ZEISS

STANDARD JUNIOR

Polarizing Microscope

CARL ZEISS

DESCRIPTION AND
INSTRUCTIONS FOR USE

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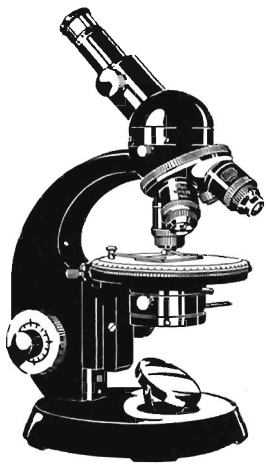
In oder to make proper use of the STANDARD JUNIOR Polarizing Microscope apart from the basic knowledge of microscopic technique it is important to observe these Instructions for Use. They convey a survey on the properties of the instrument, thus making possible its optimal utilization.



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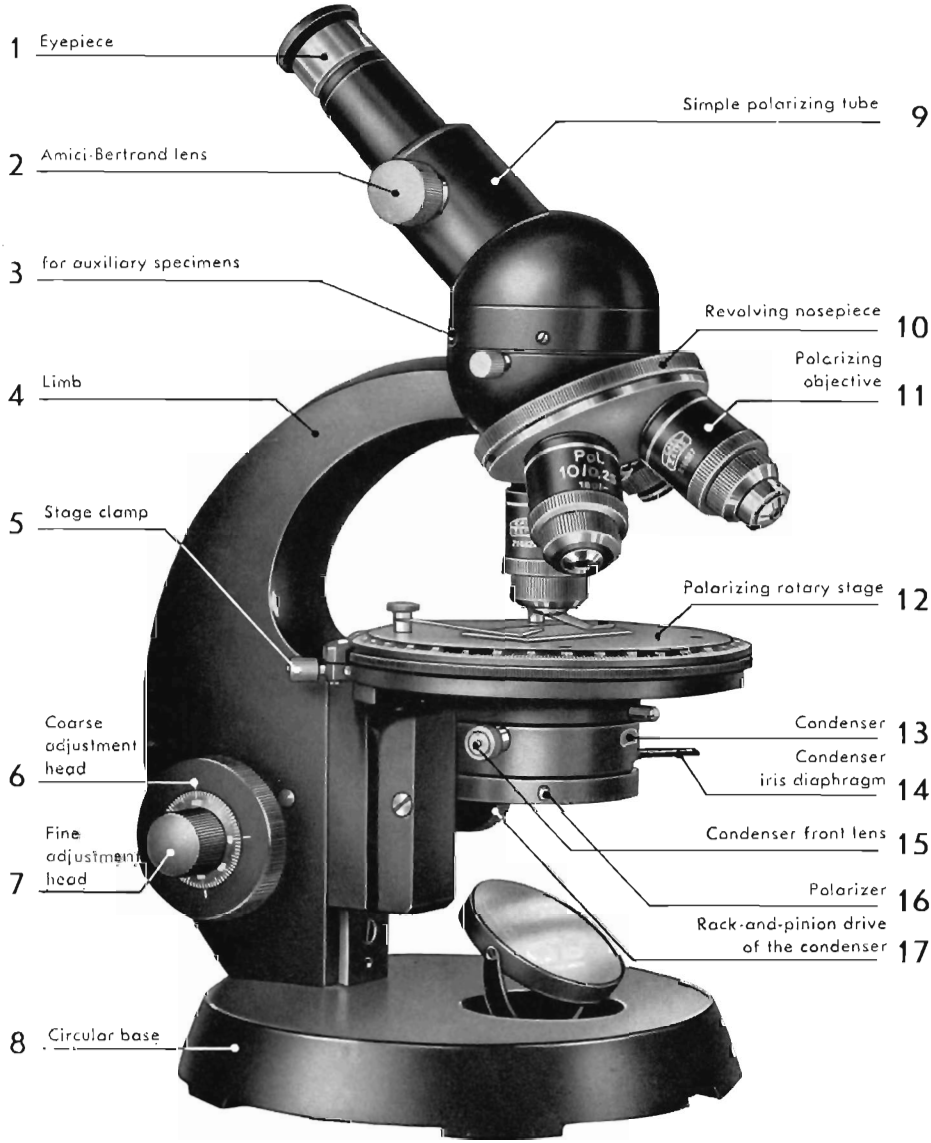

Fig. 1

STANDARD JUNIOR Polarizing Microscope KFT 134-255

1 Unpacking the Microscope

The stand is secured from below by a screw passing through the floor of the microscope case. It is unscrewed with the small screwdriver supplied, the case being slightly tilted.

