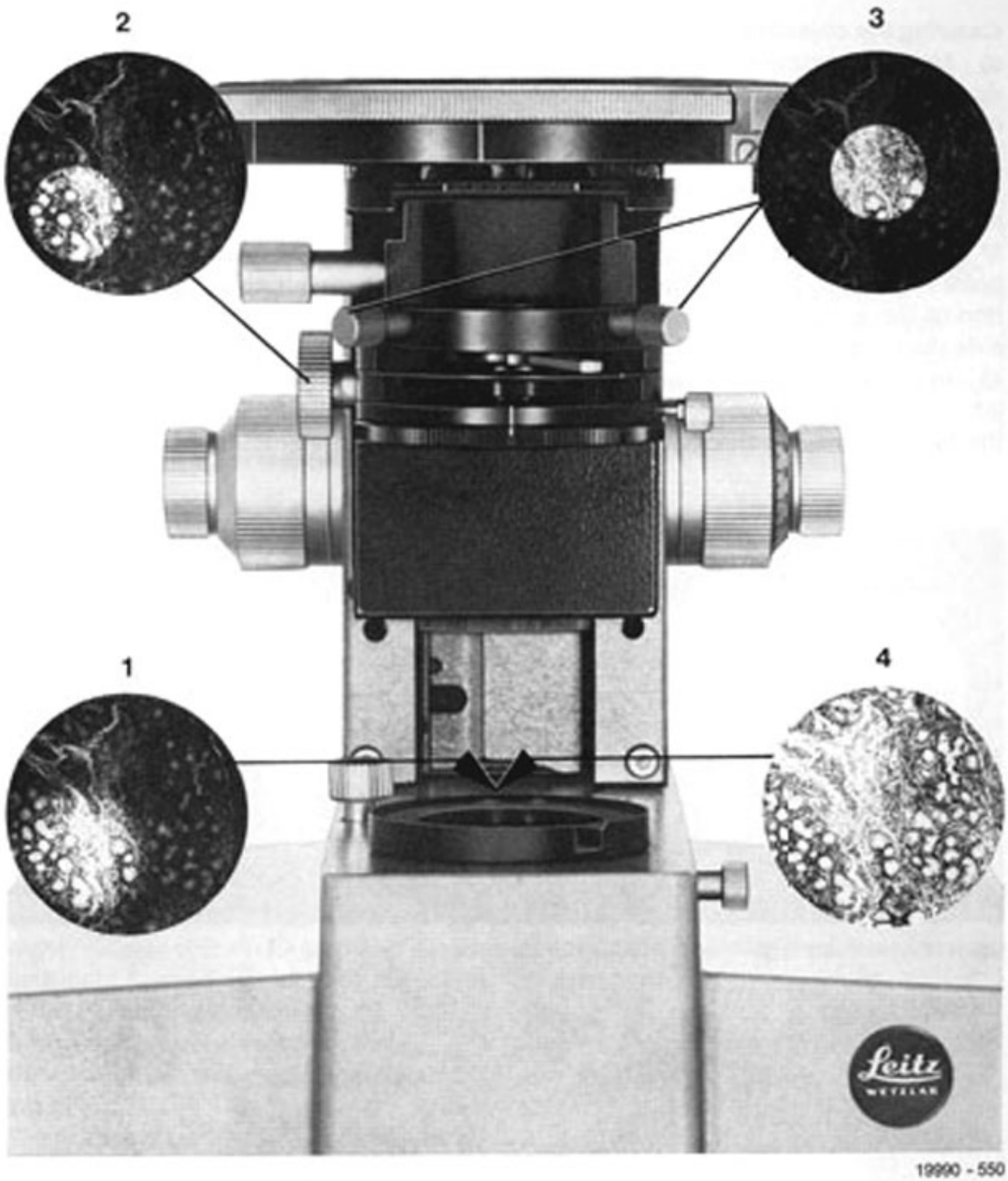



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Fig. 9 Centring the field diaphragm

**1** Half close the field diaphragm.
**2** By vertical adjustment of the condenser focus the image of the field diaphragm visible in the microscope.
**3** Move the image of the field diaphragm into the centre of the field of view by means of the two centring screws.
**4** Open the field diaphragm just far enough for the edge of the diaphragm to move beyond the field of view.

**Centring the objective**

**a)** Move a prominent portion of the specimen into the centre of the crosslines M.

**b)** Rotate the object stage until the portion of the specimen is furthest removed from the centre of the crosslines M (position A). In extreme cases the point A (maximum deflection of the portion of the specimen) may even be outside the field of view.

**c)** Insert both centring keys (Fig. 11) into the bushes above the objective in the beam. Move the microscopic image by turning the centring keys so that the portion of the specimen is precisely halfway (position B) between the crosslines M and the furthest position A.

**d)** Move the specimen by hand or with the aid of the attachable mechanical stage until the prominent portion is in the centre of the crosslines (M).

Rotate the object stage and check whether the axis of rotation of the object stage coincides with the centre of the crosslines in the eyepiece. Repeat the centring procedure if coincidence is not yet precise.

