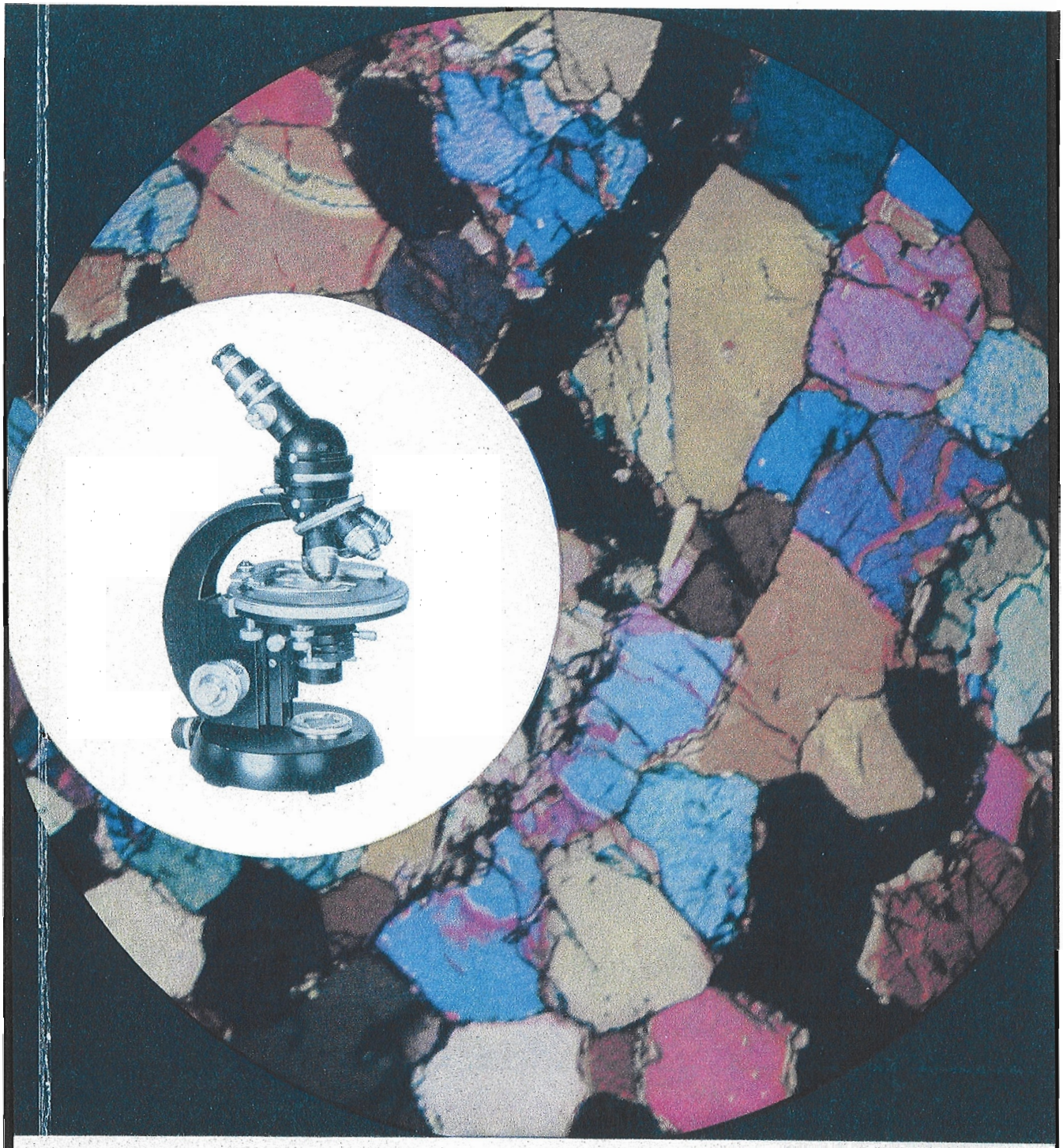
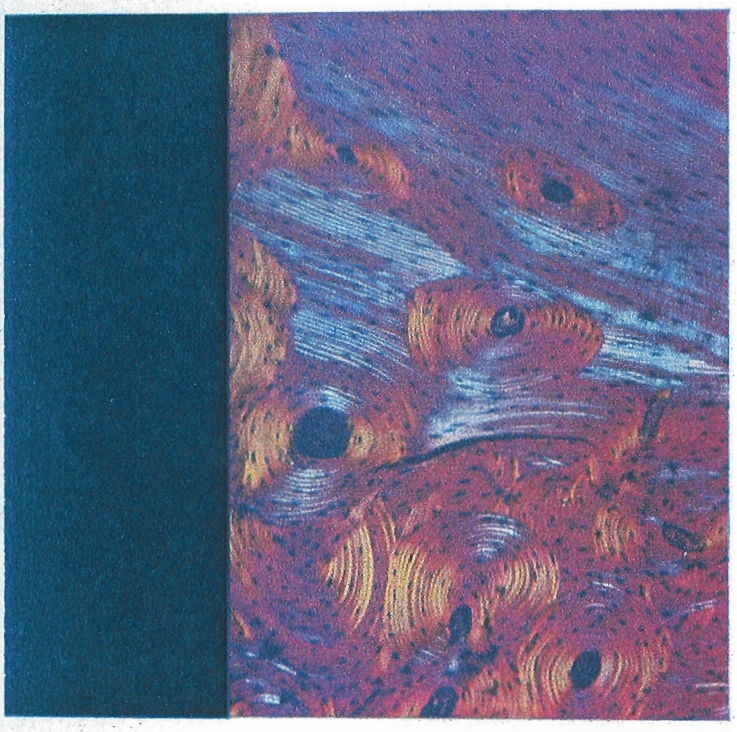


CARL ZEISS

INSTRUMENTS FOR POLARIZING MICROSCOPY

CARL ZEISS



Bone, decalcified

Thin section 30 μ

crossed polarizer and analyzer

Image scale 100 : 1

STANDARD GFL POL Microscope

Attachment Camera with CONTAX

Multi-purpose microscope lamp

with low-voltage bulb 12 V, 8 A

NEOFLUAR 16/0.40, eyepiece Kpl 8 x

Front cover:
Thin section of a dunite
from Bjoerkedalen (Norway)
crossed polarizer and analyzer
Image scale 65 : 1
PHOTOMICROSCOPE
Projective 3.2
OPTOVAR 1.25
Planachromat 2.5/0.08 "POL"

CONTENTS

The manufacture of polarizing microscopes and accessories has been a specialty of our firm for many years. Our own extensive experience, together with the cooperation of leading scientists, enables us to design new models which meet all the requirements of modern research methods.

With the single exception of the simplest type of student microscope for transmitted light, all Carl Zeiss microscopes for polarizing microscopy can also be used for
epi-microscopy,
phase contrast microscopy,
dark field microscopy,
fluorescence microscopy,
transmitted-light interference microscopy
or combination methods, depending upon whether the need is one pertaining to minerology, biology, or of a technical nature.

We manufacture:

ULTRAPHOT II POL
a large camera polarizing microscope with completely automatic exposure control

PHOTOMICROSCOPE POL
a large research microscope with built-in miniature camera and automatic exposure control

STANDARD UNIVERSAL POL
a large research microscope

STANDARD WL POL
a research microscope

STANDARD GFL POL 668 – 666
a simple research microscope and an old favorite in laboratory work

STANDARD GFL POL 668 – 655
a plain workroom microscope, also handy student microscope

STANDARD JUNIOR POL
a microscope stand for laboratory use and for classes in transmitted-light polarizing microscopy.

The following outstanding characteristics are shared by all these instruments:

The coarse and fine focusing adjustments are placed low and arranged co-axially, with pinion heads that work completely independently of each other.

The inclined monocular and the binocular tubes have no depolarizing effect. The binocular tube suffers no serious losses of light through beam-splitting, as the "analyzer effect" is eliminated by a "high-order white" quartz plate. Wide angle eyepieces can also be used in the inclined binocular tube.

The Universal Rotary Stage with large working surface and special objectives (Achromats UD) for orthoscopic and conoscopic observation can be used on all the microscopes with the exception of the STANDARD JUNIOR POL.

The source of light is utilized to the utmost, and the specimen is uniformly illuminated.

Spring mount on all objectives for transmitted light, unless the specimen is protected by a large working distance. The lens surfaces are coated.

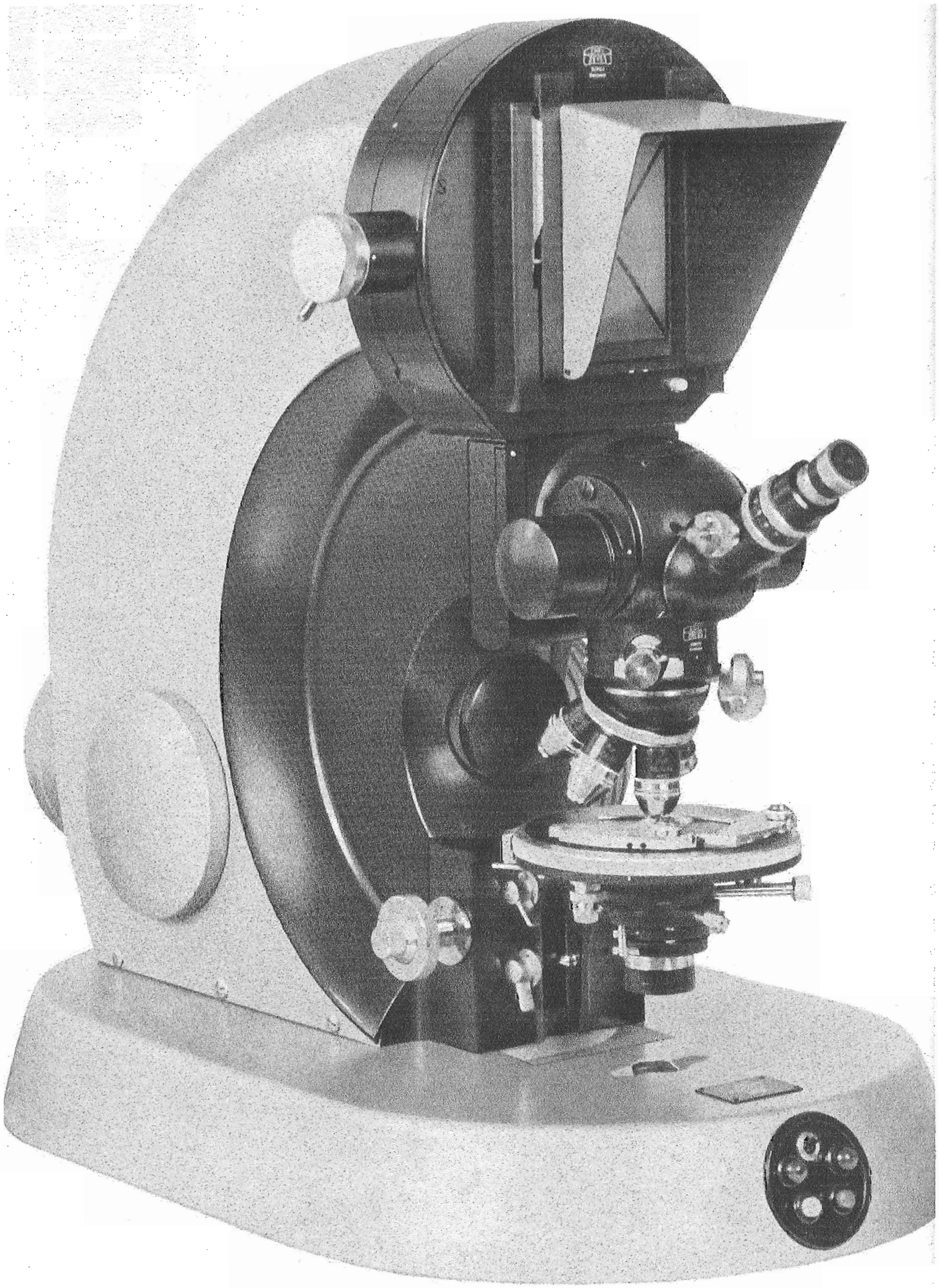
A quadruple or quintuple exchangeable revolving nosepiece with ball-bearing click-stop guarantees firm centering of the objective.

The polarizing filters are highly effective, dampness resisting and constant with regard to temperature influences to a considerable extent.

STEREOMICROSCOPE II POL
has a convenient rapid magnification changer, and is provided with auxiliary equipment for measurements in polarized light. A wide range of requirements can be met by attaching additional parts to the basic body.

The individual instruments with their equipment, both mechanical and optical, are described on the following pages. The usual equipment for all ZEISS-Polarizing microscopes is listed in the order sheet B 40 – 100. This gives the user the opportunity to select the microscope best suited to his needs or, if he prefers, to assemble one according to his own ideas

A detailed bibliography at the end of this booklet will be of help to the scientist and to those doing research, when working on the theoretical basis of polarizing microscopy.



ULTRAPHOT II POL

Technical description of the stand

Types of illumination:

The ULTRAPHOT II POL can be used for observation by both transmitted and incident light. The illumination follows Köhler's principle.

Source of light:

Three different lamps can be attached simultaneously. A low-voltage 12 V 8 A bulb comes with the regular equipment. Super-pressure mercury, sodium or carbon arc lamps can also be used.

The path of rays:

Both monocular and binocular systems are suitable for working in the orthoscopic and conoscopic path of rays. The transition from transmitted to incident light is effected by means of a deflecting mirror. Transmitted-light two-beam interference is possible; accordingly, observations by interference contrast, and interferometric measurements can be made.
The needed change of the optical and mechanical parts is effected by a few manipulations.

Camera set-up:

The ULTRAPHOT II POL has a built-in camera with completely automatic exposure for 9 x 12 cm. plates or cut film. Photographs in smaller sizes can be made with use of proper inserts. Such inserts for formats 6 x 9 cm. and 27 x 45 mm. come with each instrument. 24 x 36 mm. photos can be taken with a completely automatic 35 mm. adapter.
The length of the camera, and consequently the magnification, can be constantly changed and read right on a graduated drum.

(For tubes see page 44;
for stages, page 48.)

Optical equipment:

Condensers for transmitted light are described on page 28;
those for incident light on page 30.
Objectives are listed on page 32,
the eyepieces on page 37,
and both polarizers and analyzers will be found on page 42.

A second Amici-Bertrand lens in the OPTOVAR permits conoscopic image observation with both eyes, proper focusing control of phase contrast and interference illumination, as well as conoscopic image photography.

The ULTRAPHOT II POL camera microscope can be used for a great variety of purposes, and is distinguished by simplicity in construction and ease in manipulation. It can be adapted to all methods of microscopic investigation whether made by polarized or non-polarized transmitted or incident light.

With the built-in OPTOVAR magnification in three different stages can be effected by simply switching over, without change of the objective and eyepiece combination.

After the plate-holder is introduced, pressing a button is all that is needed to open the camera shutter, make the exposure, and again close the shutter. The proper exposure time is automatically controlled by the instrument itself.

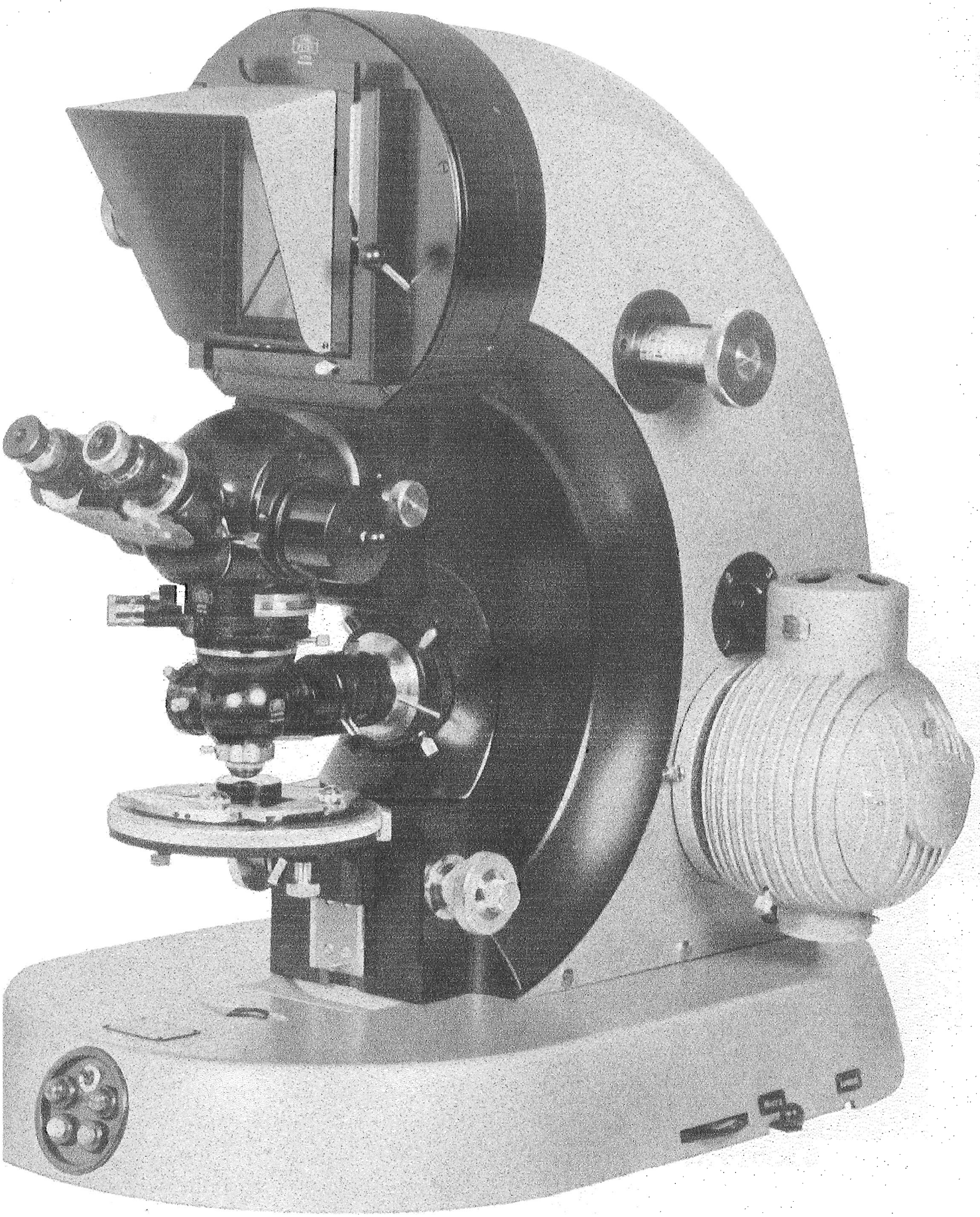
The tube head POL can be replaced by a **luminar head.** LUMINARS serve for taking survey photographs at low magnification, without use of an eyepiece. The photographs are characterized by uniform sharpness over the entire image field.