2 Care and Treatment of the Microscope

The STANDARD JUNIOR Polarizing Microscope is a precision and measuring instrument and must be handled carefully and protected against dust. When not in use the microscope should be protected with a cover of plexiglass or foldable plastic cloth, if it is not kept in the microscope case supplied with it.

The optical parts of the microscope, above all, have to be treated carefully. The reflex-reducing coating on glass surfaces is to be treated like any optical component. Dust may be removed from the optical system with a brush freed from grease by washing in ether. The glass surfaces between polarizer and analyzer including the surface of the polarizer should freqently be freed from dust, because the field of view between crossed analyzer and polarizer is elucidated by stray light due to even smallest particles.

The reflecting layer of the microscope mirror is applied to its surface. Before cleaning the mirror, it is recommended to blow off the dust.

When not used, the instrument should never be without its tube and the latter never without eyepiece cover as protection against dust, or with compensator slots left open.

Finger prints and similar stains are best removed with a soft linen cloth which is free from dust and grease.

Hard jolts as well as considerable temperature fluctuations affect the strain-free "state" of the optical components.

If immersion oil has been used, it must be thoroughly removed from all optical and mechanical parts immediately after the work is completed. This is done with a linen cloth moistened with benzine or xylol. Instead of the linen cloth, also the rice paper which we supply, may be used. Alcohol must not be used. The transparent containers in which our objectives are supplied are sensitive to xylol and must not be brought into contact with it.

In the event of any unexpected difficulty which recourse to these Directions for Use cannot eliminate, please consult our competent agent or an experienced precision-instrument maker. Also, please do not attempt to grease or oil pinion mechanisms or sliding planes yourself. You will avoid unnecessary repair costs by leaving such work to the expert.

3 Microscope Stand (Fig. 1)

The two basic types of the Polarizing Microscope STANDARD JUNIOR, K with common pinion heads on either side for coarse and fine adjustment (7) are either equipped with a vertically adjustable (17) or with a fixed sliding sleeve to hold condensers with a mount of 39.5 mm ∅. The drive movement for the sharp focusing of the image operates the microscope stage. It has a vertical range of adjustment of 25 mm.

The graduation and index marks of the fine adjustment (7) at the right head of the drive KFT serve for measuring the thickness of the specimen. The turning of the head by one interval corresponds to a vertical movement of the specimen by 5 μ. For exact measurements it is recommended to calibrate the fine-adjustment graduation with the help of test specimens of known thickness and to trace graphically potential deviations from the theoretical value.[1])

The rotary stage of the microscope (12), having a diameter of 126 mm, resting in a slide bearing, is centered in such a way that its center lies in the optical axis of the objective 2.5 Pol which cannot be centered. At two verniers the angle of rotation may be read off with a precision of up to 0.1 °.

A uniform centering rotation of the microscope stage is guaranteed, if it is moved with both hands at the same time. By slightly tightening the milled screw (5) the stage may be clamped in position.

Various tubes at the STANDARD JUNIOR Polarizing Microscope are interchangeable with the quick-change device.

[1]) For instance see Rosenbusch: "Mikroskopische Physiographie der petrographisch wichtigen Mineralien", vol. I, 1st half, 5th edition, by E. A. Wülfing, Stuttgart 1921-24, p. 436-442.

Instead of the fixed revolving nosepiece (10) the microscope may be equipped with a carriage revolving nosepiece. To position it, the clamping screw at the revolving nosepiece is unscrewed and the slide in which this clamping screw rests is placed for about $^2/_3$ in its longitudinal direction in the track of the tube carrier. Then the other slide of the revolving nosepiece is swung upward, the revolving nosepiece is moved in both tracks towards the limb (4) up to the stop, and then clamped in position.