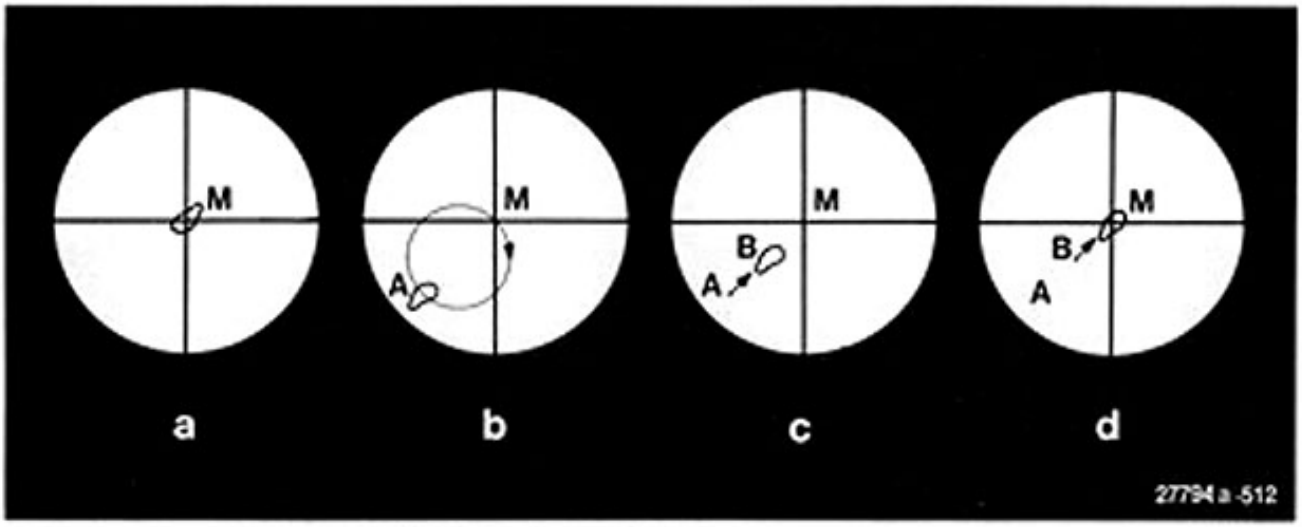



Fig. 10 Diagrammatic representation: Centring an objective


Fig. 11 Centring the objectives

The following table provides information about the use of the condenser No. 702 f:

| Object ve aperture: | Condensor top: | Vertical setting of the condenser: |
|---|---|---|
| Larger than 0.25 | Remains swung in | Approximately in topmost position. A sharp image must be formed of the field diaphragm. |
| Smaller than 0.25 | Swung out | With visual work approximately in top-most position; no image need be formed of the field diaphragm. With photomicrography lower the condenser until a sharp image is formed of the field diaphragm. |

**Crossing the polarizer and analyser**

Move an empty portion of the specimen into the optical path or remove the specimen from the optical path.
Set lamp at maximum brightness.
Move condenser (1.11) into topmost position.
Open the aperture diaphragm (1.13).
Swing analyser (1.5) into the beam.
Swing Bertrand lens (1.4) into the beam.
Move the pinhole stop (1.3) out.
Rotate the polarizer until maximum extinction is obtained in the eyepiece. (If higher-power objectives are used a symmetrical, blurred cross will be seen when the setting is correct.)
Swing out Bertrand lens.
Set concenser and diaphragms according to Fig. 9.
The microscope is now ready for orthoscopic observation.

**Adjustment of the 6v 15W light source:**

Normally this illuminator has a lamp which is centred as follows:
Place the centring disc on the dust glass in the foot of the stand (1.17).
Release knurled screw (1.21).
Vertically adjust the lamp mount:
When the setting is correct, the illumination of the setting disc will change concentrically. Failing this, adjust the centring screws (1.22) so that the luminous patch is in the centre of the centring disc.
Remove the centring disc from the foot of the stand.
Check the microscopic image for even illumination; if necessary repeat centration.
(Ensure that the illuminating lens (1.15) is swung into the beam. It must be swung out only when the Pl 1/0.04 P objective is used.)
On request a lamp with precentred mount is supplied, so that centration is no longer necessary.

# 8 Investigation of birefringent objects in the orthoscopic beam

Orthoscopy is the normal observation of the enlarged object image in a polarizing microscope. Conoscopy or observation in the divergent or convergent beam is used for the investigation of the interference figure produced in the rear focal plane of the objective. As a rule this interference figure is viewed by means of the Bertrand lens swung into the beam and the ordinary eyepiece. The Bertrand lens here takes over the function of an objective and together with the eyepiece forms a microscope which permits the observation of the magnified interference figure (Fig. 18).

Birefringent objects (except sections vertical to an optical axis) appear dark, when the object stage is rotated, after 90° intervals (= normal position) and bright or coloured respectively in the intermediate regions (= diagonal position).

Isotropic objects (in addition, empty spaces as well as birefringent objects cut vertically to an optical axis), on the other hand, show no intensity differences during rotation of the object stage.

The causes of the alternate extinction and appearance of the interference colours are:

Birefringent objects (except in the direction towards a crystallographic axis in which the object exhibits isotropy) split the light into two rays vibrating vertically to one another. In a fibre, for instance, one ray vibrates parallel, the second ray transversely to the longitudinal axis.

The dark position will occur when both rays vibrate parallel to the transmission directions of the polarizers.

Brightness (interference colour) occurs when both rays vibrate diagonally to the transmission direction of the polarizers.

Both rays have differential rates of propagation, i.e. two different refractive indices. Generally the higher refractive index is called $n\gamma'$, the lower $n\alpha'$. The magnitude of these refractive indices changes with the transmission direction in the specimen. In the direction of an optical axis both refractive indices are identical, in this direction the object appears isotropic. The maximum values of both refractive indices are called $n\gamma$ and $n\alpha$, and the corresponding birefringence will then be:

$$\Delta n = n\gamma - n\alpha$$

The spatial distribution of the refractive indices and of the vibration directions is represented in a three-dimensional model, the so-called indicatrix. Details can be obtained from special guide books on polarized-light microscopy.