Projection is possible on a ground glass. For this all that is needed is to substitute the 9 x 12 cm photo head by a **projection head** with an exchangeable, revolving ground glass 190 mm in diameter.

Disturbing depolarization in beam-splitting and reflecting systems in polarizing-optical measurements is eliminated by a built-in crystallographic and optically aligned birefringent layer of a fixed thickness.

In working with special objectives which are attached singly (for example the UD, phase contrast or interference objectives listed on pages 34, 51 and 66), a holder for single objectives is used instead of the revolving nosepiece. The system to be used is set inside it with a centering changing ring.

Further information on the camera microscope ULTRAPHOT II POL is given in leaflet 40-451.



PHOTOMICROSCOPE POL

Technical description of the stand:

Types of illumination:

The PHOTOMICROSCOPE POL can be used for observation by both transmitted and incident light. The illumination follows the KOEHLER method.

Source of light:

The instrument is equipped with a built-in low voltage 6 V – 15 W lamp in the base of the microscope. In case a higher illumination intensity is required (for example in ore microscopy, coal petrography or transmitted-light interference microscopy), this can be changed for a 60 W lamp. Carbon arc lamps, high-pressure mercury lamps and certain spectral lamps can also be used.

The path of rays:

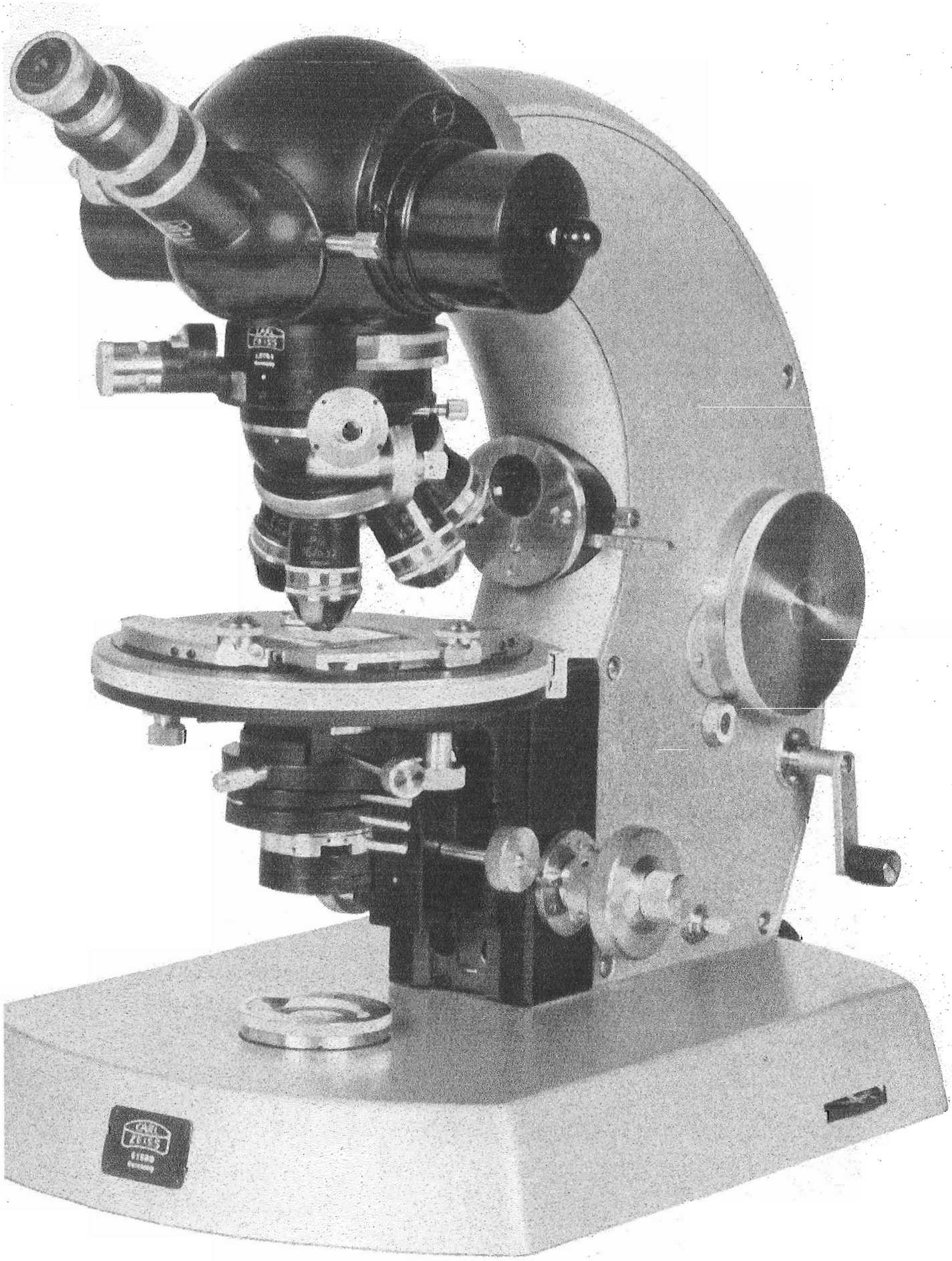
Both monocular and binocular systems are suitable for working in the orthoscopic and conoscopic path of rays. The transition from transmitted to incident light is effected by means of a deflecting mirror. Transmitted light two-beam interference is possible; accordingly, observations by interference contrast and interferometric measurements can be made.
The required optical change is effected by a few manipulations.

Camera device:

The PHOTOMICROSCOPE POL has a completely automatic built-in miniature camera for a 24 x 36 mm. format. One push of the button and the electronic control takes care of the exposure time, the opening and closing of the shutter, the film transport and the picture counter. By switching of the projective, the magnification on the photographic emulsion can be varied by two additional factors. (For tubes see page 44; for stages, page 48).

Optical equipment:

Condensers for transmitted light are described on page 28; those for incident light on page 30. Objectives are listed on page 32, the eyepieces on page 37, and both polarizers and analyzers will be found on page 42.


CARL ZEISS

A second Amici-Bertrand lens in the OPTOVAR permits conoscopic image observation with both eyes, proper focusing control of phase contrast and interference illumination, as well as conoscopic image photography.

Both as regards form and construction, the PHOTOMICROSCOPE POL carries on the well-established qualities of the STANDARD polarizing microscope.

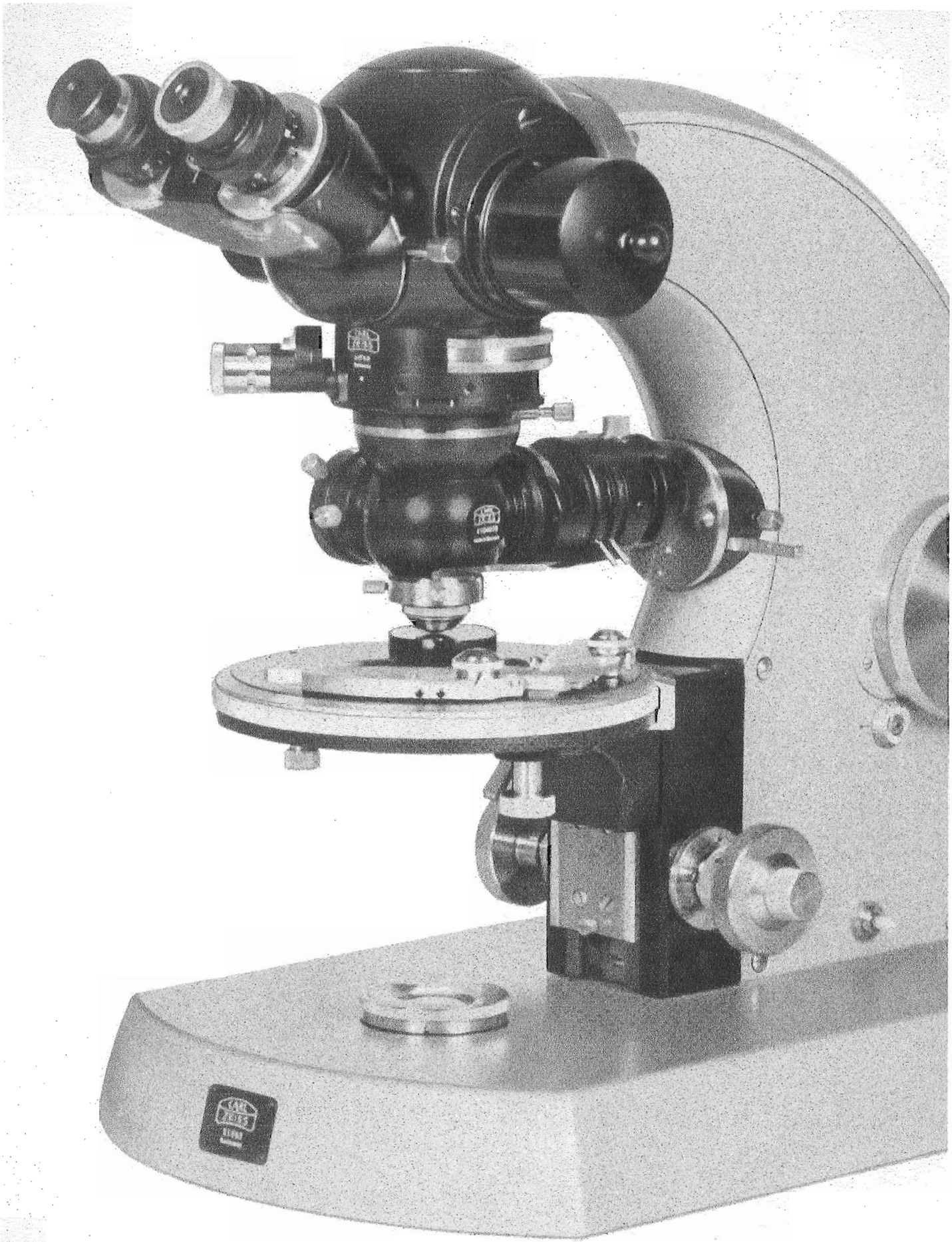
Simultaneously with visual observation the microscopic image is also sharply focused for photomicrography, and can then be photographed directly on 24 x 36 mm. miniature film. The film is in a special holder. If several of these holders are employed, each with different type of film, a photographic series can be interrupted whenever desired and continued with some other film material.

With the built-in OPTOVAR, magnification in three different stages can be effected by simply switching over, without change of the objective and eyepiece combination.

Depolarization in beam-splitting and reflecting systems which disturbs the polarizing-optical measurements is eliminated by a built-in crystallographic and optically aligned birefringent layer of a fixed thickness.

In working with special objectives which are attached singly (for example UD, phase contrast or interference objectives listed on pages 34, 51 and 66), a holder for single objectives is used instead of the revolving nosepiece. The system to be used is set inside it with a centering changing ring.

Further information on the PHOTOMICROSCOPE is given in leaflet 40-430.



STANDARD UNIVERSAL POL

The series of microscopes for visual observation by transmitted and incident light without built-in camera, is opened by the large research microscope, the STANDARD UNIVERSAL POL. The stand, as well as the optical and mechanical structure of the illumination and observation units, resembles that of the PHOTOMICROSCOPE POL. It is exceptionally sturdy.

The technical details follow.

Types of illumination:

The STANDARD UNIVERSAL POL can be used for observation by both transmitted and incident light. The illumination follows KOEHLER's principle.

Source of light:

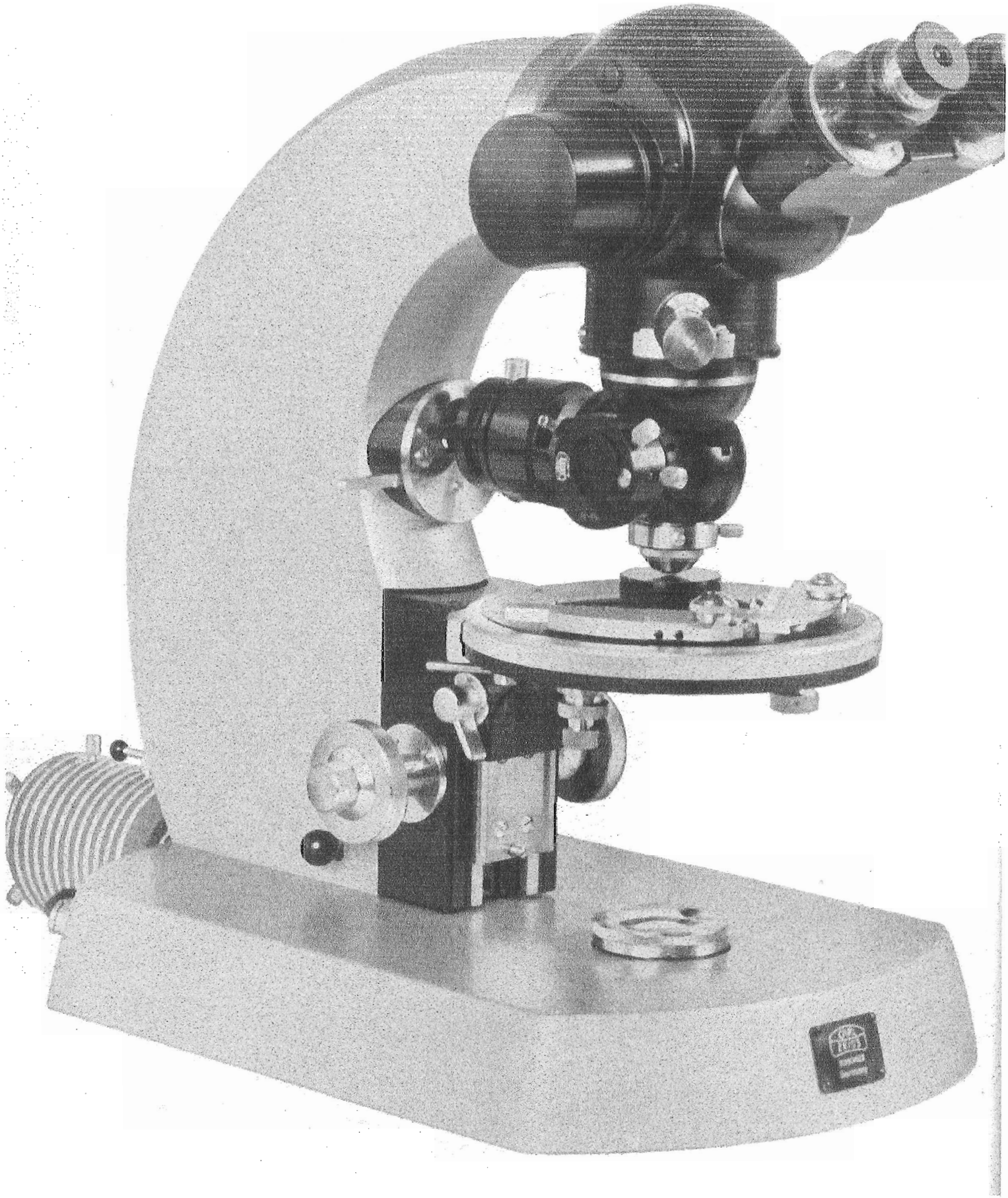
The instrument is equipped with a built-in 6 V – 15 W low-voltage lamp in the base of the microscope. In case a higher illumination intensity is required (for example in ore microscopy, coal petrography or transmitted light interference microscopy), this can be changed for a 60 W lamp. Carbon arc lamps, high-pressure mercury lamps and certain spectral lamps can also be used.