4 Condenser (13)

The STANDARD JUNIOR Polarizing Microscope is equipped with a condenser of the numerical aperture 0.9 or 1.3. Its designation engraved in red refers to its strain-free optical system.

For observation with the oil immersion 100/1.30 Pol, the condenser 1.3 is indispensable for judging the conoscopic interference image. For this purpose the specimen is not only to be optically connected through oil immersion with the front lens of the objective, but also with the front lens of the condenser. The oil must not have any bubbles.

For regulating the illumination aperture the condenser contains an iris diaphragm (14). In order to produce the necessary contrast in the specimen this **aperture diaphragm** has to be stopped down by $^1/_2$ or $^1/_3$. Its image may be observed after removing the eyepiece from the tube, or with the eyepiece and the engaged Amici-Bertrand lens.

If a relatively small convergence of the illuminating beams is desired, such as for the determination of the direction of extinction of anisotropic crystals, or with the observation of the Becke line etc., contrary to this rule the aperture diaphragm has to be closed to a pinhole. Moreover, it is quite useful to lower the condenser in such cases. If the attachable illuminator is used, the polarizer must not contact it.

With objectives of low magnification the opening of the condenser front lens is not large enough to illuminate the entire field of view. In this case the condenser front lens is to be swung out. This holds also,

if a microscope lamp is used whose opening is not as large as the field of view of the eyepiece employed, and if an eyepiece with higher magnification (giving a smaller field of view) is not available.

With swung-out front lens the condenser (aperture) diaphragm (14) is deprived of its function. It has to be opened completely. In this case the diaphragm of the microscope lamp operates as aperture diaphragm.

With attachable illuminator not having a collector diaphragm, the variation of the illumination aperture can only be effected by vertical movement of the condenser. If in this case the condenser diaphragm is adjusted, a fading away of brightness towards the edges of the image will be the result. Conoscopic observation is made only with engaged front lens, while the aperture diaphragm is completely opened.

For inserting the condenser it is recommended to bring the condenser carrier with its drive head (17) into its highest position. When inserting it from below up to its stop, care should be taken that the guide pin on the cylindrical mount of the condenser glides in the groove of the sliding sleeve. The milled head (15) for swinging out the front lens is then on the right hand side. This is important for the adjustment of the polarizer (16).

5 Polarizer (16)

For both the polarizer and the analyzer specially selected polarizing filters are used. These filters have various advantages as against the calcspar prisms formerly employed.[2])

The polarizer is fitted in a swing-out carrier (16) beneath the condenser. Its direction of vibration runs parallel to the horizontal hairline of the cross-hairs in the eyepiece.

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[1]) e. g. Schumann und Piller, Neues Jahrbuch der Mineralogie (1950, p. 1-16).

6 Objectives (11)

The objectives for measurements in polarized microscopy are equipped with special strain-free mounted lenses and partly with lenses produced from precision-cooled glass. They are labeled with the designation "Pol". Also engraved on their mounts are the component magnification and the aperture (e. g. 40/0.85) as well as the thickness of the cover glass for which they are designed (0.17 mm). Objectives with the designation "Oel" (all objectives with the numerical aperture higher than 1.0) have to be optically connected with the specimen by adding a drop of the immersion oil supplied. All objectives are par-focal so that after switching the revolving nosepiece (10) the image is still visible to such an extent that only a slight adjustment is necessary to attain perfect sharpness. The high-power systems with short working distance are resiliently mounted, thus guaranteing protection of the specimen. The suspension is so accurately designed that no centering errors will occur due to its resiliency.

Fig. 2. Centering of the objective of the lower milled knob

Fig. 3. Centering of the objective on the upper milled knob

As immersion liquid only the non-resinifying oil supplied by us should be used.

The objectives are **centered** in two steps:

1. **Marking of the Axis of Rotation of the Stage**

   This is noticeable by a surface element of the object turning around itself in that spot while others describe a circle which grows with increasing distance. Mark this point of rotation by placing a punctiform object particle in its place with the mechanical stage.