The differential rate of propagation of both rays causes a phase difference $\Gamma$, which depends both on the magnitude of the effective birefringence $\Delta n$ and on the thickness d of the object:

$$\Gamma = d \cdot \Delta n$$

Both rays, after passing through the analyser, interfere. Depending on the magnitude of the phase difference produced in the specimen, a specific interference or polarizing colour will appear, which can be obtained from the table on the facing page.

Interference colours are divided into orders. The unit chosen is the wave length 551nm, which corresponds approximately to the brightness maximum of the solar spectrum. Colours of the first order correspond to a phase difference from 0–551nm, colours of the second order from 551 to 1102nm etc. With some practice the magnitude of the phase difference can be estimated already on the basis of the interference colours.

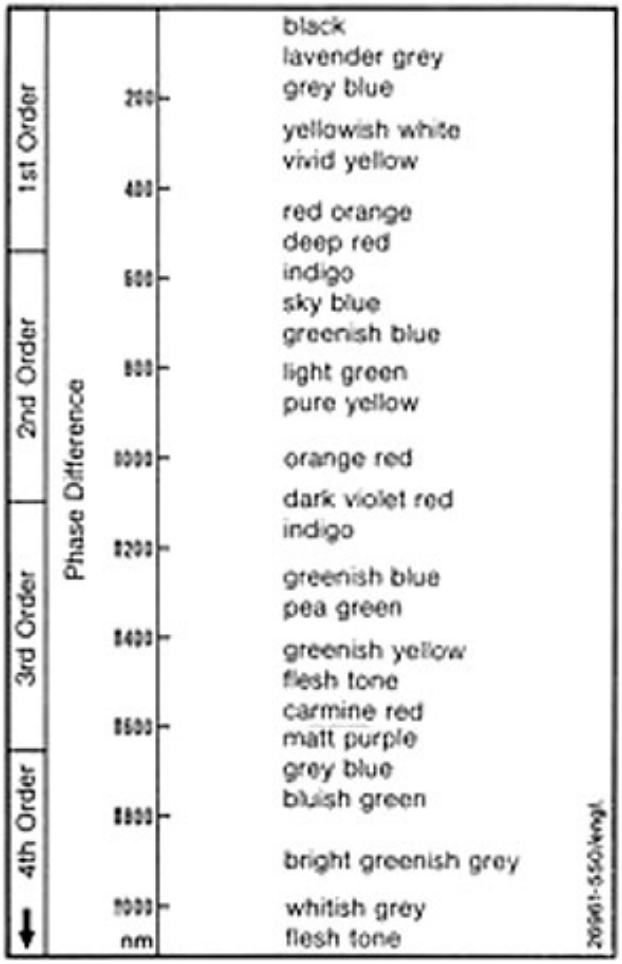



Fig. 12 Table of the interference colours of 1st to 4th order

With ascending orders the interference colours become increasingly pale and merge into the so called "higher-order white". Adjustable compensators – see p. 19) – serve for the accurate measurement of the phase differences. The sequence of the interference colours up to the fourth order can be observed through the adjustment of the quartz wedge (Fig. 14) or of the tilting compensator (Fig. 16). To do this, the quartz wedge or the tilting compensator is inserted in the tube slot (1.6). For observation the Bertrand lens (1.4) can also be inserted in the beam.

## The use of $\lambda/4$ and $\lambda$-plates

The vibration directions $\gamma'$ and $\alpha'$, which correspond to the rays of refractive indices $n\gamma'$ and $n\alpha'$, as well as the angles including these vibration directions with

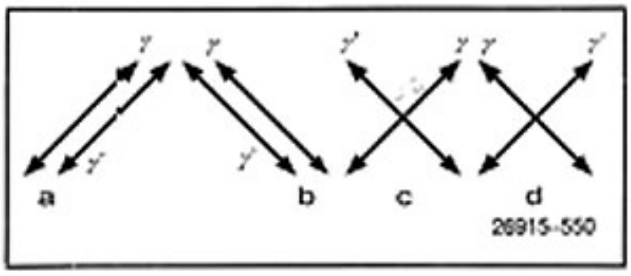



Fig. 13 a and b addition position
c and d subtraction position

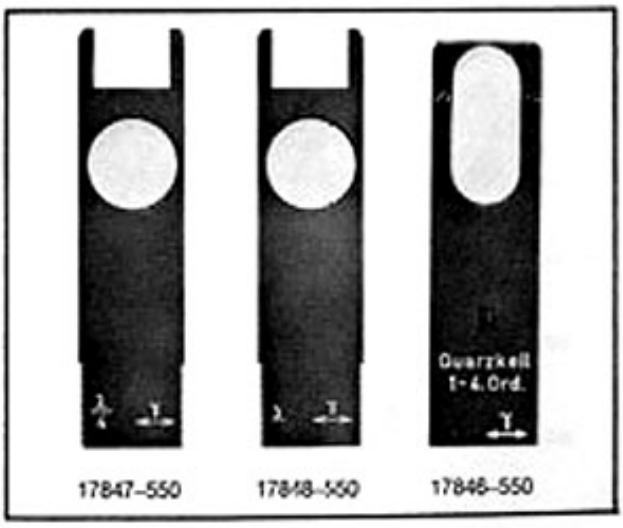



Fig. 14 Compensators and quartz wedge 1st to 4th order

fissures, crystal planes, etc., are frequently of interest. The vibration directions can be determined by the introduction of an auxiliary specimen (compensator) in one of the tube slots of the microscope. If the vibration directions of the specimen $n\gamma'$ and compensator $n\gamma$ corresponding to the higher refractive index are parallel to each other, the total phase difference in the microscope will be increased and a "higher" interference colour will be observed. If, however, the two vibration directions corresponding to the rays of the higher refractive indices are vertical to each other (Fig. 13) the phase difference will be decreased. The vibration direction $\gamma$ of the auxiliary compensator is engraved on the mount with an arrow (Fig. 14).