The path of rays:

Both monocular and binocular systems are suitable for working in the orthoscopic and conoscopic path of rays. The transition from transmitted to incident light is effected by means of a deflecting mirror. Transmitted light two-beam interference is possible; accordingly, observations by interference contrast and interference measurements can be made. The required optical change is effected by a few manipulations. (For tubes see page 44; for stages, page 48).

Optical equipment:

Condensers for transmitted light are described on page 28; those for incident light on page 30. The objectives are listed on page 32, the eyepieces on page 37, and both polarizers and analyzers will be found on page 42.



A second Amici-Bertrand lens built-in the OPTOVAR permits conoscopic image observation with both eyes, proper focusing control of phase contrast and interference illumination, as well as conoscopic image photography.

Coarse and fine adjustment are mounted co-axially and act on the stage by means of separate mechanisms. Adjustments can be read directly from 0.002 mm. Dependence of the knob movements on temperature is reduced to a minimum by ball-bearing lining.

The **condenser carrier** is detachable; this increases the height adjustment of the microscope stage by 45 mm. and allows room for especially thick specimens for incident light microscopy.

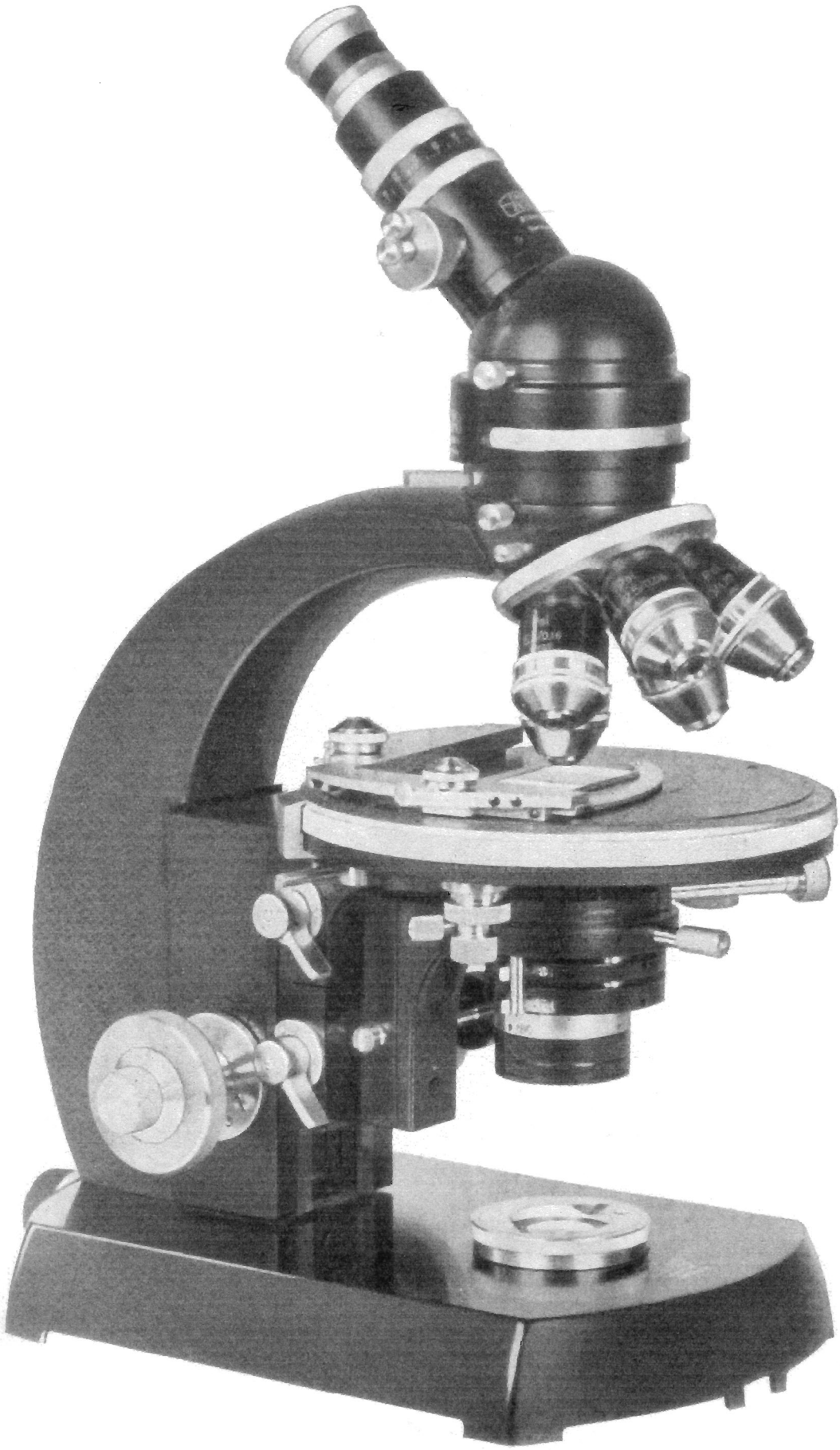
Generally a polarizing rotary stage (see page 48) is attached to the **stage support.** Since the stage support is firm and easy to fasten or change without disturbing the stage centering, other stages listed in our prospectus can be used if desired.

The **objective holders** are interchangeable. For example the quintuple revolving nosepiece for transmitted light can be changed for a single objective holder on a centerable changer (a phase contrast objective, UD objective, interference objective etc.) or for an illuminator housing for observations with incident light.

The STANDARD UNIVERSAL POL microscope is especially well suited to incident light microscopy (ore microscopy, coal petrography etc.) with very strong magnification because of its resistance to vibration. The light source is built into the base of the microscope or securely attached to it also for incident light illumination. The transition from transmitted to incident light requires only a push of the lever.

The **POL tube head** contains the rotary analyzer, a slit for auxiliary objects and compensators as well as the OPTOVAR, with which the magnification can be changed within three fixed stages (the ratio is as 1 : 1.25 : 1.6 : 2) while the combination of objective and eyepiece is left untouched.

The POL tube head can be supplied in simplified form without OPTOVAR.



STANDARD WL POL

Technical description of the stand:

Types of illumination:

The STANDARD WL POL can be used for observation by both transmitted and incident light. The illumination follows KOEHLER's principle.

Source of light:

The instrument is equipped with a built-in 6 V – 15 W low-voltage lamp in the base of the microscope. High power lamps with 12 V – 100 W bulbs or high-pressure mercury lamps (see leaflet 40 – 340) can be attached to the microscope for use by a connecting rod. A rotating microscope mirror placed on the diaphragm inset then directs the light into the condenser.
For incident light observations (ore microscopy, coal petrography etc.) the epi-condenser II B with built-in lamp and slide changer (see leaflet 40 – 650) is available.

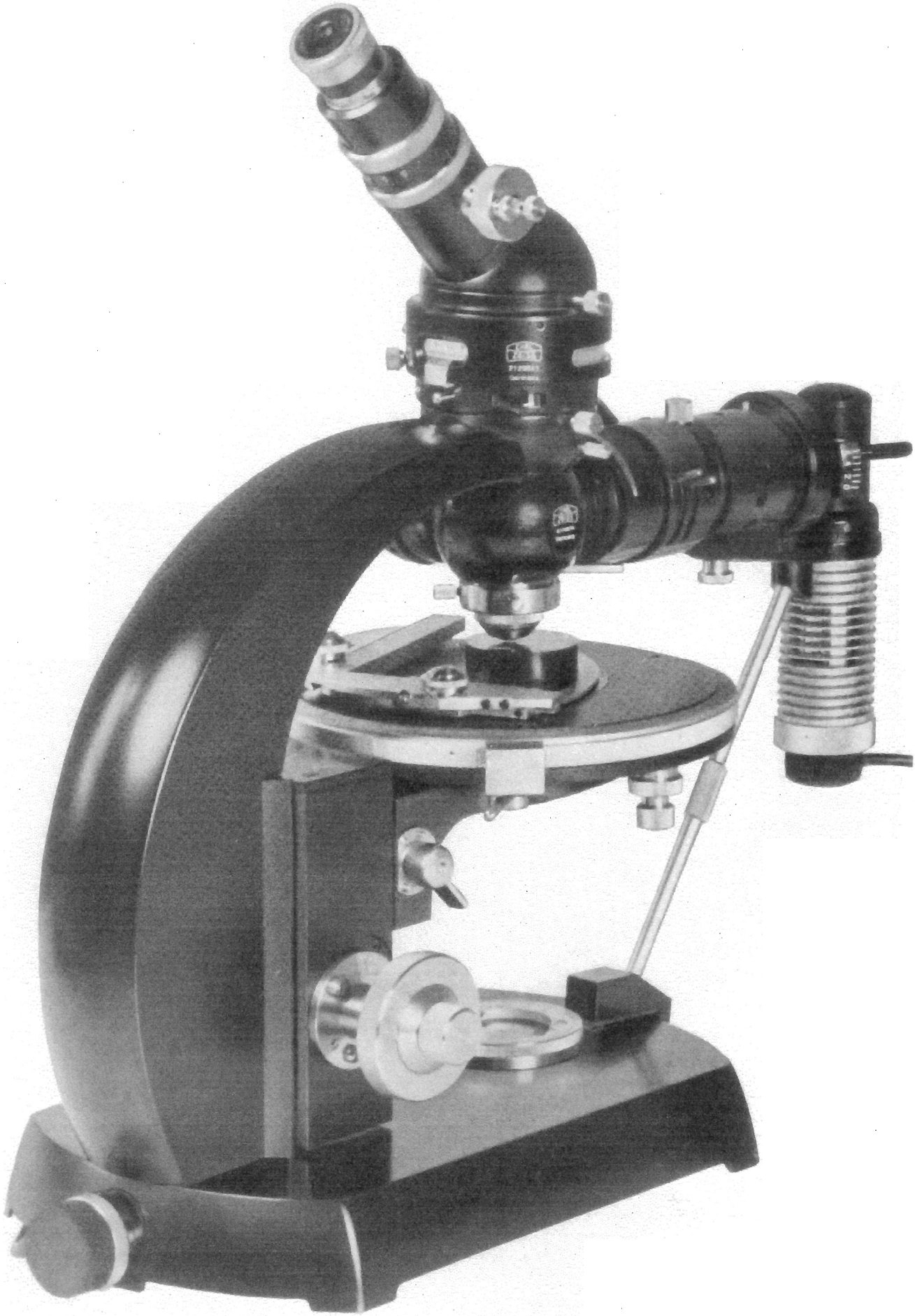
The path of rays:

Both monocular and binocular systems are suitable for working in the orthoscopic and conoscopic path of rays. Transmitted light two-beam interference is possible; accordingly, observations by interference contrast and interferometric measurements can be made. (For tubes see page 44; for stages, page 48).

Optical equipment:

Condensers for transmitted light are described on page 28; those for incident light on page 30. The objectives are listed on page 32, the eyepieces on page 37, the polarizers on page 42 and the analyzer intermediate tubes on page 43.

The STANDARD WL POL is a research microscope and is as adaptable as the STANDARD UNIVERSAL POL. Its tube carrier, however, is not as elaborate, so that separate light sources have to be used for observations in transmitted and incident light.



Coarse and fine adjustment are mounted co-axially and act on the stage by means of separate mechanisms. Adjustments can be read directly from 0.002 mm. Dependence of the knob movements on temperature is reduced to a minimum by ball-bearings.

The **condenser carrier** is detachable; this increases the height adjustment of the microscope stage by 45 mm. and allows room for placing especially thick specimens for incident light microscopy.

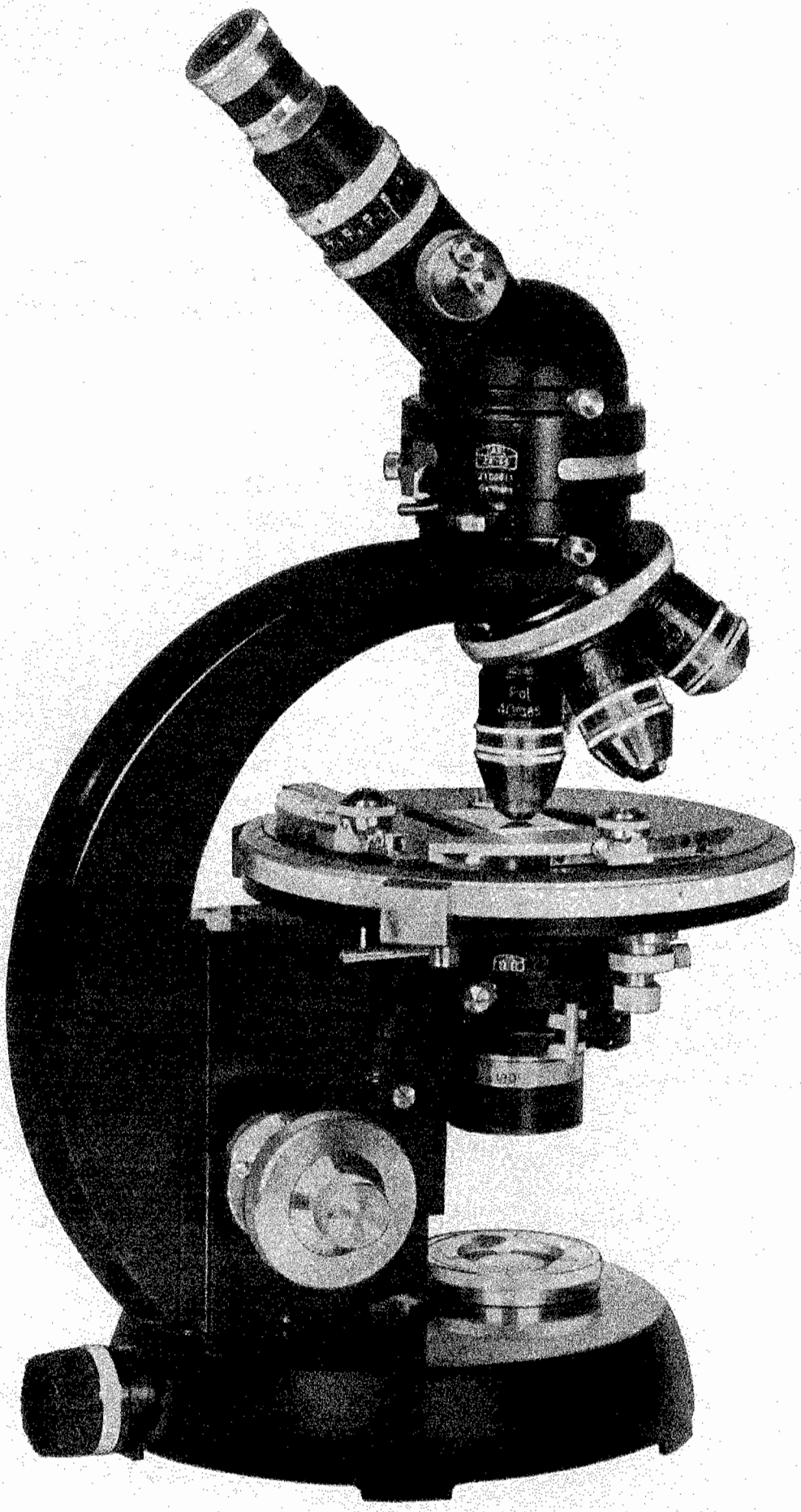
Generally a polarizing rotary stage (see page 48) is attached to the **stage support.** Since the stage support is firm and easy to fasten or change without disturbing the stage centering, other stages listed in our prospectus can be used if desired.

The **objective holders** (as well as the epi-condensers) are provided with a short slide for quick changing. Unintentional loosening or shifting is prevented by a fixing screw

For observation with transmitted light and measurements in polarized light, the objectives, which are provided with a centering mount (see page 33), are screwed on to a revolving nosepiece. Objectives for special types of work (the UD objective, phase contrast objective, transmitted-light interference objective etc.) and **LUMINARS** are to be fastened and centered singly on single changers.

The stand is sturdy and lends itself easily to **photomicrographic purposes** with an attachment camera (see page 67 and leaflet 40 – 410).

In case strong vibrations in the work room cannot be avoided, it is advisable to attach the epi-condenser B to the base of the microscope by an auxiliary carrier.



STANDARD GFL POL 668 - 666

Technical description of the stand:

Types of illumination, source of light, the path of rays and optical equipment are exactly as described for the research microscope STANDARD WL POL (see page 19). For tubes see page 44; for stages, page 48.

In recent years the STANDARD GFL POL has made a name for itself as a work and research microscope. Like the STANDARD WL POL, it is suitable for all microscopic investigations and measurements in polarized transmitted and incident light (ore microscopy etc.).

Coarse and fine adjustment are mounted co-axially and act on the stage and tube carrier by means of separate mechanisms. Adjustments can be read directly from 0.002 mm. Dependence of the knob movements on temperature is reduced to a minimum by ball-bearings.

In this stand the condenser carrier with polarizer and stage support are built-in.

The objective holders are the same as those for the STANDARD WL POL (see page 21).

The stand is very sturdy and lends itself easily to photomicrographic purposes with an attachment camera (see page 67 and leaflet 40 - 410).