2. **Combining Axis of Rotation of the Stage with optical Axis of the Microscope**

   For this purpose actuate the centering device of the objectives as shown in

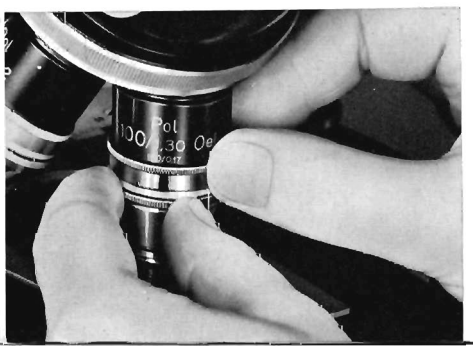


Fig. 4. Centering of the objective on both knobs simultaneously

fig. 2—4. The point marking the axis of rotation of the stage must be placed always closer to, and finally into the center of the cross hairs.

Changing the objectives is effected by turning the milled rim of the revolving nosepiece (10). Using the objectives for achieving this process would, of course, affect their accurate centering.

A rotation of the plane of polarization and depolarization of the light — particularly noticeable with high-power systems — occurs at the surfaces of the lenses. As a matter of fact, this phenomenon cannot be eliminated.[3]) Consequently, with crossed polarizer and analyzer there is always a slight elucidation of the field of view which intensifies with increasing aperture of the illuminating beams. Thus, conoscopic observation without specimen conveys the impression of an optically uniaxial, slightly positive double-refractive crystal, cut perpendicular to its optical axis.

7 Simple Polarizing Tube (9)

The analyzer is situated within the tube and, even if switched out of the path of rays by means of a lever, remains dust-proof. This is also true for the Amici-Bertrand lens. It is operated with the milled head (12). Due to its depth of focus conoscopic observation may be made with all objectives, the interference images always appearing equally sharp.

Fig. 5. Attaching the tube

[3]) F. E. Wright, The formation of interference figures. A study of the phenomena exhibited by transparent inactive crystal plates in convergent polarized light. Journ. Opt. Soc. Am. 7 (1923), 779-817.

When the microscope is not being used, the slot (3) for inserting the auxiliary specimens, as for instance quartz red of the first grade, should be closed with the metal cover plate. Rotating compensators may be inserted at any inclination of the compensator platelet. These have a marking of the γ-direction, i. e. of that direction in which the slower wave vibrates. $\lambda/4$-mica sheets have a marking of the direction β, i. e. the direction of vibration with the s m a l l e r speed propagation.

When attaching and taking off the tube, after unscrewing the clamping screw, a slight pressure has to be exerted against its spring bolt. The tube is attached by tilting it somewhat (Fig. 4) and then the spring bolt is pressed back with its dovetail ring. After being attached, the tube is turned until the spring bolt clickstops in one of the two grooves in the dovetail ring; then the clamping screw is tightened. For photography the monocular straight tube is attached to the microscope. This tube may be provided with an analyzer which is screwed in at its lower end.

8 Eyepiece (1)

The eyelens of the cross-hair or micrometer eyepieces may be focused to the graduation by turning it. Proper focusing can best be done by looking through the eyepiece taken out of the tube with relaxed, non-accomodated eye and turning the eyelens inwards until the cross-hairs or micrometer appear optimally sharp.

If the guide pin of the eyepiece rests in the middle groove of the tube, the lines in the eyepiece run parallel to the principal sections of the engaged polarizers. Their direction is diagonal to the planes of light vibration, if the pin rests in the grooves shifted by 45^0.

9 Illuminators

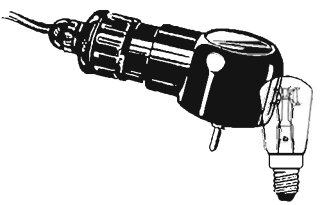
If daylight or an ordinary lamp is employed, the microscope mirror has to be adjusted in such a way that the exit aperture of the objective is fully and brightly illuminated. This is checked by looking through the tube with the eyepiece removed, or with eyepiece and engaged Bertrand lens.

The concave mirror of the microscope is used only in cases where together with the specimen disturbing contours, such as the window cross or similar things, are imaged.