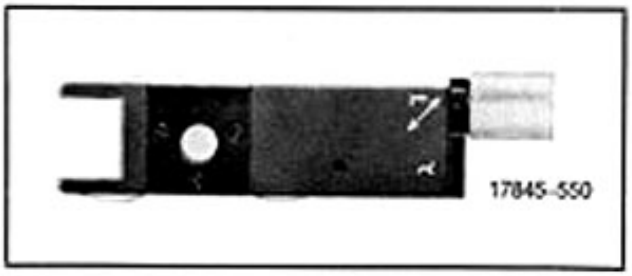



Fig. 15 Compensator with λ-plate in sub-parallel position

**Example 1:**
A specimen exhibits the interference colour first-order yellowish-white (see table). After introduction of the $\lambda/4$-plate (phase difference about 137nm) into the tube slot of the microscope the specimen exhibits the colour red-orange. The phase difference, as can be seen from the table, therefore has increased:
the vibration direction $\gamma'$ (specimen) is parallel tc the vibration direction $\gamma$ (compensator) Fig. 13a.

**Example 2:**
Interference colour of the specimen: grey-blue, with λ-plate sky blue.
The phase difference therefore has increased: $\gamma'$ (specimen) is parallel to $\gamma$ (compensator) Fig. 13a.

**Example 3:**
Interference colour of the specimen: vivid yellow;
With $\lambda/4$-plate: yellowish-white.
The phase difference has decreased:
$\gamma'$ (specimen) is vertical to $\gamma$ (compensator) Fig. 13.
In place of the two fixed compensators, the quartz wedge (Fig. 14) and the tilting compensator (Fig. 16) can be used for the determination. The choice of the compensator to be used depends on which compensator yields the definite results.

## Use of the λ-plate in sub-parallel position

This compensator serves for the identification of very weak birefringence ($\Gamma < 20$nm) and the determination of the vibration directions $\gamma'$ and $\alpha'$ in weakly birefringent specimens.

The vibration direction $\gamma$ of the rotating λ-plate is parallel to the transmission direction of the polarizer (East-West) when the two red dots face each other. After negligible rotation of this plate towards the right or left from the normal position, areas of the specimen of very small phase difference will be identified by a colour shift towards blue (addition) or yellow (subtraction). Since the orientation of the λ-plate is known because of the subsequent rotation (WSW-ENE and WNW-ESE), the vibration direction $\gamma$ in weakly birefringent samples can be determined as with the use of the λ- and λ/4-plate (Fig. 13).


**References:**

LAVES, F., und Th. Ernst: Die Sichtbarmachung des Charakters äußerst schwacher Doppelbrechungseffekte.
Naturwiss. **31**, 68-69, 1943.

SCHMIDT, W. J.: Diagonale und subparallele Gipsplatte Rot I und verwandte Hilfsmittel in der histologischen Polarisationsmikroskopie.
Leitz-Mitteilungen Wiss. Techn. **III** (6), 234-243, 1967.


## Quantitative determination of phase differences through the use of compensators

Adjustable compensators serve for the exact measurement of phase differences. When the thickness of the specimen d is known the birefringence Δn can be calculated according to the following formula:

$\Gamma = d \cdot \Delta n'$ [nm]

For the measurement the compensator is introduced into the tube slot and adjusted until maximum extinction is obtained on the area of the specimen to be measured. For this purpose the specimen must be brought into a certain diagonal position. Details can be obtained from the directions for the use of the compensators.

The following compensators are available:

## Elliptical compensator according to Brace-Köhler

The compensator is supplied with a choice of compensator plates of phase differences of λ/10, λ/20, λ/30. The maximum measuring range always corresponds to the phase difference of the built-in compensator plate. The measurement is carried out in white or in monochromatic light.

Main field of application:

Specimens of very small phase differences.

**Elliptical compensator according to Senarmont**

($\lambda/4$-plate in sub-parallel position).

The measurement is carried out in monochromatic light, version for 589nm (Na) or 546nm (Hg), requiring the use of a rotating analyser (Wright eyepiece). The setting accuracy is considerably improved through the use of a half-shadow device in the tube with intermediate image formation (Wright eyepiece). Normally this compensator serves for the measurement of phase differences of 1 order. Higher phase differences, can, of course, also be measured. But in this case the compensator will not yield the entire phase difference, but only the amount that exceeds a whole wave length or a multiple thereof. Whole wave lengths must be determined with a tilting compensator, quartz wedge, or by estimation of the interference colour. Accuracy is greater than with the tilting compensator only.

**Tilting compensator M, measuring range of up to 4 orders**

Compensator with $MgF_2$ plate for measurements in monochromatic or white light up to about 4 orders' phase difference. The phase difference can be read off a calibrating table supplied. Its values result from the sum of the two compensating angles obtained by tilting the compensator plate in both directions.

**Tilting compensator K, measuring range of up to 10 and up to 30 orders**

For the measurement of phase differences in white or monochromatic light up to the maximum phase difference stated. The compensator plate consists of calcite; evaluation by simple calculation by means of the tables supplied and the calibrating constants indicated.