The STANDARD GFL POL can be used in connection with the micro-projection equipment POL for micro-projection in auditoriums and class-rooms. For demonstration in smaller circles the "projection attachment", a smaller device, is very practical.

STANDARD GFL POL 668 - 655

for general instruction purposes.

Technical details:

Types of illumination, source of light, the path of rays are exactly the same as for the research microscope STANDARD WL POL (see page 19).

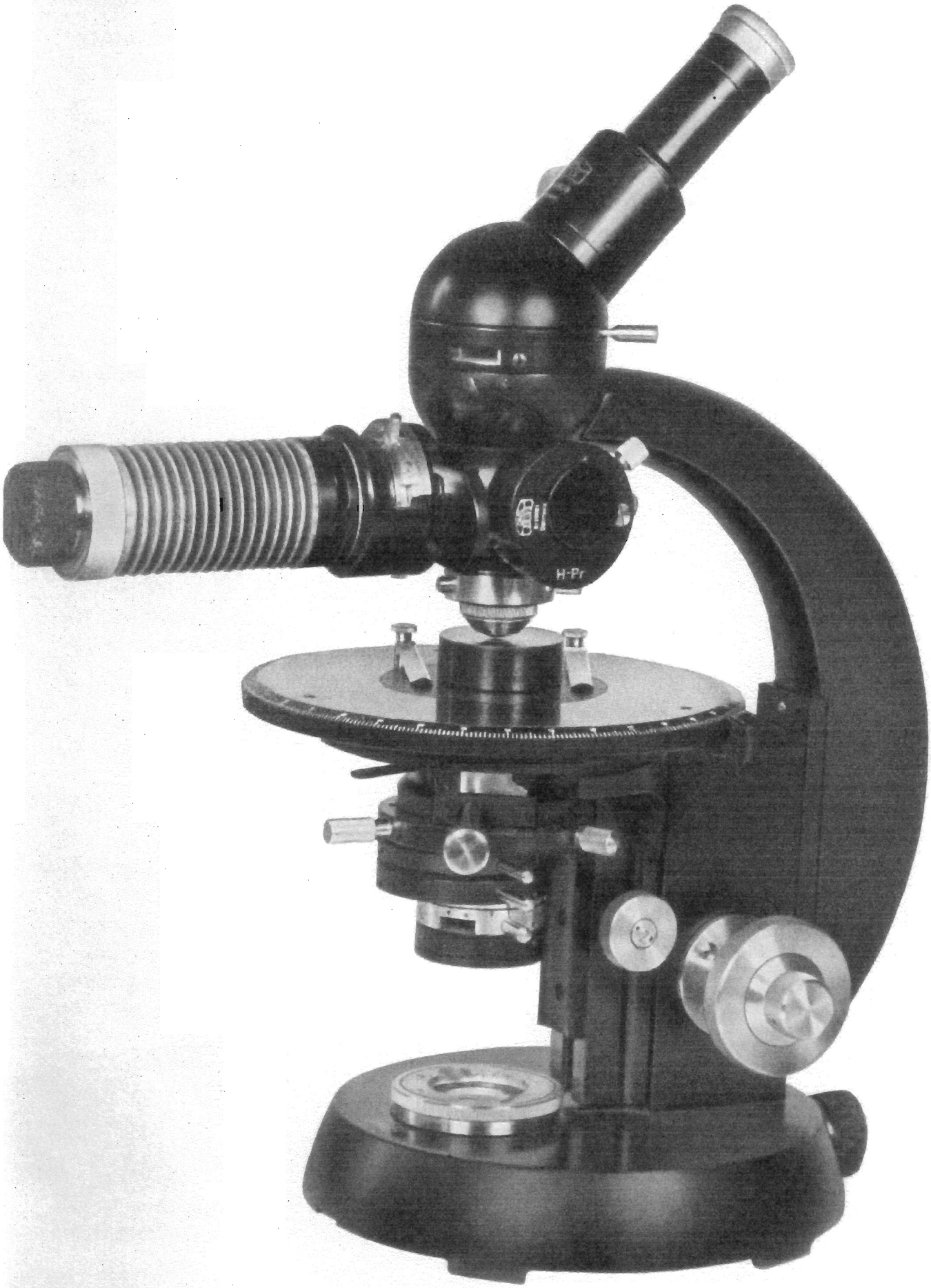
Tubes,
stages
and optical equipment

are available in various forms suited to different types of application.

This instrument is recommended for use as a simple work microscope, and for courses in microscopy in which universal rotary stage methods and ore microscopy are taught in addition to transmitted-light polarizing microscopy.

The chief difference as compared with the STANDARD GFL POL 668 - 666 is the fact that this instrument is equipped with the monocular polarizing tube I and the simple polarizing rotary stage. It comes with a set of objectives selected with instructional purposes in mind.

The epi-condenser II A (Ore) (see leaflet 40 - 650) is recommended for courses in ore microscopy. It can be interchanged with the slide revolving nosepiece for investigation by transmitted light.


H-Pr

STANDARD JUNIOR POL

The STANDARD JUNIOR POL stand is a bit smaller and simpler than that of the STANDARD GFL POL, but very similar with respect to operation and structure. It is meant above all for routine investigation in laboratories, as a working microscope for students and for the class-room. For use as a **travelling-microscope** its base is made a little narrower, so that it can be conveniently fitted into a portable case.

The condenser is placed in the sliding sleeve on a condenser carrier which is adjustable by rack and pinion.

The bright field, bright field phase-contrast and dark field condensers are interchangeable.

The focusing drive KFT has two co-axially arranged knobs on each side. A graduation on the right knob for fine adjustment is for direct reading of the vertical adjustment of 0.005 mm., often needed in determining thicknesses for detection of birefringence.

For light sources there are microscope lamps corresponding to different needs, or separately mounted lamps (see leaflet 40 – 340).

The polarizer can be swung out but not rotated. When connected, its direction of vibration runs from right to left.

The rotary sliding stage is 126 mm. in diameter, and has a graduation scale and two verniers for direct reading of the angle of rotation from 0.1°. It also has a clamping device.

Generally the STANDARD JUNIOR polarizing microscope is equipped with the monocular polarizing tube I.

Use of wide angle eyepieces is possible; but investigations with the universal stage, and observations by incident light are not feasible.

Microscope equipment

Condensers for transmitted light

We manufacture two types of condensers:

a) with dovetail,

to fit into the centering condenser carrier of the STANDARD GFL POL, the WL POL or UNIVERSAL POL, the ULTRAPHOT II POL or the PHOTOMICROSCOPE POL (designation "Z").

b) with sliding sleeve,

to fit into the condenser carrier of the STANDARD JUNIOR POL (designation "S").

The condensers for bright field investigation in polarized and nonpolarized light have an aperture iris diaphragm and a front lens that can swing out. When the front lens is swung in, the diaphragm on the condenser regulates the illumination aperture; when it is swung out, the collector diaphragm of the lamp becomes active.

The condenser is illuminated in accordance with KOEHLER's principle.

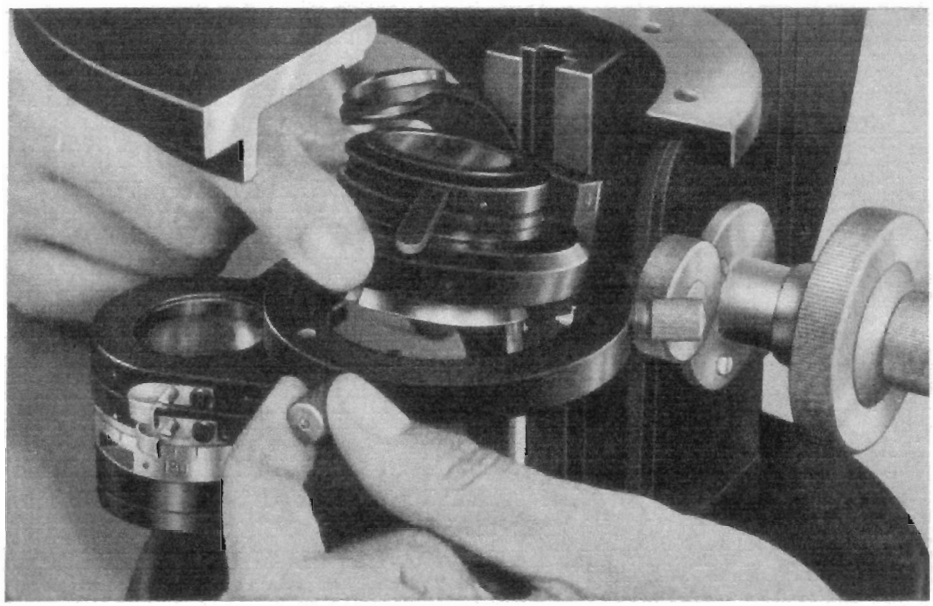
List of condensers

a) strain free condensers

1. Condenser with maximum aperture 0.9 (Z "POL" and S "POL").

2. Condenser with maximum aperture 1.3 (Z "POL" and S "POL").

3. Phase contrast condenser II Z "POL" with maximum aperture 0.9 for transmitted light; can also be used for bright field observation in the orthoscopic and conoscopic path of rays.



4. Strain-free condenser with maximum aperture 0.6 for conoscopic and orthoscopic investigation on the universal stage.

5. Five strain-free spectacle lens condensers for photomicrographic survey photos with LUMINARS.

6. Special condensers for transmitted-light interference microscopy (for description see page 66).

b) condensers for special purposes, not strain free.

7. Dry dark field condensers with maximum apertures 0.85 – 0.95 and 0.65 – 0.85 in models Z and S.

8. Ultracondenser 1.1/1.4 Z and S (0.75/1.0).

9. Bright field – phase contrast – dark field for rapid change of type of illumination in routine observations.

Epi-condensers

For observations in incident light, Epi-condensers are attached to the slide changer of the STANDARD GFL or STANDARD WL polarizing microscopes, or to the changing device of the STANDARD UNIVERSAL POL and the PHOTOMICROSCOPE POL and ULTRAPHOT II POL camera microscopes, instead of revolving nosepieces.

Investigations in polarized and non-polarized light are possible in
incident light bright field illumination,
dark field illumination,
fluorescence illumination
and, with the ULTRAPHOT II POL,
also in incident light phase contrast illumination.

The source of light for observations in incident light is always firmly bound to the condenser, which makes adjustment between the light source and the illumination system superfluous.

The illuminator housing II is arranged for receiving various reflectors:

reflector "H-Pl"
with a plane glass;

reflector "H-Pr POL"
with a trapezoid prism (used especially in ore microscopy);

reflector "D"
with annular diaphragm for dark field investigations.

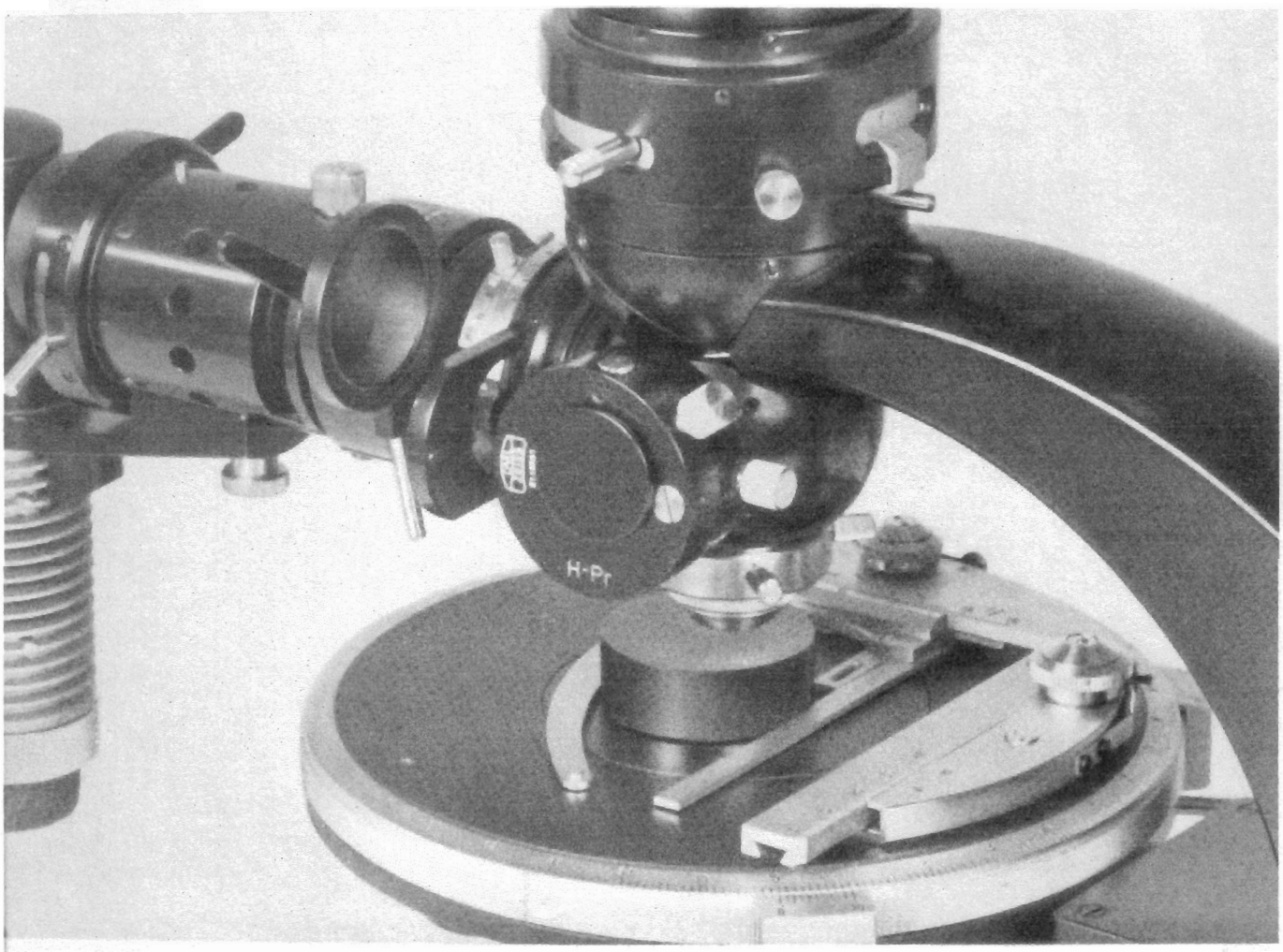
The objectives can be interchanged in the illuminator housing II by means of the centering changing ring. Because of the large number of objectives needed in ore microscopy, a revolving nosepiece is less practical.

Three different illuminator attachments are available for Epi-condensers.

Illuminator attachment A
is the simplest of these. It has no diaphragms, so that KOEHLER's illumination

rules cannot be applied; for instructional purposes, though, it provides an adequately bright and uniform light.

Illuminator attachment B
makes possible an intense even illumination free from reflection as in KOEHLER's principle, by the adjustment of the illumination aperture and the size of the radiant field.



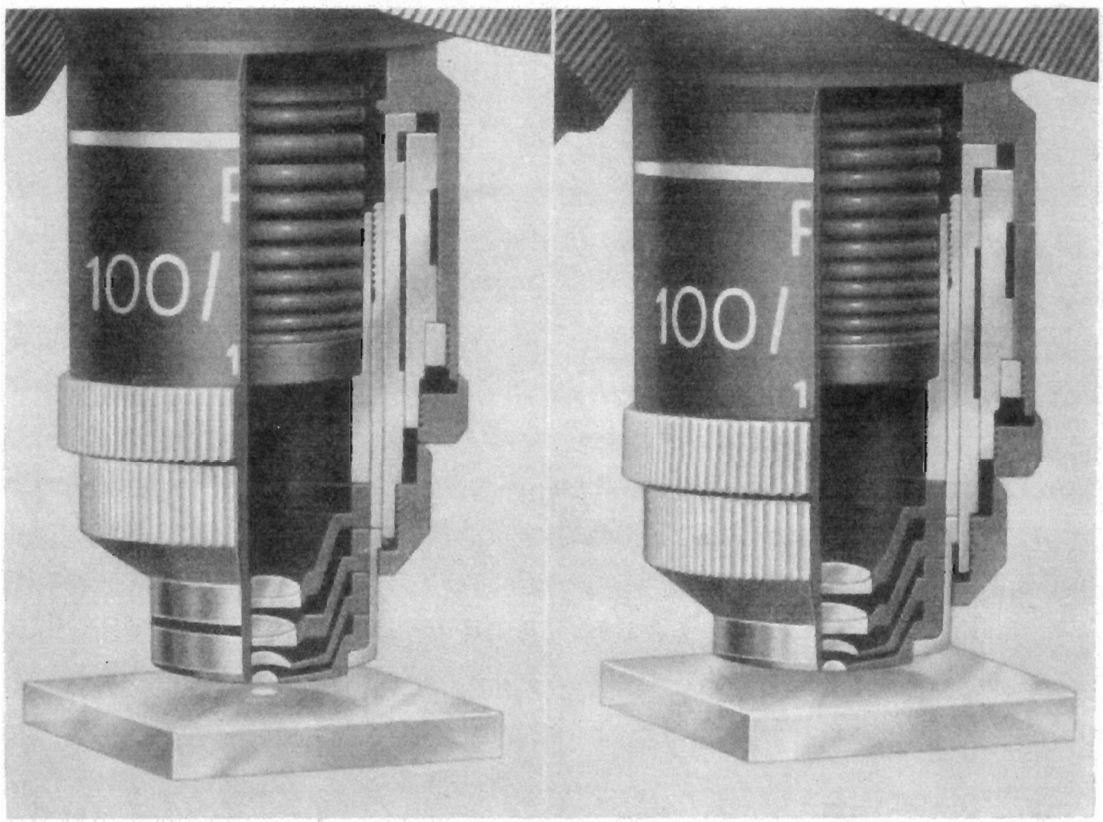
Illuminator attachment C
is for the STANDARD UNIVERSAL polarizing microscope as well as for the camera microscopes PHOTOMICROSCOPE POL and ULTRAPHOT II POL. This is functionally the same as illuminator attachment B, differing only in construction.