Attachable Illuminators

These are inserted into the base of the microscope instead of the concave and plane mirror which may be rotated and swivelled in all directions.

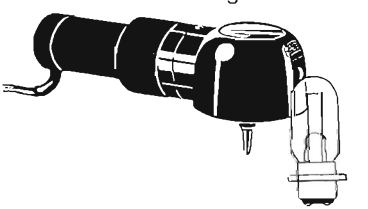
9.1 Attachable Simple Substage Illuminator for Direct Connection to the Power Supply



It contains a bulb of 15 W with a thread base diameter of 14 mm. Before connecting it, be sure that the voltage indicated on the bulb corresponds with that of the power supply.

For exchanging the bulb the lamp socket is taken out of its casing. Both parts are properly attached, if the small shoulder in the casing rests in the recess of the lamp socket.

9.2 Attachable Low-Voltage Substage Illuminator



It is equipped with a three-lens collector making best use of the light of the low-voltage bulb 6 V 15 W. To alternating current it is always connected via a transformer, to direct current via a resistance. The transformer may be adjusted for voltages of 110, 125, 150, or 220 V. For this purpose the bottom plate has to be removed. At four plug sockets 5, 6, or 8 V may be tapped at option. If the bulb is supplied with designed voltage of 6 V, the brightness is often too intense for many observations. Therefore, a charge of 5 V will be sufficient in most cases. The bulb may only be charged for a short time with the excessive voltage of 8 V, because this will considerably reduce the life of the bulb

A resilient cover, slipped onto the lamp, serves as additional protection against blinding.

Since the low-voltage substage illuminator is susceptible to shock while in use, it is advisable to avoid any rocking in this state.

The low-voltage bulb 6 V 15 W has the order No. 38 01 77. It is inserted into the socket — red dot opposite red line — with light pressure and then turned until it sits firmly in the socket.

If one of the two slip-in diaphragms with free diameter of 0.6 and 4.5 mm. is inserted into the slot at the illuminator, it will restrict the illumination aperture only if the front lens of the condenser is swung out.

9.3 Microscope Lamps attached to a special Stand

These lamps are equipped with a collector and a radiant field stop and permit proper illumination according to the Koehler Principle. The latter renders optimal illumination conditions, especially for photomicrographic purposes. This procedure asks for a microscope with a vertically adjustable condenser support.

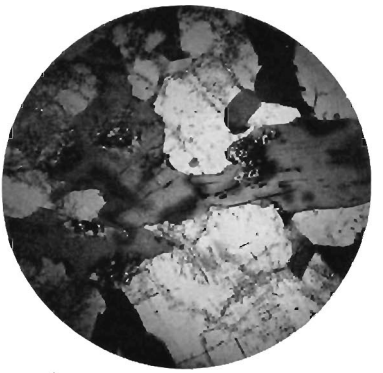


Fig. 6

Fig. 7

Adjusting the Illumination according to the Koehler Principle

-1. Set up the microscope lamp in front of the microscope so that its collector produces an image of the light source in the center of the plane mirror of the microscope.

-2. Sharply focus the microscope with objective 10 or 16 on the specimen.

-3. Stop down completely the radiant field stop of the microscope lamp (Fig. 6).

-4. With engaged front lens, adjust the condenser vertically at its head (17) so that the radiant field stop together with the specimen is sharply imaged (Fig. 7).

-5. Focus this diaphragm image in the center of the field of view by turning and swivelling of the microscope mirror (Fig. 8).

-6. Open the radiant field stop to such an extent that its image is just disappearing beyond the edge of the field of view (Fig. 9). Only when employing objectives with high magnification, this diaphragm is opened somewhat further.