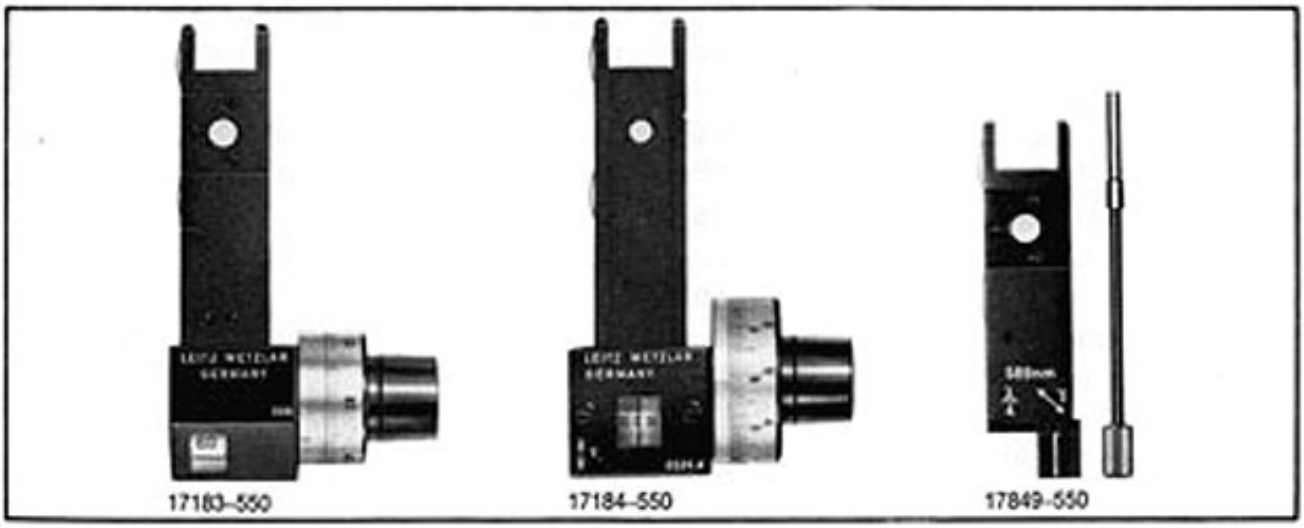



Fig. 16 Compensator according to Brace-Köhler, tilting compensator, compensator with $\lambda/4$-plate in sub-parallel position

# 9 Microscopic measurement

Linear measurements of microscopic specimens are carried out in conjunction with a micrometer eyepiece (graduation usually 10mm = 100 intervals). Before measurement is begun the micrometer value of the objective used must be known. The micrometer value is the distance in the object plane of which the objective forms an image coinciding precisely with 1 interval of the graticule graduation in the micrometer eyepiece. Since the optical constants of the objectives are subject to slight deviations, the user is recommended to determine the micrometer values with the aid of a stage micrometer himself.


Fig. 17 Division of the graticule in the eyepiece and image of the stage micrometer

Example
Determination of the micrometer value with the aid of a stage micrometer 2mm = 200 intervals and a micrometer eyepiece with graticule 10mm = 100 intervals.
Make the zero lines of micrometer eyepiece and stage micrometer coincide in the microscope. The micrometer value is read off at this setting at the end of the graduation of the micrometer eyepiece (Fig. 17).
If 1.220mm of the stage micrometer coincide with 100 intervals of the micrometer eyepiece, the micrometer value = 1.220 : 100 = 0.01220mm = 12.20µm.
With low-power objectives, which do not form an image of the graduation of the stage micrometer across the entire graduation of the micrometer eyepiece, only 10 intervals of the micrometer eyepiece are compared. If, then, 0.36mm of the stage micrometer coincide with 10 intervals of the micrometer eyepiece, the micrometer value = 0.36 : 10 = 0.036mm = 36µm. The screw micrometer eyepiece is used for highly accurate measurements in the microscope. List 513-17 contains detailed relevant information.

# 10 Investigation of birefringent objects in the conoscopic beam

The optical axes of crystals are demonstrated and the optical character (positive or negative birefringence) determined in the conoscopic beam. The sample is transilluminated in directions which are as different as possible, i.e. at large condenser aperture, and the interference figure produced in the rear focal plane of the objective is observed with the Bertrand lens in the optical path*. If the sample is cut in a suitable plane, the shape of the interference figure can indicate whether the crystal is uniaxial or biaxial (Fig. 18). The additional use of fixed and variable compensators also allows the determination of the optical character on the basis of the displacement of the interference fringes in the various quadrants and sectors of the interference figure. Details of the determination can be obtained from guide books of polarized-light microscopy.

**Operation of the microscope for conoscopy**

Look for a sample of suitable cutting direction in the parallel beam, if necessary with a low-to-medium-power objective.

Turn an objective of the highest possible aperture into the beam, e.g. 63/0.85 or Oil 100/1.30 objective (if oil immersion objectives are used the condenser top No. 004 Oil 1.33 P must be turned in).

Turn the condenser top and the Bertrand lens* into the beam.

As a rule the interference figure can be observed already now.

Only with small granules is it necessary to mask the field of view by means of stopping down the field diaphragm (1.60) and turning the pinhole stop into the tube (1.3).

* With tubes without Bertrand lens the interference figures will become visible after removal of the eyepiece. The image will be improved after the pinhole stop 563 031 has been mounted.