Further details on our instruments for Epi-microscopy are given in leaflet 40 – 650.

Objectives

For polarizing-optical investigation and especially for measurements, we manufacture anti-reflection coated objectives which are completely free from optical strain and therefore carry the special designation "POL". These are achromats and, to the extent that complete absence of strain can be guaranteed, also planachromats.

These POL systems are placed in centering mounts, that is in two cylinder rings which can be rotated eccentrically toward each other. In this manner rapid and reliable centering is assured.



Powerful objectives for transmitted light with small working distance are provided with spring mounts. These prevent both the front lens and the test specimen from being crushed. When using lower power objectives contact between object and objective is prevented by limiting the coarse focusing adjustment.

All the objectives are parfocalized from the scale number 6.3 on, so that the microscopic image remains visible while they are being changed, and only slight adjustment of the fine movement is required.

Strain-free achromatic objectives

Magnification, numerical aperture	Working distance mm	Applied with = w without = o cover-glass	Identification color*)	Code number	Used with eyepiece**)
Planachromat 1.0/0.04 strain-free with illumination lens	4.4	w/o	none	48 20 10	Kpl
Planachromat 2.5/0.08 POL in centering mount	9.0	w/o	brown	46 01 18	Kpl
Achromat 6.3/0.16 POL in centering mount	10.3	w/o	orange	46 03 08	C/Kpl
Achromat 10/0.22 POL in centering mount	5.0	w/o	yellow	46 04 08	C/Kpl
Achromat 16/0.32 POL in centering mount	3.5	w/o	bright green	46 05 08	C/Kpl
Achromat 40/0.85 POL in centering spring mount	0.18	w	bright blue	46 07 08	C/Kpl
Achromat 100/1.25 POL in centering spring mount, oil immersion, specimen protection	0.09	w/o	white	46 19 08	C/Kpl

*) Colored ring on objective mount for rapid recognition of system.
**) Kpl = compensating plane-eyepiece, C = compensating eyepiece, see page 38.

The **planachromats** are distinguished for outstanding aplanatic field of view, and are recommended for photomicrography and for polarizing-optical observations. As objectives of this type have more lenses than the achromatic, they accordingly have a stronger depolarization effect and, with the exception of the planachromat 2.5 "POL" Z, are not unconditionally strain-free.

For investigations with especially weak magnification and a large object field, we recommend planachromat 1.0/0.04 with illumination lens. Because of the weak magnification, a special centering device is generally unnecessary.

Owing to their improved spherical and chromatic correction, **neofluars** bring out brilliant pictures rich in contrast.

The planachromats are objectives that represent the best possible that can be attained with present-day techniques with regard to correction of imaging errors, and they bring out a perfect aplanatic field of view.

The outstanding merits of both planachromats and neofluars show off to best advantage with a full illumination aperture, where their resolving properties are put to the utmost use.

There are often lattice disturbances in the crystal lens of the neofluars and planachromats which become noticeable by a rather strong brightening of the image background through crossed polarizer and analyzer. Those objectives are consequently less suited to polarizing-optical measurements.

For use on the polarizing microscope, we pick out the objectives that are strain-free and distinguish them by red lettering.

Luminars are special objectives for use in photomicrography with "simple" microscopes (without eyepieces) at weak magnification.

Phase contrast objectives (Ph) differ from the usual bright field objectives by the annular phase plate set in their focal plane (see leaflet 40 – 160).

Unless the objectives are marked "o. D." (without cover) it is advisable to use them only with covered specimens the cover-glass thickness of which is given

as 0.17 mm. In this way the sharpest possible image is obtained. Both covered and uncovered specimens can be examined with apertures smaller than 0.40 and with LUMINARS.

The following **Epi-objectives** are available:

For observations and measurements in polarized light:

the achromats "Aufl. POL", used as dry objectives and for oil immersion.

For bright field microscopy and photography:

the EPIPLAN objectives,

EPIPLAN antiflex-systems,

EPIPLAN antiflex-immersions
(oil and methylene-iodide),

antiflex-EPI-achromats
(oil and methylene-iodide),

and **for bright and dark field microscopy and photography:**

the EPIPLAN objectives "HD" and

the achromats "Aufl. HD".

The antiflex objectives have a device for the removal of reflex and deviating light. Consequently they bring out outstanding pictures that are rich in contrast even with very weakly reflecting objects (such as polished cuts of coal, for example) (see Piller, Contrast climaxes in Epi-microscopy, ZEISS-Werkzeitschrift Heft 34).

Further details are given in leaflet 40 - 650.

Because of the rotation of the plane of vibration of light on a highly curved lens surface, when using strongly magnifying objectives there is always an increase in brightness in the field of view between the crossed polarizer and analyzer. In conoscopic observation this brings about the impression of the interference image of an optically uniaxial, slightly positively birefringent specimen viewed perpendicularly to the optical axis.

OBJECTIVE CHANGERS

Work and research microscopes are generally provided with a revolving nosepiece for **5 objectives**. A ball-bearing arrangement guarantees easy and even rotation in changing objectives as well as complete stability of the objective centering.
In place of the revolving nosepiece, centering **changers for single objectives** can be used.

The STANDARD GFL and the STANDARD WL polarizing microscopes have centering slide changers for single objectives into which the objectives are screwed.

The polarizing microscopes STANDARD UNIVERSAL, PHOTOMICROSCOPE POL and ULTRAPHOT II POL have holders for the single objectives into which the objectives are placed by means of a firm or centerable changing ring.

Centerable slide changers and changing rings are for attaching special objectives which have no centering mounts, as for example:

the UD achromats for work with the universal stage;

objectives for investigation by phase contrast;

objectives for transmitted light interference observation;

LUMINARS for photomicrographic survey photos;

and epi-objectives.

A special holder is made for LUMINARS on the camera microscope ULTRAPHOT II.

A special holder is made for LUMINARS on the camera microscope ULTRAPHOT II.

The polarizing microscope STANDARD JUNIOR has a firm quadruple objective revolving nosepiece.

Epi-condensers can also be attached instead of the objective changers referred to. The single objectives can easily be interchanged on these with centering rings.

EYEPIECES

In general, crosshair eyepieces, especially those that can receive an eyepiece micrometer or a similar measuring device, are used with polarizing microscopes. They have an adjustable eyelens which is focused by turning on the crosshair or micrometer. Crosshair eyepieces are fitted with an orientation peg which marks the exact parallel or 45° relation to the vibration direction of the polarizer or analyzer.

There are various types of eyepiece micrometers available for changing over at will.

Our wide angle eyepieces often called large field eyepieces with field of view numbers $y' = 18$ and $y'' = 20$, are calculated and formed mechanically in such a way that they can be placed in tubes of normal diameter (23.2 mm.). They come with the basic equipment of the microscopes STANDARD GFL and STANDARD WL POL.

Wide angle eyepieces can also be used in binocular tubes and on the microscopes STANDARD UNIVERSAL POL, PHOTOMICROSCOPE POL and ULTRAPHOT II POL. In this case $y' = 18$ is the upper limit for the field of view number.

Spectacle eyepieces with exit pupil placed on the outside, assure a complete utilization of the possibilities offered by the field of view when using the microscope both **with and without** spectacles.

As second eyepiece for binocular observation, one can use an eyepiece with a fixed eyelens, accordingly without crosshair or micrometer.

For photomicrography with attachment camera or ordinary type camera, eyepieces without crosshair should be used. Otherwise there is the danger that a more or less sharp image of the line scale will distort the photograph. Our compensating eyepieces Kpl are most suited to this type of work because of their reduced image field curvature.

When using PHOTOMICROSCOPE POL or ULTRAPHOT II POL for photomicrography no change of eyepiece is necessary.

Eyepiece system	Magnification	Field of view y′ number	Image angle	For eyepiece micrometer 17 mm. diam.	Code number
C eyepiece	5 x	20	23°		46 37 10
C eyepiece	6.3 x	18	26°	x	46 38 10
C eyepiece	8 x	16	30°		46 39 10
C eyepiece with focusing eyelens	8 x	16	30°	x	46 39 13
C eyepiece with indicator	8 x	16	30°		46 39 18
Kpl eyepiece	8 x	18	33°		46 39 20
Kpl eyepiece with focusing eyelens	8 x	18	33°	x	46 39 23
Kpl crosshair eyepiece POL	8 x	18	33°	x *	46 39 25
Integrating eyepiece I, Kpl	8 x	18	33°		47 40 36
Integrating eyepiece II, Kpl	8 x	18	33°		47 40 37
Goniometer eyepiece	8 x	18	33°		46 39 94
Counter eyepiece, Kpl	8 x	9.5 - 0	27°		46 39 71
Kpl eyepiece, spectacle	8 x	18	32°		46 39 22
Kpl wide angle crosshair eyepiece POL	8 x	20	36°	x *	46 39 45
Eyepiece screw-micrometer	8 x	16	29°		46 39 92
Eyepiece for graduated-dial revolving nosepiece, K	8 x	16	29°	x	46 39 95
Double eyepiece with indicator, K	8 x	16	29°		46 49 22
C eyepiece	10 x	16	36°		46 40 10
Kpl eyepiece	10 x	16	36°		46 40 20
C eyepiece	12.5 x	12.5	36°	x	46 41 10
C eyepiece with focusing eyelens	12.5 x	12.5	36°	x	46 41 13
Kpl eyepiece, spectacle	12.5 x	12.5	36°		46 41 20
Kpl eyepiece with focusing eyelens	12.5 x	12.5	36°	x	46 41 23
Kpl eyepiece POL with crosshair micrometer	12.5 x	12.5	36°	x *	46 41 25
Kpl eyepiece with indicator	12.5 x	12.5	36°		46 41 28
Kpl wide angle eyepiece, spectacle	12.5 x	18	**48°**		46 41 42
Kpl eyepiece W-POL with crosshair micrometer	12.5 x	18	**48°**	x *	46 41 45
Kpl eyepiece	16 x	10	36°		46 42 20
Eyepiece screw-micrometer, K	16 x	10	37°		46 42 92
Kpl eyepiece	20 x	8	36°		46 43 20
Kpl eyepiece with focusing eyelens	20 x	8	36°	x	46 43 23
Kpl eyepiece	25 x	6.3	36°		46 44 20

* Micrometer solidly built in.

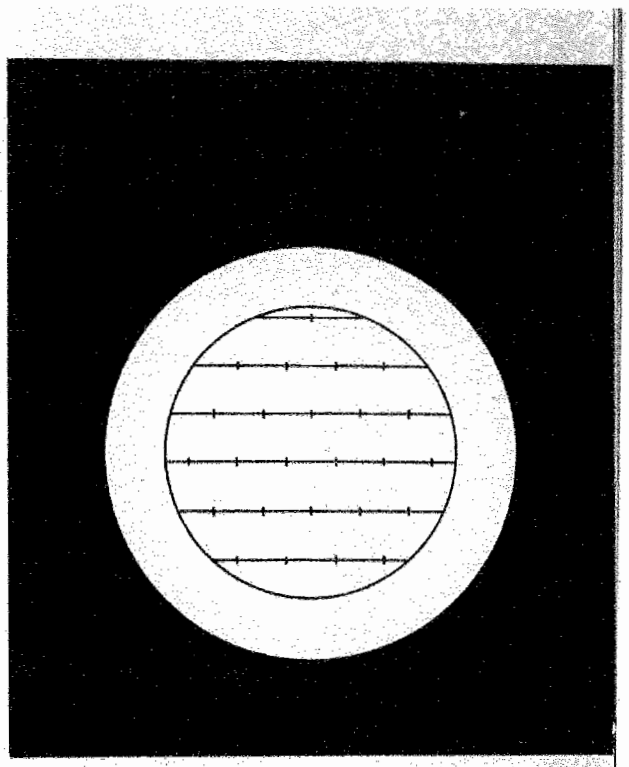
The systems printed in darker type are especially suited to polarizing-optical observation.

With the polarizing microscopes ULTRAPHOT II, PHOTOMICROSCOPE and STANDARD UNIVERSAL, eyepieces both monocular and binocular with a field of view number up to y′ = 18 can be used.

The diameter y (in mm.) of the field of view which is projected in the object place is determined with the aid of the field of view number y′ according to the formula

$$y = \frac{y'}{m}$$

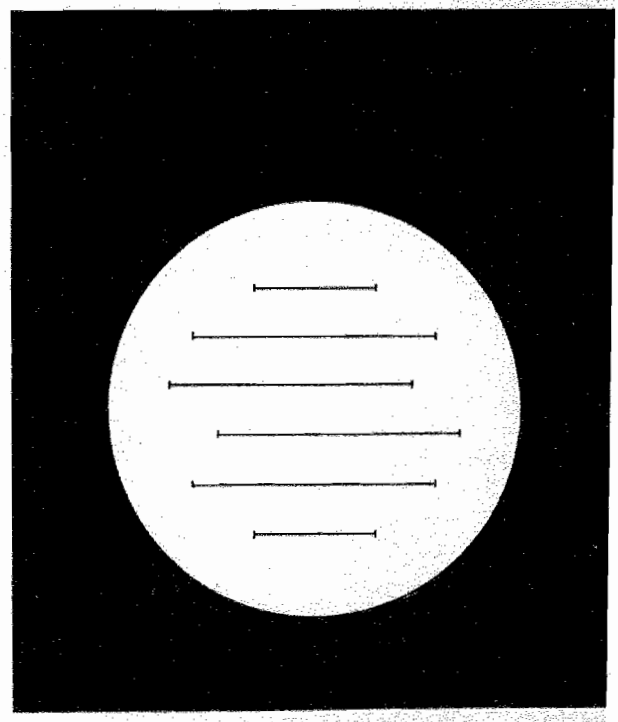
in which m is the scale number of the objective that is used.



INTEGRATING EYEPIECES

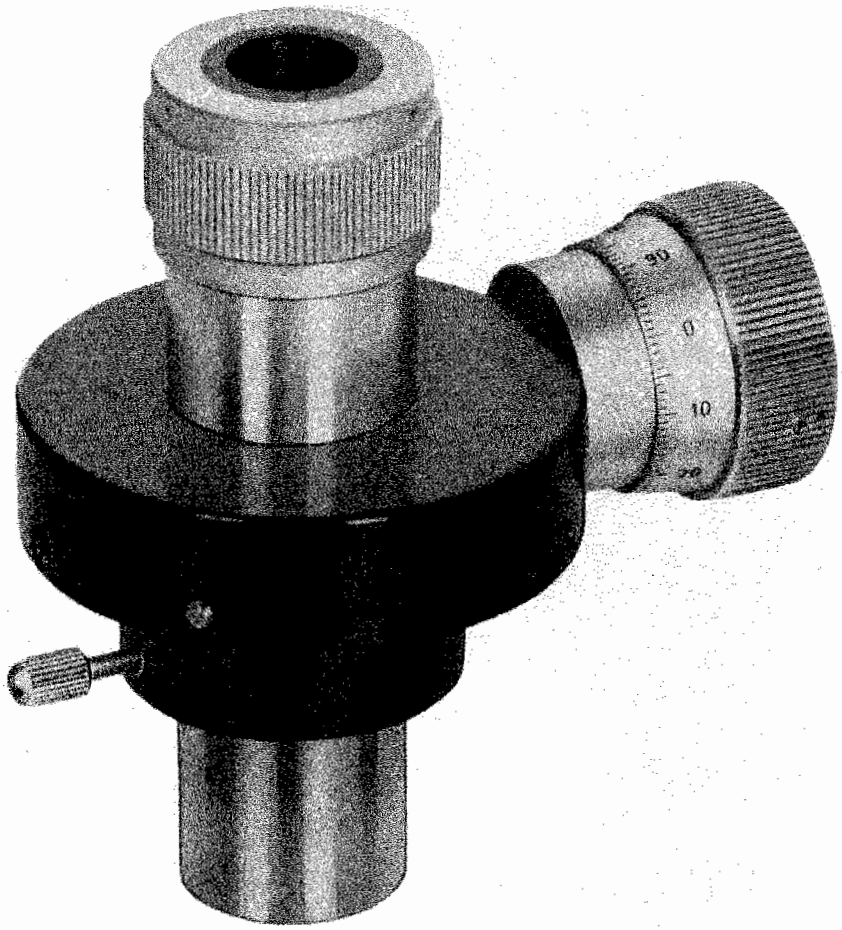
Integrating eyepiece I makes it possible to determine components by the point counting method very easily and rapidly. This surprisingly simple, helpful and reliable instrument is also to be recommended for field work in minerology.