Fig. 8

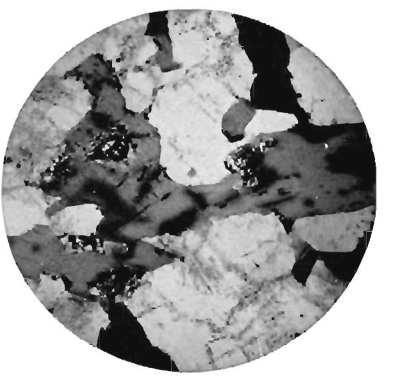


Fig. 9

10 Path of Rays in the Polarizing Microscope STANDARD JUNIOR

Fig. 10 and 11 on page 15 show the path of rays in the properly focused microscope. For the sake of convenience the optical systems are represented as simple lenses. For the same reason an eyepiece after Ramsden was chosen. With other eyepieces the field stop is situated between the lenses. Only the eye lens of these eyepieces has the effect of a magnifier.

Particular significance is attributed to the **diaphragms.** Besides the correction of the lens systems, a decisive factor in the quality of the microscopic images is the geometrical definition of the light beam; the significance of this fact is often underrated, especially by inexperienced microscopists.

We can distinguish between two types of beam-defining stops:

a) The first group, the *pupils,* comprises those which define the light source and its images. They function as aperture stops and determine the aperture angles of the optical systems. With the aperture the defining property of the system and the brightness of the image is increased. At the same time depth of focus is decreasing.

   The aperture of the condenser has to be in a certain relation to that of the objective. The opening of the aperture iris diaphragm at the condenser has to be adjusted to the requirements of the specimen. On no account should the brightness of the microscopic image be adjusted with this diaphragm. For this purpose the voltage of the lamp is regulated or neutral gray lenses are inserted into the filter holder.

As a rule the aperture diaphragm will be stopped down so that only about ⅔ of the opening of the objective is illuminated. This is observed while the Amici-Bertrand lens is engaged, or by looking through the tube with the eyepiece removed.

b) The field diaphragms are assigned to the object plane and are imaged together with it. The field stop of the microscope is situated in the focal plane of the eye lens of the eyepiece. Its projection on the object plane determines the diameter of the field

of view. A possibility to alter the diameter of the field of view is generally not provided with the microcope. If it is to be altered, instead of eyepieces with fixed diaphragm such with iris diaphragm have to be used (for instance, after Czapski, Klein, Wright).

In its capacity as radiant field stop the iris diaphragm at the microscope lamp permits choosing the size of the illuminated specimen spot according to the size of the field of view. Thus, internal reflections in the lenses and tubes, and consequently a blurring of the image, may be avoided. With attachable illuminators such an iris diaphragm is not provided. Hence, with these lamps there is no possibility of adjusting the radiant field to the field of view.

A diaphragm above the Bertrand lens serves to stop out the surroundings of the smallest crystals when their conoscopic interference image is being observed and to increase the depth of focus of this image. This diaphragm comprises the image of the object projected in the plane O'.

10.1 Orthoscopic Path of Rays

Illuminating Pencil

(Fig. 10, shading from the upper left to the lower right)

The collector images the light source L in the front focal plane of the condenser L', the entrance pupil of the microscope. The condenser (aperture) diaphragm is also situated in this plane. The condenser deflects tele-centrically the beams coming from its focal point to the object plane O.

Then the objective combines the beams in its back focal plane L'', the exit pupil of the objective. A further image of the light source is produced in the plane L''', the exit pupil of the entire microscope.

Image-Forming Pencil

(Fig. 10, shading from the upper left to the lower right)

The object in the plane O is imaged through the objective in the plane O'. In this plane it appears as a real, i. e., intermediate image that may be produced on a ground glass. Also placed in this plane is

the field stop as well as the eyepiece cross-hairs and/or eyepiece micrometer. Together with the specimen they are observed through the eyepiece as through a magnifier. The eye lens of the observer forms the image O'' on the retina.

From the objective plane O traced backward, the beams meet again in the plane $\overline{O}$. The radiant field stop placed in this plane is also assigned to the specimen plane.

10.2 **Conoscopic Path of Rays** (Fig. 11)

In conjunction with the eyepiece the engaged Amici-Bertrand lens is employed as an auxiliary microscope for observing the interference images in the back focal plane of the objective L''. Image-forming and illuminating pencils change their function:

The rays proceeding from o n e point of the light source image L' penetrate the object, being parallel to each other after leaving the condenser, but then become convergent to an extent which depends on the condenser aperture. Here, they are affected by it and interfere in the back focal plane of the objective L''.