## Determination of the optical character

### Uniaxial crystals:

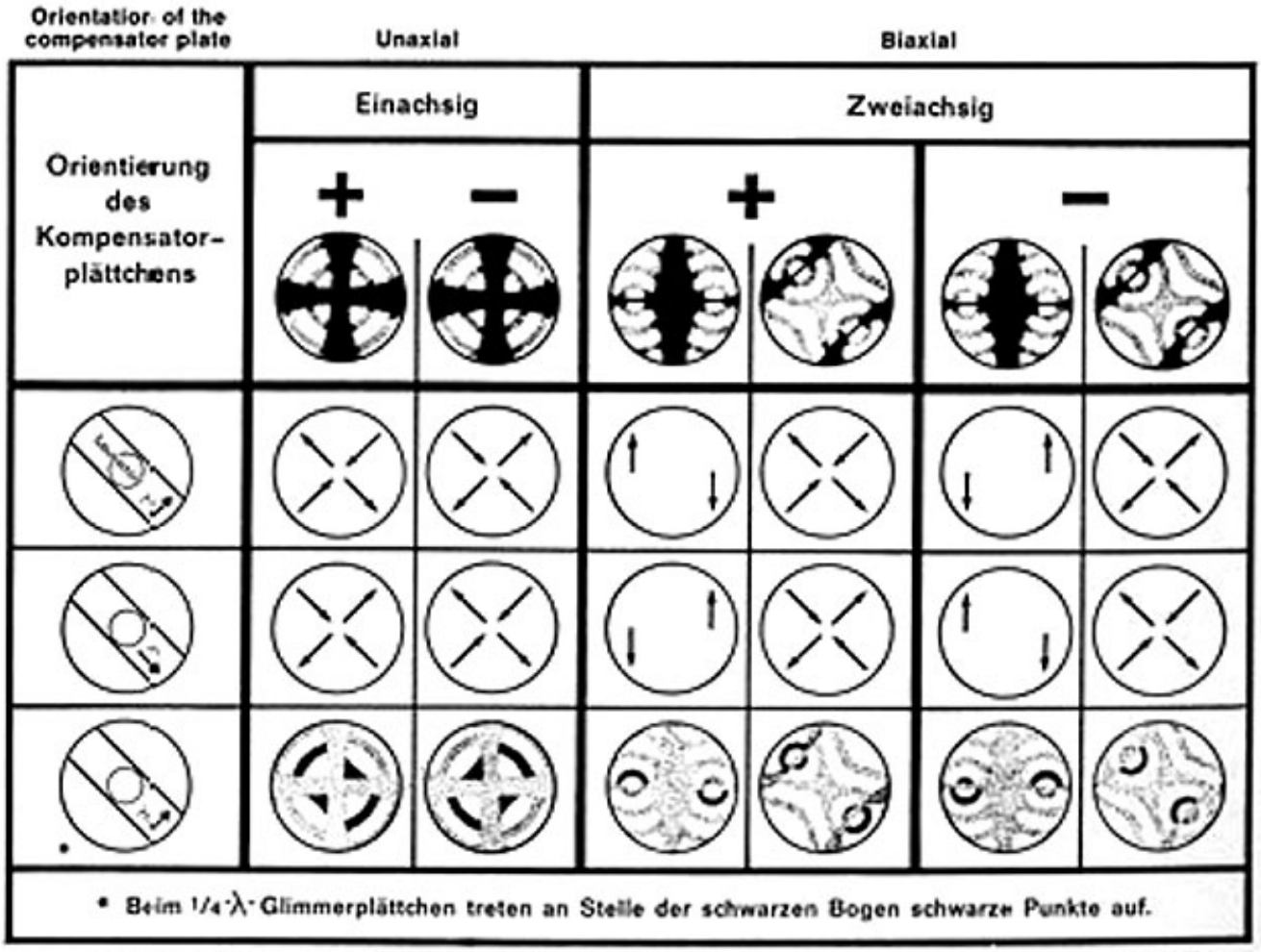
For the determination of the optical character cutting planes are particularly suitable in which the optical axes of the crystal and of the microscope are parallel to each other. In the orthoscopic beam samples orientated in this way show no or only small phase differences when the object stage is rotated. Uniaxial crystals when viewed in the conoscopic (divergent) beam exhibit a dark cross, whose point of intersection indicates the location of the optical axis. The cross is surrounded by coloured interference fringes. When a variable compensator (quartz wedge or tilting compensator) is operated, the rings in two diametrically opposed quadrants of the cross move towards the centre and the periphery respectively. The optical character is determinec from the movement direction of the rings according to the following rule (Fig. 18):

Uniaxially positive crystals

The movement direction of the fringes from the intersection of the cross towards the periphery is vertical to the engraved $\gamma$-direction on the compensator.

Uniaxially negative crystals

The movement direction of the fringes from the intersection of the cross towards the periphery is parallel to the $\gamma$-direction of the compensator.




* With the ¼-λ-mica plate black dots replace the black arcs.

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Fig. 18 Table for the determination of the optical character

For the determination of the optical character cutting planes are also suitable in which the optical axis of the crystal is slightly inclined to the observation direction. The optical character can usually be determined even when the intersection of the cross is outside the field of view. Fig. 18 shows that for the determination of the optical character fixed compensators can be used in place of variable ones.

**Biaxial crystals**

For the determination of the optical character particularly those cutting planes are suitable in which the angle bisector of the two optical axes is roughly parallel to the viewing direction (section vertical to the acute bisectrix). In the divergent beam a dark cross will be seen which, when the object stage is rotated, opens out into two legs of a hyperbola, the so-called isogyres. The cross and the legs of the hyperbola respectively are surrounded by coloured interference fringes. The optical character can be determined from the displacement direction of these fringes after the compensator has been operated according to Fig. 18 or to the rule below. The plane of symmetry of the isogyres (= axial plane) must now be vertical to the $\gamma$-direction of the compensator.