Integrating eyepiece II was developed for ascertaining surface dimensions of space elements in the test specimen that border on each other.



Numerous tests have demonstrated the superiority of the integrating method with these eyepieces as compared with methods used previously (surface or distance integration) with respect to time saving, reliability and simplicity of operation (see leaflet 40 – 195 and ZEISS-Werkzeitschrift, Heft 30).

In many cases of quantitative analyses it is well worth while to use Integrating eyepiece I and to fix the focusing adjustments on the specimen with the aid of **attachable mechanical stage POL** (see page 49) fitted with the "point-counter". Counting can be further simplified by the use of an ordinary mechanical or electric counter.

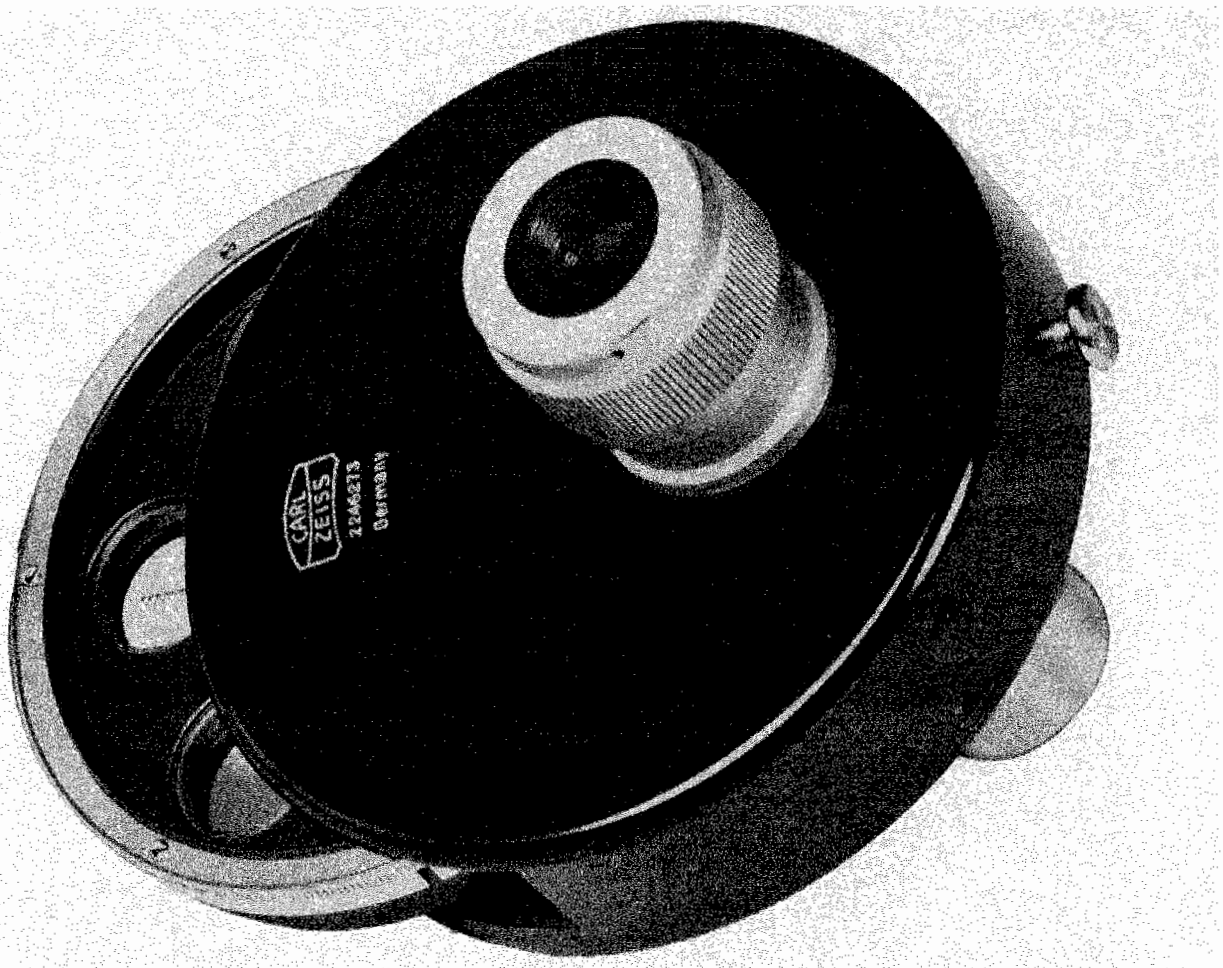


Eyepiece screw-micrometer

In order to increase the exactness of length or breadth measurements under the microscope, it is advisable to use an eyepiece screw-micrometer available in two models (eyepiece screw-micrometer K 8x and eyepiece screw-micrometer K 16x).

Double eyepiece

The double eyepiece K 8x permits simultaneous observation of the specimen by two persons. The built-in indicator is in the center of the double eyepiece and can be adjusted by either one of the observers.



Eyepiece K 8 x for reticle revolving nosepiece

Any of the following reticle revolving nosepieces can be used in the eyepiece K 8 x:
Reticle revolving nosepiece 1 x 6 with openings for a choice of six different line or micrometer plates;
Reticle revolving nosepiece 2 x 7 with openings for a choice of fourteen different line or micrometer plates which are to be used in combinations of two;
Reticle revolving nosepiece for ASTM grain-size measurements, with solidly built-in standardized reticle.

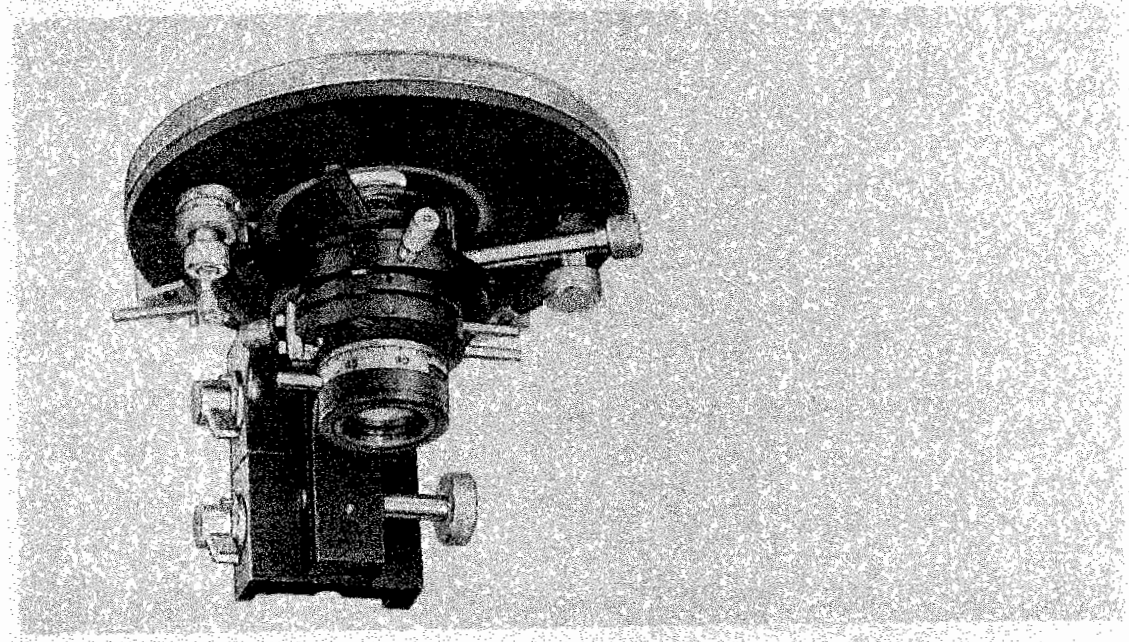
The changing over of various measuring devices while observing is greatly simplified by this reticle revolving nosepiece.

The order list B 40 – 100 gives information on the different eyepiece micrometers, contrast micrometers, line-contrast micrometers, net micrometers and graduated dials that can be inserted in the 1 x 6 and the 2 x 7 reticle revolving nosepieces.

The polarizer

can be swung out;
can be rotated up to 210°;
has a graduation of 15° intervals;
and clicks in from 90° to 90° when rotated.

There is a slit in the polarizer mount for an additional auxiliary device (for example a $\lambda/4$ plate or a compensator for the correction of strains.



The 90° directions so important in investigation of a birefringent object can thus be quickly marked.

The vibration direction is from right to left, so that in observations between crossed polarizer and analyzer in case of a change from transmitted to incident light, optimum conditions are retained and the analyzer does not have to be changed.

The analyzer

for the polarizing microscopes ULTRAPHOT II, PHOTOMICROSCOPE and STANDARD UNIVERSAL can be connected and disconnected by a slide;
can be rotated 360°;
can be clamped fast in any turning position;
and gives exact readings by 0.1°.

Thus the analyzer can be used for the compensation method after Senarmont for example, as well as for determination of main swinging directions in ore microscopy, and makes the use of a special attachment analyzer unnecessary.

The intermediate analyzer tube

for the polarizing microscopes STANDARD WL, STANDARD GFL and STANDARD JUNIOR is to be placed between the observation tube and the objective revolving nosepiece in the image forming path of rays.

The analyzer which is built-in within it can be swung in and out;
can be rotated to 210°;
has a graduation scale and vernier.
The tube has a slot for introducing auxiliary devices and compensators.

The compensator can be inserted and removed at any inclination.

Orientation grooves on the dovetail clamp make the exact adjustment of the analyzer possible when fastening the analyzer intermediate tube to the microscope stand.

The intermediate filter tube

It is similar to the intermediate analyzer tube and takes its place in fluorescence microscopy. The intermediate filter tube contains two revolving disks with suppression filters of different colours.

Device for synchronizing the rotation of polarizer and analyzer

This device can only be used on polarizing microscopes with intermediate analyzer tube (STANDARD GFL POL and STANDARD WL POL). It consists of an arc-shaped piece that can be screwed onto the bottom side of the microscope stage, and a connecting rod with two forked ends which are placed on the levers of the analyzer and polarizer and clamped fast.

An adjusting mechanism on the lower end of the connecting rod makes possible the placing of polarizer and analyzer exactly in crossed position.

The rotation range comes to 190°;

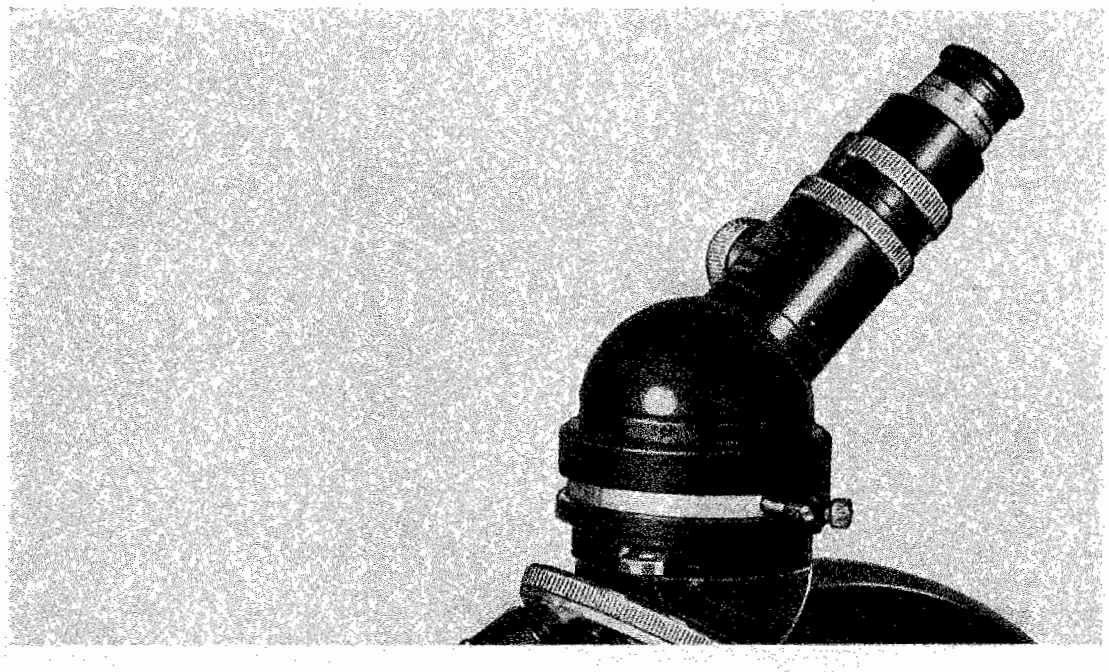
the rotation angle can be read on the graduation scale of the analyzer;

the analyzer can be made effective or ineffective in any position.

The tubes

A rapid changing device permits use of different tubes as well as the placing and changing of intermediate tube pieces which contain optical and mechanical matter for widening the methods of investigation and microscopic measuring procedures. Excepting the straight tube for photomicrography on the STANDARD JUNIOR polarizing microscope, each tube is attachable in adjusted position, and is provided on its upper edge with three notches placed at 45° to each other as guides for the crosshair eyepiece.

For visual microscopy we recommend the inclined tubes because of the convenience in observing. Thus, for example, when working with immersion objectives on specimens in liquid mounting media, the stage can always remain



level. There is no disturbing depolarization effect in any of the instruments due to deflection of rays.

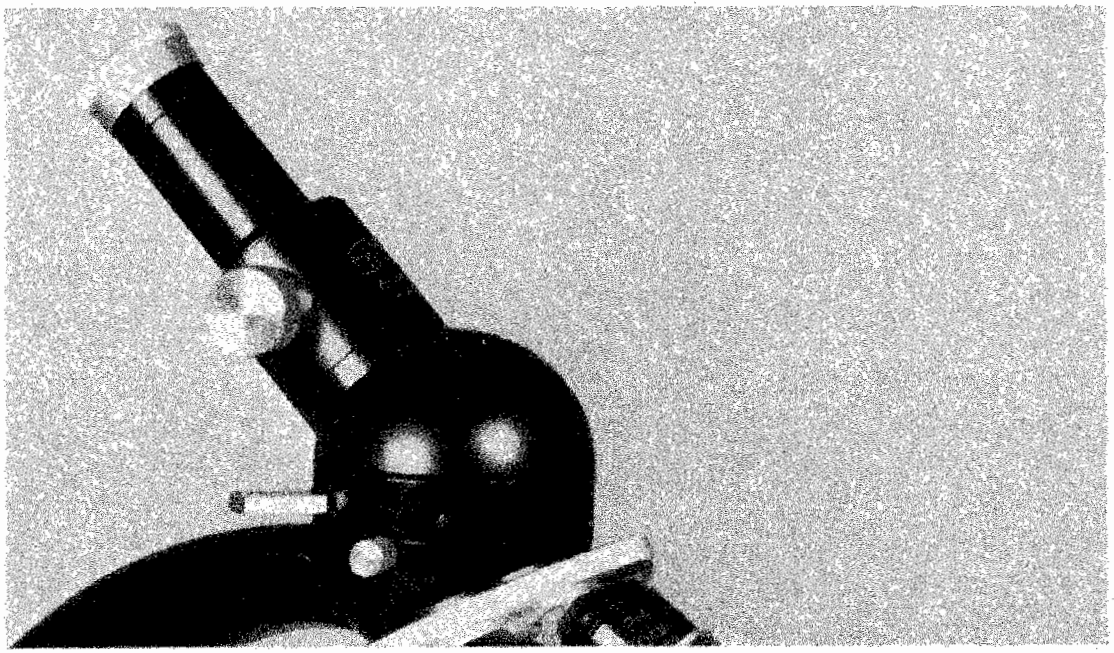
The **monocular axis image tube** is the special tube for polarizing-optical observations and measurements with orthoscopic and conoscopic path of rays. For the investigations in the conoscopic path there is a Bertrand lens which is protected from dust, is centerable, and can be swung in and out. There is a draw-tube with helical arrangement for focusing the conoscopic interference images, and a tube iris-diaphragm for isolating small crystals and for regulating the intensity of the light while observing the axis images. Thus exceptionally sharp and well

illuminated conoscopic interference images can be made. The conoscopic interference images of very small birefringent objects (only a few μ in size) can be recognized.

The monocular axis image tube loses none of its qualities when designed as a straight tube for work in photomicrography and projection.