The pencils are divergent on proceeding from L'' and after passing through the analyzer they are united in the plane of the field stop of the eyepiece to form the image L''' of the aperture stop image L''. This image L''' is observed through the eye lens of the eyepiece in the normal way and appears finally as image L'''' on the retina of the eye.

With the various objectives the light source image L'' lies at different heights. Accordingly the distance of the interference image L''' from the Amici-Bertrand lens also varies. Therefore, the lens must have a rather great depth of focus or its distance to plane L'' must be adjustable.

The image O' of the specimen O is moved by the Amici-Bertrand lens to the plane of an isolating stop which is automatically switched in with this lens, and then, as image O'', is brought by the eyepiece approximately into the plane of the exit pupil of the microscope — where the pupil of the eye should be situated.

11 Important Literature on Polarizing Microscopy

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Path of Rays

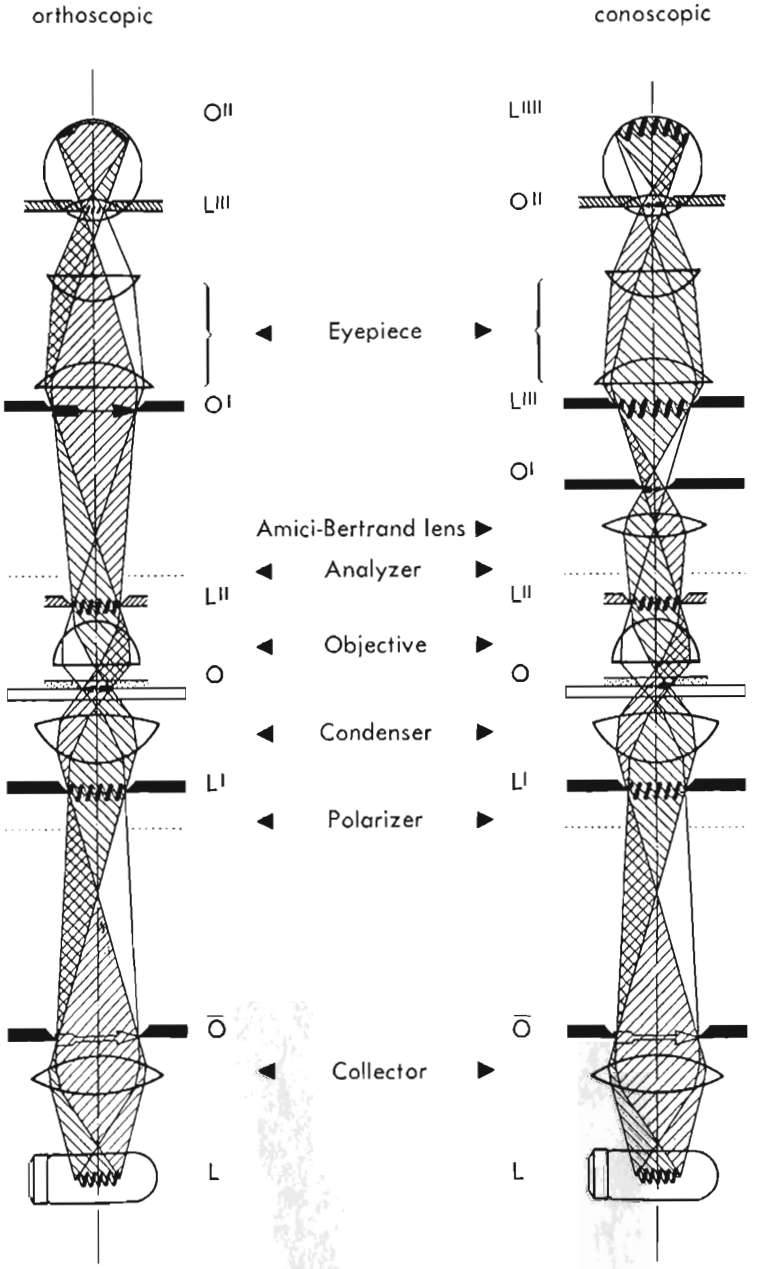

Fig. 10

Fig. 11

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