Biaxially positive crystals

When the compensator is operated, the interference fringes move from the convex to the concave side of the isogyres.

Biaxially negative crystals

The interference fringes move from the concave to the convex side.

Usually the optical character can be determined even when only one of the optical axes is located in the viewing direction of the observer. In the parallel beam the brightness of samples orientated in this way changes little if at all. In the divergent beam, only one of the two isogyres becomes visible.

# 11 Further accessories for polarized-light microscopy

### Circular polarization

Birefringent samples show the extinction effect (normal position) described on p. 14 when they are rotated. Especially with low-power observation, some of a large number of birefringent objects in the field of view will always be in the extinction position. For simultaneous observation of all objects in their interference colours (diagonal position) circular polarization is used:

For this purpose the λ/4-plate is introduced into the tube, and an additional λ/4-plate (Code No. 513 090) in the crossed position into the appropriate slot in the condenser (Fig. 19).

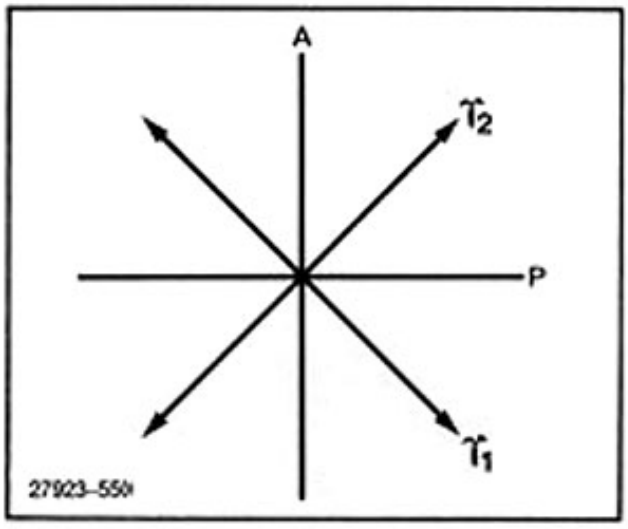


Fig. 19
P = Polarizer
A = Analyser
$\gamma_1$ = vibration direction of the lower λ/4-plate
$\gamma_2$ = vibration direction of the upper λ/4-plate

**References:**
MEDENBACH, K.: Über die Untersuchung von größeren Objekten im linear- und zirkular-polarisierten Licht am ORTHOPLAN-POL.
LEITZ-Mitteilungen für Wissenschaft und Technik V (3-4), 81-84, 1970.

### SM-LUX-POL with Pol-interference contrast device R

The Pol-interference contrast device R consists of:
Illuminator, pol objectives and adapters with Wollaston prisms, polarizer, and analyser.
It is fitted in the same way as the incident-light device, p. 24.

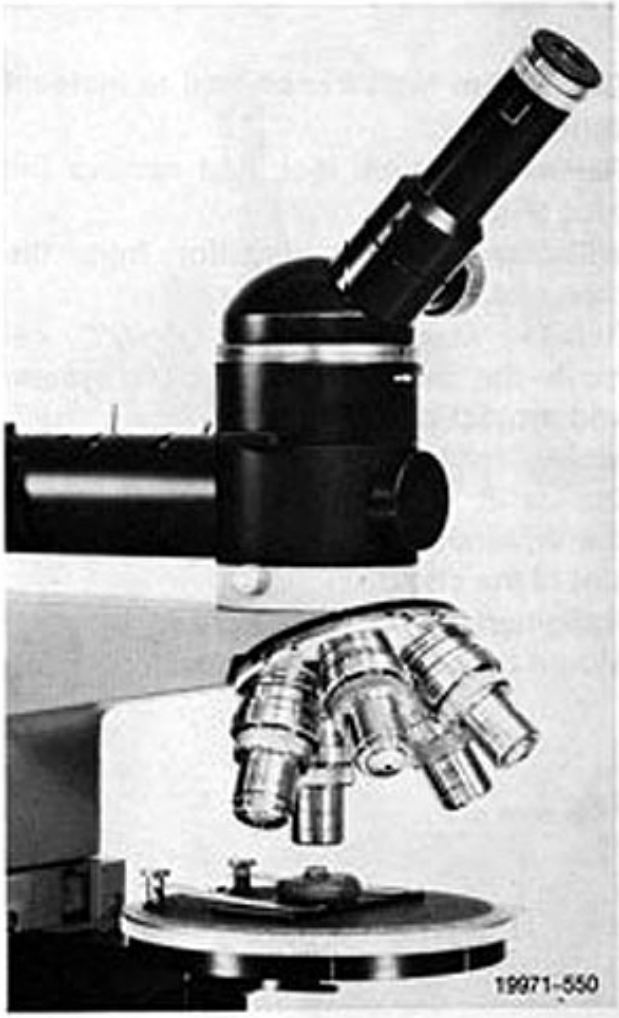


Fig. 20
Pol interference device R

Application: contrasty representation of the surface relief of samples viewed in incident light.

# 12 SM-LUX-POL with incident-light attachment

This incident-light device serves for the observation of polished sections in ordinary and in polarized incident light. Special incident-light objectives* with adapter rings are required. A hand press is necessary for the exact alignment of the surface of the sample (Fig. 23).

**Conversion from transmitted to incident light**

Release the tube lock and remove the tube (Fig. 21).
Withdraw the compensator from the tube slot.
Release clamping screw (Fig. 22), remove the intermediate optical system and protect it from dust.
Mount the incident-light attachment on the stand, ensure that the guide pin on the underside of the device enters the slot of the stand.
Retighten the clamping screw.
Mount tube and lock it in position.