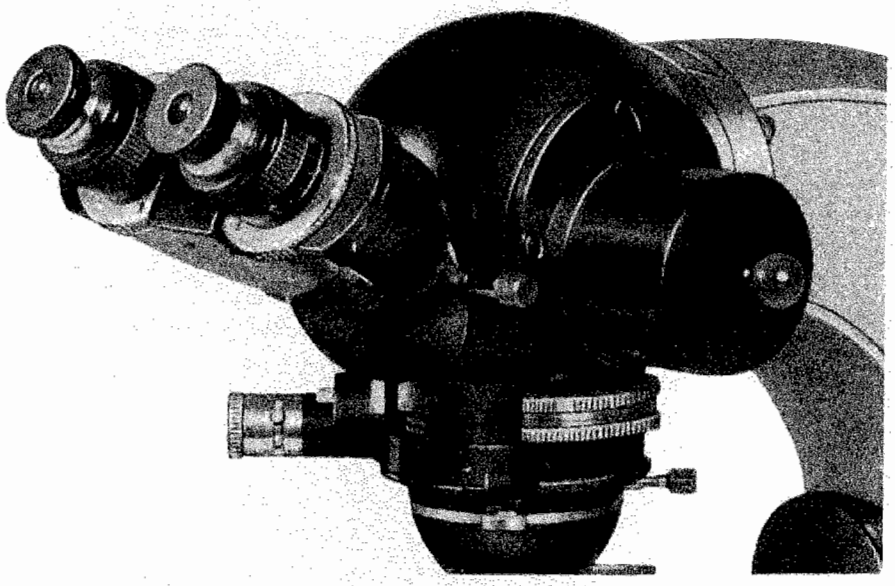
When mounted, the monocular axis image tube is attached to the analyzer intermediate tube, except in use with the ULTRAPHOT II, PHOTOMICROSCOPE and STANDARD UNIVERSAL microscopes, where it is attached to the tube head "POL".

The **monocular polarizing tube I** is a combination of intermediate analyzer tube and observation tube, and is used in simple types of work. The analyzer can be



swung in and out but does not rotate. It is protected from dust by the housing even when swung out. The focusing difference which results from the analyzer is corrected by an auxiliary lens.

There is a slot underneath the analyzer into which auxiliary parts and compensators can be inserted. Rotary compensators can be introduced at any inclination of the crystal plate. The built-in dust-proof Bertrand lens is provided with a diaphragm, and is adjusted in such a way as to bring out a clear conoscopic interference image also of smaller objects with any combination of objective and eyepiece.



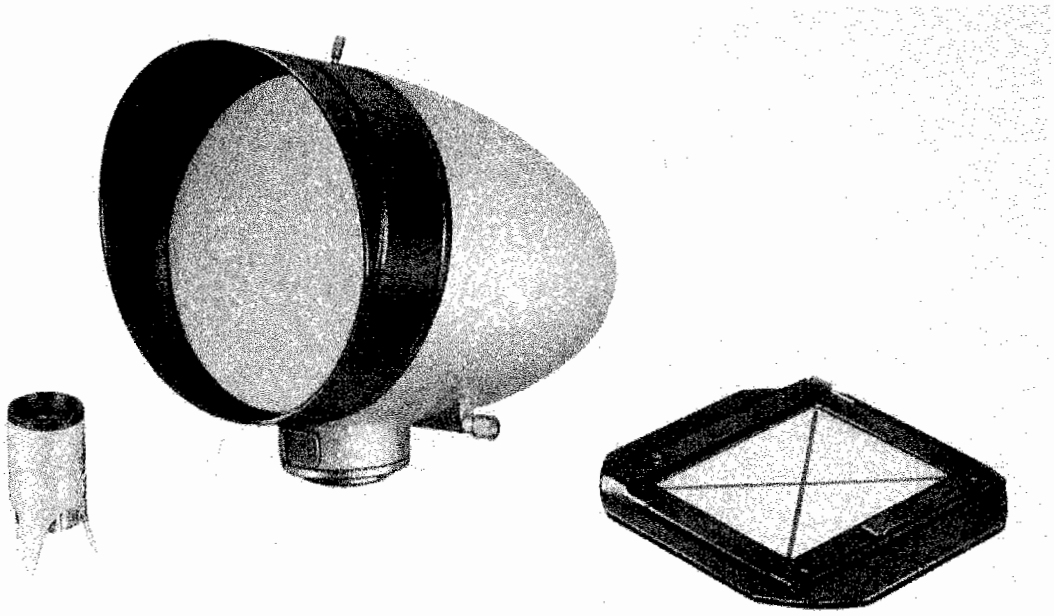
The **binocular inclined tube POL** is especially helpful to the observer in morphological studies, investigation of color phenomena, and in lengthy work periods. The microscopic images are more impressive and the prolonged observations less of a strain when both eyes are used.

This tube was developed when methods were found for removing the disturbing depolarizing effect (analyzer effect) of the beam-splitting prisms and mirrors without bringing about noticeable loss of light*). For carrying this out it has a crystal-optically aligned birefringent plate of a fixed thickness underneath the deflecting prisms. Unlike other experiments with the path of rays for effecting the same thing, this measure ensures a perfectly bright picture, true in color with equal color in the both eyepieces.

Conoscopic observation of larger objects with both eyes is possible by using the Bertrand lens in the OPTOVAR. Likewise, simultaneous observation of the orthoscopic and conoscopic image can be made by leaving one observation eyepiece in its sleeve, and inserting a device for axis image observation (a diaphragm or auxiliary microscope) in the sleeve of the other eyepiece. An adjusted crosshair eyepiece can also be inserted into one of the sleeves.

The tube can be adjusted to any interpupillary distance; the mechanical tube length is variable; enlarged prisms and light apertures permit the use of eyepieces with field of view number up to $y' = 18$.

*) See B. Bordet, Remarques sur le microscope polarisant binoculaire, Bull. Soc. Fr. Univ. 1949.



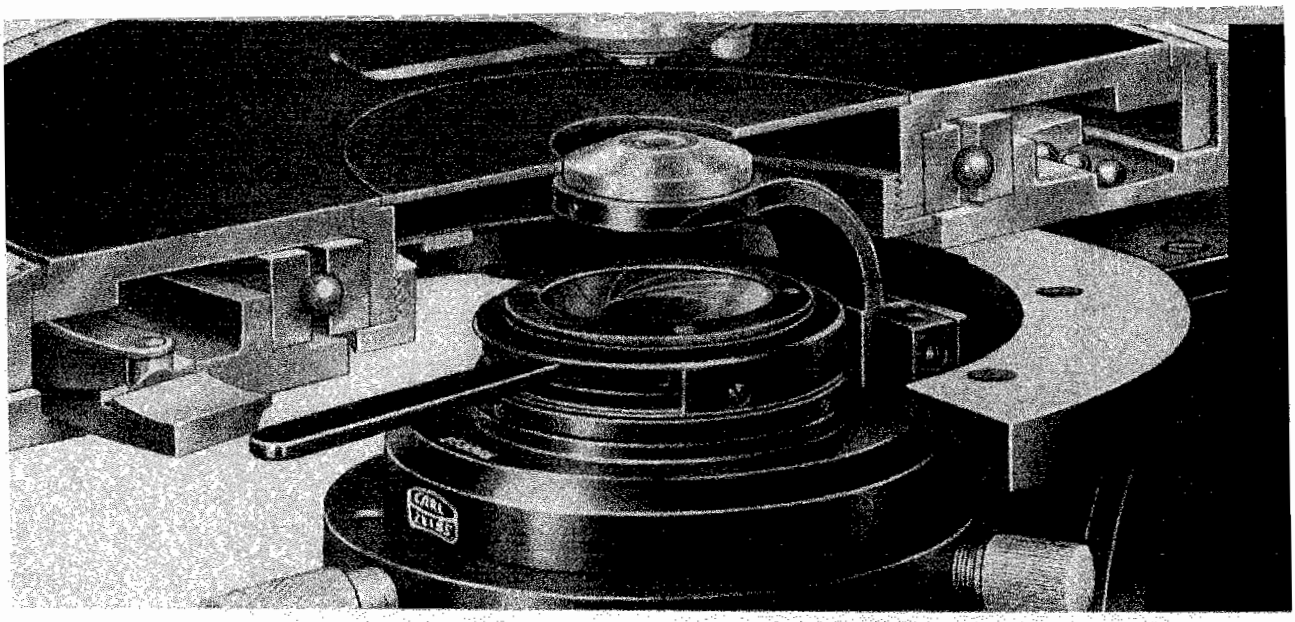
The **straight tube POL** is used in simple, polarizing-optical, photomicrographic work with the attachment camera. It has a pin for alignment when being mounted, and notches for insertion of the crosshair eyepieces. It is used in connection with the intermediate analyzer tube. Microscopes without the intermediate analyzer tube can only use a simple straight tube in which, if necessary, the analyzer can be screwed in from below, while adjusting is done by rotation of the tube.

As the **micro-projection tube POL** is considered a part of the microprojection equipment POL, it will be described on page 72.

The **projection attachment** can be attached to all the ZEISS polarizing microscopes except the ULTRAPHOT II instead of the tubes just described which are for visual observation or for photomicrography with the aid of eyepieces. It is an excellent auxiliary apparatus for observing the microscopic image on a projection area 15 cm. in diameter, and for the demonstration of microscopic specimens in smaller circles. Photomicrographs can be taken with it on plates or 9 x 12 plane film.

Further details will be found in leaflet 40 - 360.

For micro-projection in polarized light stronger light sources are naturally desirable. We therefore recommend a carbon arc lamp or a 12 V - 100 W high efficiency microscope lamp for the projection attachment. If differentiation of color phenomena is not of importance, a high performance microscope lamp with an HBO high-pressure mercury lamp would be the best suited.



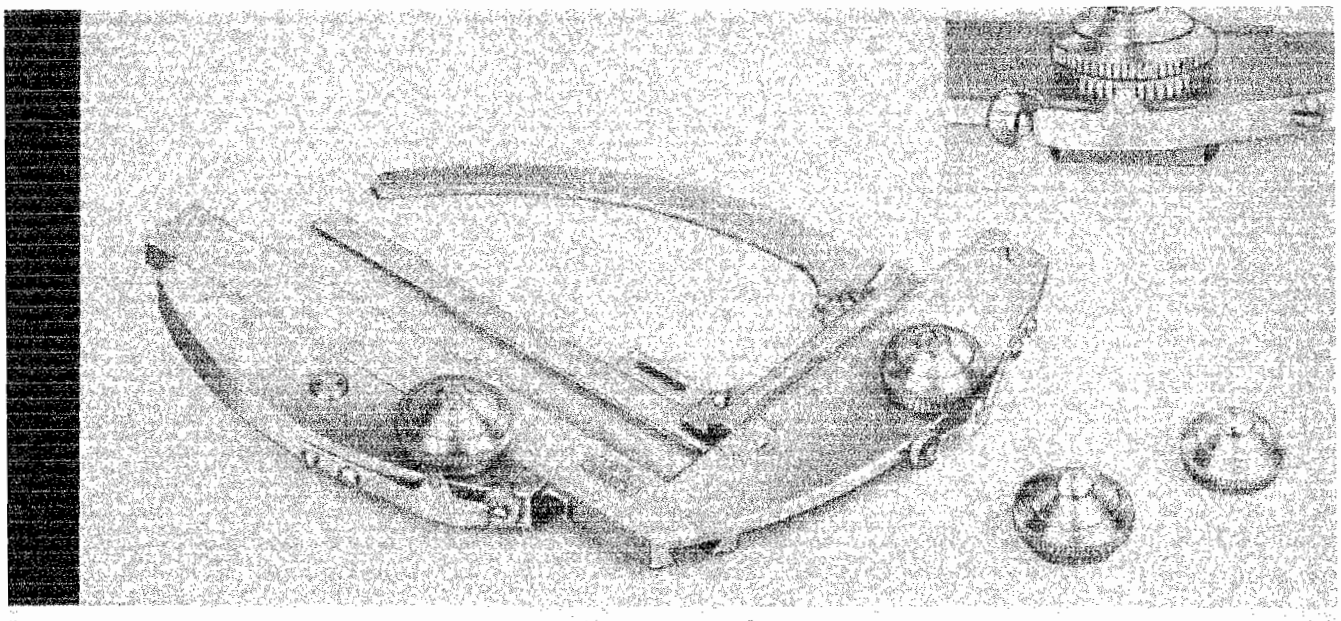
Stages

The **ball-bearing rotary stage** for the polarizing microscope STANDARD JUNIOR is 126 mm. in diameter and has a graduation scale, two verniers for direct reading of the angle of rotation from 0.1°, and a clamping device. The attachable mechanical stage POL can be used with it.

Simple polarizing rotary stage with ball-bearings, solidly mounted on the stage-support of the polarizing microscope STANDARD GFL POL 668 - 655 for general instruction purposes, has a large stage area with a diameter of 160 mm. and possibilities for using the large surface ZEISS Universal Rotary Stage and an attachable mechanical stage POL with a wide shifting range and point counting device. Graduation and 2 verniers adjusted at 90° from each other by which the angle of rotation can be read directly from 0.1°. It also has a clamping device.

The **polarizing rotary stage** with double ball bearings is solidly mounted on the stage-support of the polarizing microscope STANDARD GFL POL 668 – 666, while for the polarizing microscopes STANDARD WL, STANDARD UNIVERSAL, PHOTOMICROSCOPE and ULTRAPHOT II it is mounted on a stage-support that is clamped on. It has a large stage area with a diameter of 160 mm, possibilities for attaching the large-surface ZEISS Universal Rotary Stage, and an attachable mechanical stage POL with a wide shifting range and a point-counting device.

It has a graduation scale and two verniers at 90° from each other on which the angle of rotation can be read directly from 0.1°. It also has a clamping device.



The double ball-bearing arrangement of the polarizing rotary stage makes it possible to hold the stage in any position by a click stop. Each further interval of 45° is marked by a slight click, as for example the marking of the starting azimuth for the Universal Stage, or the change over to a diagonal position in determining optical directions. More delicate rotating motions of the stage can be controlled by a fine precision drive which can be connected at will.

The **attachable mechanical stage POL** is for the cross-guiding of the objects as well as for distinguishing specific parts in the specimen. Its range of motion is 30 x 40 mm. when used with the polarizing rotary stage and the simple polarizing rotary stage; the range is 20 x 25 mm. when used with the ball-bearing rotary stage of the STANDARD JUNIOR POL. Specimen slides of all usual sizes can be used. The attachable mechanical stage POL is so flat, that notwithstanding the large range of motion for the object no contact of the mechanical stage with the objective is possible on changing the objective even though it be done with the revolving nosepiece.

Point counter for the attachable mechanical stage POL.

For applying the point counter method which again is attracting attention, the attachable mechanical stage POL is perfected to the point where counting can begin immediately on insertion of the detachable click knobs. These knobs are used in place of the ordinary type without click, and stop at intervals of 0.2 or 0.3 mm. The counting process can be still further simplified with the aid of a common mechanical or electrical counter.

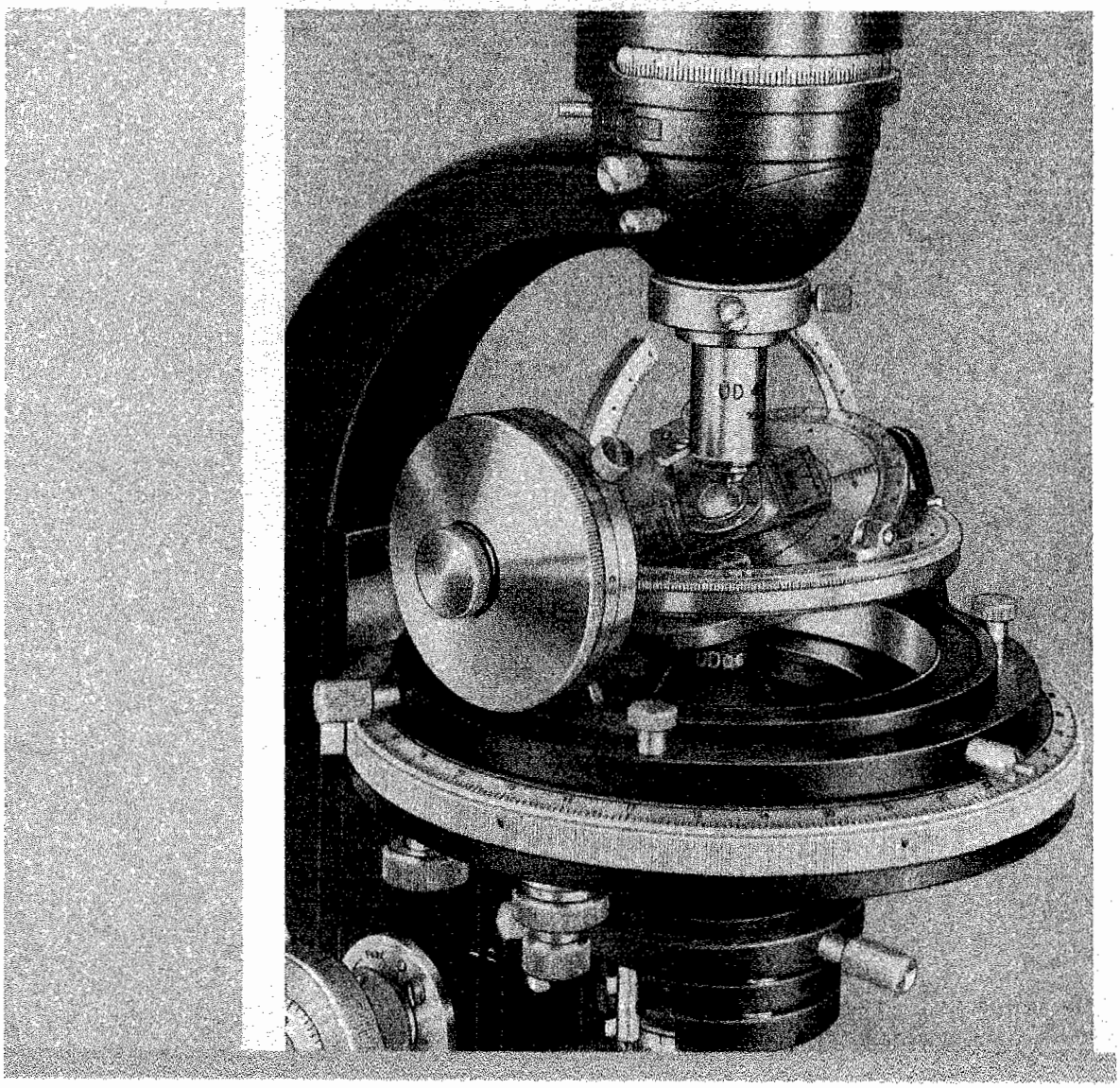
The four-axis Universal Stage and accessories

This Universal Stage is distinguished for its large stage surface, a large tilting range also in conoscopic observation, and by convenient manipulation. It can be attached to the polarizing rotary stages of the microscopes STANDARD GFL POL, STANDARD WL POL, PHOTOMICROSCOPE POL and ULTRAPHOT II POL.