Unscrew the transmitted-light objectives and protect them from dust.
Screw the incident-light objectives (P = strainfree) into the centring revolving nosepiece together with the adapter rings supplied.
The NPI 5 x/0.09 objectives (as well as oil and methylene iodine) are adapted with the short adapter ring (6mm), all other objectives with the broad adapter ring. (Owing to the design of the 6mm adapter ring, it is necessary to refocus through about 1mm after the NPI 5 x/0.09 objective has been turned in or out of the optical path.)

**Adjustment**

1) Align the incident-light stage micrometer or surface-silvered glass plate by means of the hand press and plasticine on a microscope slide and place it on the object stage.
2) Adjust the eyelens of the eyepiece until the crosslines appear sharp to the relaxed eye.

* See table p. 9

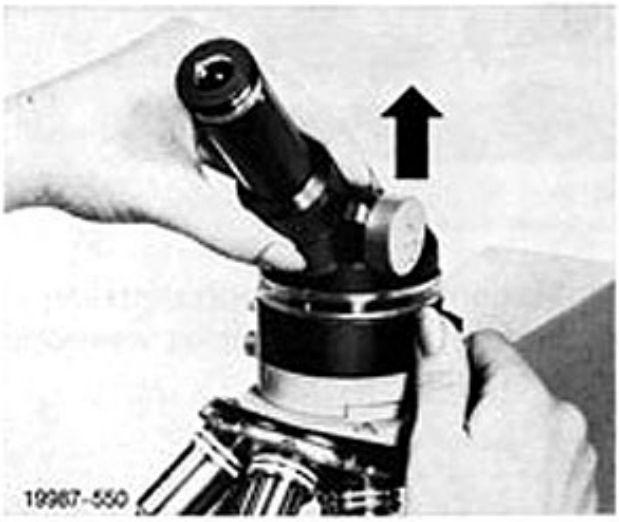


Fig. 21 Removal of the monocular pol tube


Fig. 22 Removal of the intermediate optical system

3) Swing the Bertrand lens (24.4) and pinhole stop (24.3) out of the beam.
4) Withdraw the analyser from the beam (see text Fig. 24).
5) Open the aperture and field diaphragms (24.24 and 23).
6) Centre the objective to the axis of rotation of the object stage by means of the centring keys (as for transmitted-light observation p. 11).
7) Adjust the light source for even illumination of the object field (if precentred filament lamps are used centration is not necessary). If necessary check illumination additionally with the Bertrand lens.
8) Cross the polarizers:
Insert the polarizer (24.25).
Rotate the analyser until maximum extinction occurs in the field of view.
(This adjustment cannot be carried out with samples exhibiting double reflection, a particularly precise crossed position of the polarizers is obtained if the setting is carried out with the aid of the Bertrand lens. In the crossed position a dark blurred cross will then be visible.)
Open the field diaphragm (24.23) up to the edge of the field of view, turn the desired objective in, set the aperture diaphragm depending on the desired contrast.


Fig. 23 Handpress for the alignment of objects

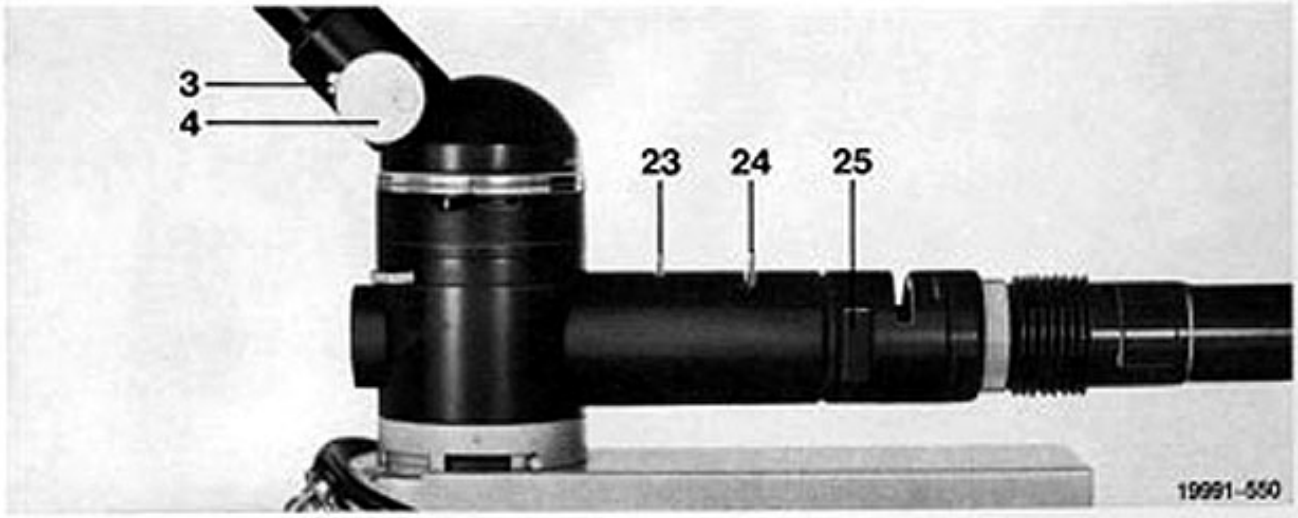


Fig. 24 Incident-light device for the SM-LUX-POL
3 Pinhole stop, 4 Bertrand lens, 23 Field diaphragm, 24 Aperture diaphragm, 25 Polarizer
Analyser not visible in Fig. 24 see Fig. 1.