The Universal Rotary Stage is especially meant for use in connection with the instruments just named. It can only be used with microscopes made by other manufactures if the diameter of the microscope stage is at least 160 mm., and if three threaded holes can be fitted in for fastening it.

Mainly because of its higher stability the four-axis Universal stage has advantages over the five-axis stage. This is especially remarkable when high-power objectives are used.

The Universal Rotary Stage is fastened to the microscope stage by a centering device. Its central stage area has a diameter of 86 mm. The height adjustment of the specimen is taken care of by a threaded ring with special handles so that the specimen cannot be moved out of place unintentionally during the height



adjustment. Since the specimen slide is placed directly on the lower hemispherical segment, a large tilting range (60° in orthoscopic, and about 55° toward each side in conoscopic observation) is possible also in conoscopic observation which is steadily taking on more importance as compared with classical orthoscopic observation methods.

Both hemispheres are fastened to a common base plate which also holds the specimen. Thereby it is easy to change the specimen or the hemisphere outside the stage. The distance between the two hemispheres can be adjusted at will. This prevents the specimen from "sticking" because of the adhesion of the contact fluid, and it remains mobile. Furthermore, when using fluid media there is no need to fear that the specimen will be crushed if the usual precautions are taken. In this case the specimen edge can be sealed off by substance insoluble in the immersion liquid (border lacquer).

The hemispheres with small radius, first introduced by us, are particularly suitable for conoscopic observation as they permit not only the use of powerful dry objectives but, for the first time, also the use of high illumination and observation apertures.

We can supply two groups of segments, each with a small upper, a large upper, and a lower segment. Group 1 is with the refractive index $n_D = 1.555$; group 2 with the refractive index $n_D = 1.649$. Segments with other refractive indices are available on special order.

Suggestions as to the most practical application of small or large upper hemispheres are given in H. Piller's article "Bemerkungen über den Einfluss der Segmentgrösse und Präparatdicke auf die Genauigkeit bei der Messung von Neigungswinkeln mit dem Universaldrehtisch", Mikroskopie, Band 12, 1957.

Measurements of the inclination angle can be made with the Wright's arcs which can be swung out on either side and have graduated scales on both sides, or from the large divided drum with graduation scales and vernier for direct reading to 0.1°.

For work with the Universal Stage, UD achromats are essential. Each of these (excepting the UD achromat 6.3/0.12) has two diaphragms inserted which limit the objective apertures, thereby contributing to the contrast comparison with crossed analyzer and polarizer. These special objectives are mounted in compact form and ensure a large working distance. When used on the STANDARD GFL polarizing microscope they need an intermediate ring.

The achromats UD 6.3/0.12 and UD 16/0.12 are used in orthoscopic investigation. The achromats UD 20/0.57 C and 40/0.65 C are used in both orthoscopic and conoscopic investigation. The latter two are distinguished by their high numerical aperture and relatively large working distance.

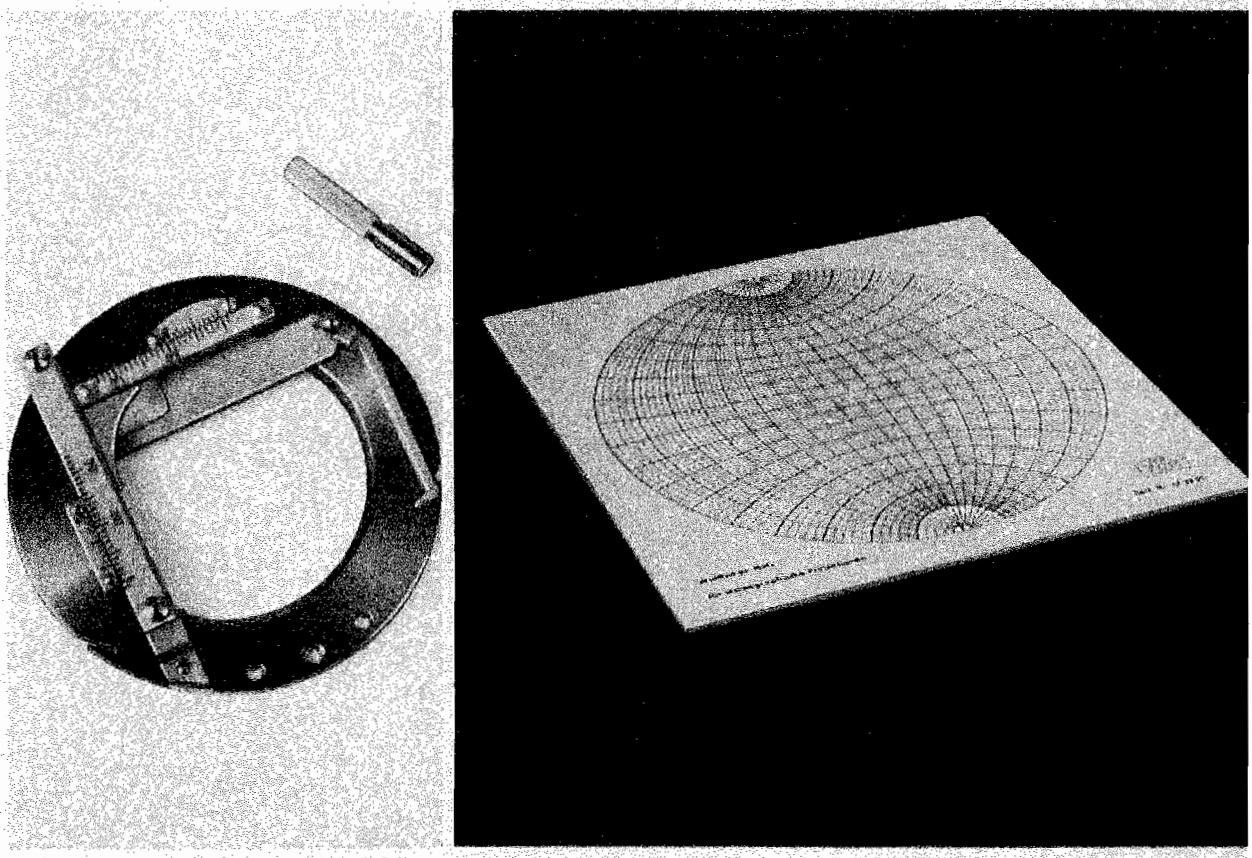
The **condenser UD 0.6** makes excellent illumination of the conoscopic interference image possible when used with the Universal Stage. It is placed in the centerable condenser carrier just like any other condenser. It also permits adjustment of the illumination by KOEHLER's principle.

When the Universal Stage is used with the polarizing microscope STANDARD GFL, a protecting bracket prevents the objective from being destroyed by hitting the upper hemispherical segment during the focusing.

Mechanical stage and parallel guides to be used with the Universal Stage, with range of motion larger than usual. The range of motion of the mechanical stage is 15 x 15 mm.; that of the parallel guide is 40 x 30 mm. The coordinates of the mechanical stage are made to agree with those of the attachable mechanical stage POL as supplied for our rotary stages. Thus an object microscopically

adjusted without the Universal Stage will appear immediately in the field of view when placed on the same coordinates on the Universal Stage. With the mechanical stage both the coordinates can be determined, with the parallel guide only one.

In connection with this mechanical stage object slides 26 x 46 mm. and 26 x 48 mm. can be used. Larger specimen slides must have their edges grounded off



correspondingly. Both these devices for the adjustable displacement of specimens are part of the normal equipment of the Universal Stage.

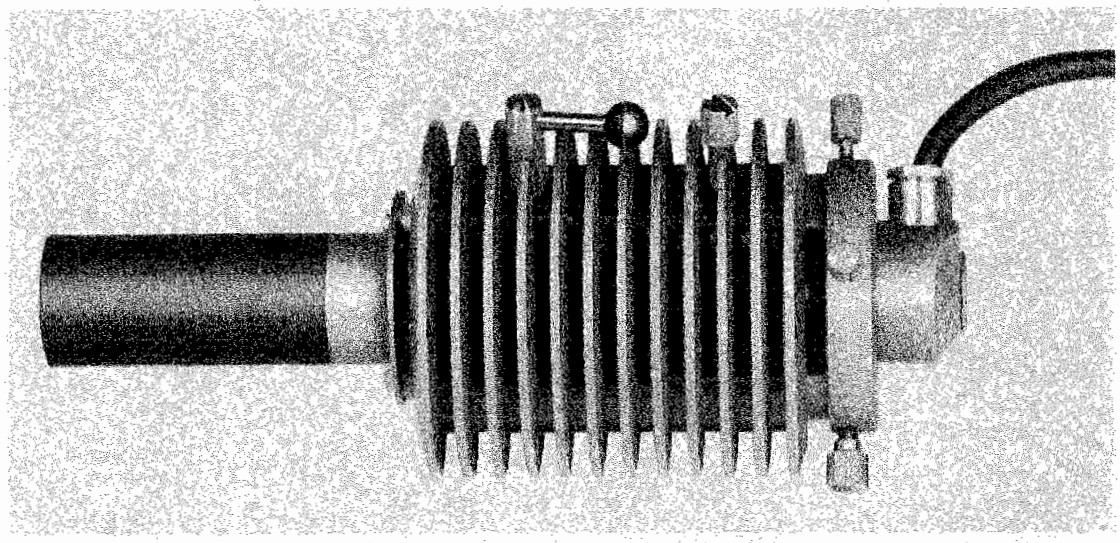
A Wulff's net for stereographic projection is available for plotting measurements made on the Universal Stage. It is etched on a metal plate with a non-sliding foam rubber base, is washable and scratch-proof. The diameter is 20 cm. The tracing paper for drawings is placed over the net and can be turned around an axis-forming pin.

Light sources for white and monochromatic light.

With the exception of the STANDARD JUNIOR, the ZEISS microscopes have built-in and solidly adjusted illumination equipment for investigations in transmitted light.

The built-in low-voltage 6 V – 15 W (2.5 A) lamp for the STANDARD GFL, STANDARD WL, STANDARD UNIVERSAL and the PHOTOMICROSCOPE is in the

12 V 60 W (5 A) lamp



base of the stand which also holds the three-lens collector. With the STANDARD UNIVERSAL and the PHOTOMICROSCOPE this light source is also suitable for incident light observations; the other microscopes, however, must use Epi-condensers A or B, which have their own 6 V – 15 W (2.5 A) illumination equipment.

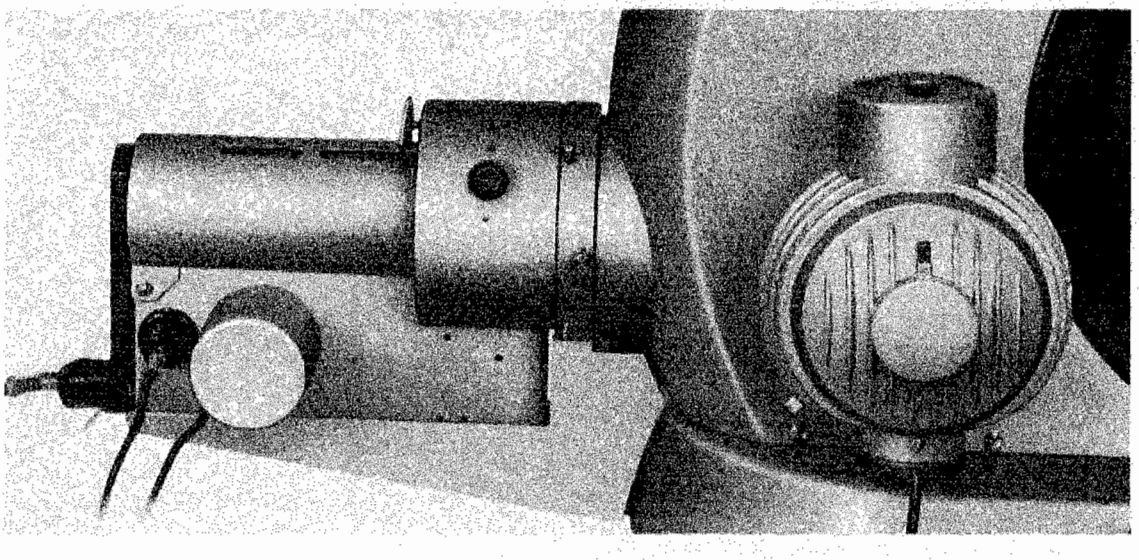
A 12 V – 60 W (5 A) lamp can be used in the base of the STANDARD UNIVERSAL or the PHOTOMICROSCOPE instead of the built-in lamp. This stronger light

source is used when special investigation procedures such as ore microscopy, coal petrography or interference microscopy require a higher light intensity.

The equipment that comes with the camera microscope ULTRAPHOT II includes a lamp house in which a 12 V – 100 W (8 A) lamp is mounted.

All of the light sources enumerated above permit the application of KOEHLER's illumination principle.

Multi-purpose microscope lamp and carbon arc lamp attached to ULTRAPHOT II

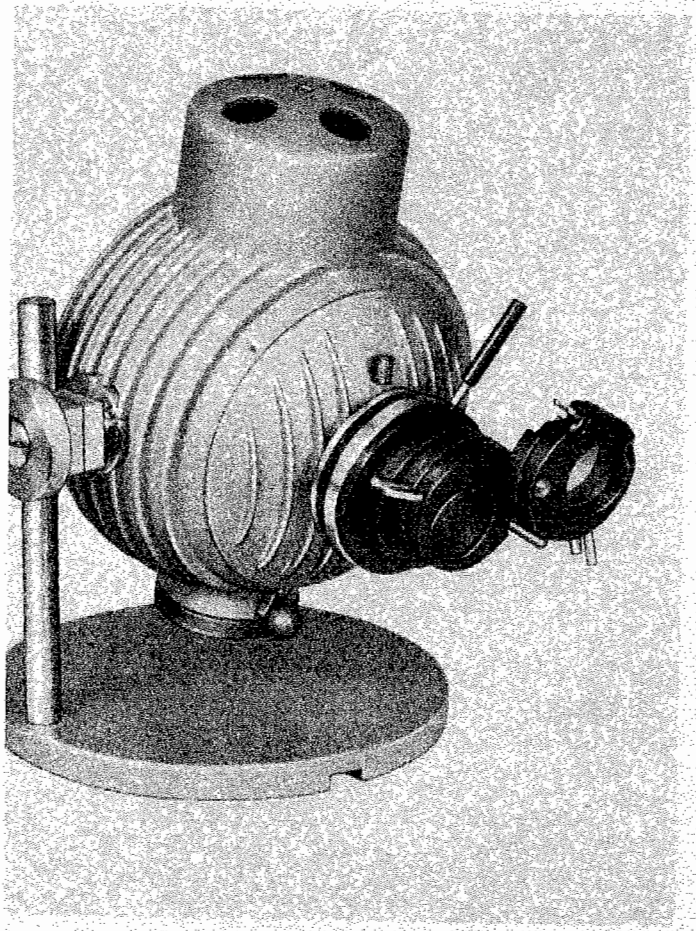


For the STANDARD JUNIOR microscope we supply either the **attachable lamp** for direct connection to the power supply as the simplest artificial light source, or the

6 V – 15 W (2.5 A) **attachable low-voltage illuminator.**

Neither one of these has a radiant field stop, consequently the KOEHLER method cannot be followed. If KOEHLER's illumination method is to be applied with the STANDARD JUNIOR, the 6 V – 15 W (2.5 A) low-voltage **microscope lamp,** which is on a stand with a three-lens collector and a radiant field stop, should be used.

For cases where more powerful light intensities are needed, we have available for use on the microscopes STANDARD JUNIOR, STANDARD GFL and STANDARD WL a **multi-purpose microscope lamp** which comes on a stand.



Any of the following can be used with it:

a) lamp mount with 12 V – 100 W (8 A) incandescent lamp;

b) lamp mount with high-pressure mercury lamp HBO 74;

c) lamp mount with high-pressure mercury lamp HBO 200;

d) lamp mount with sodium spectral lamp.

There is also a **microscope carbon arc lamp** on a stand in models

a) with clock-work mechanism, and

b) with automatic carbon advance.

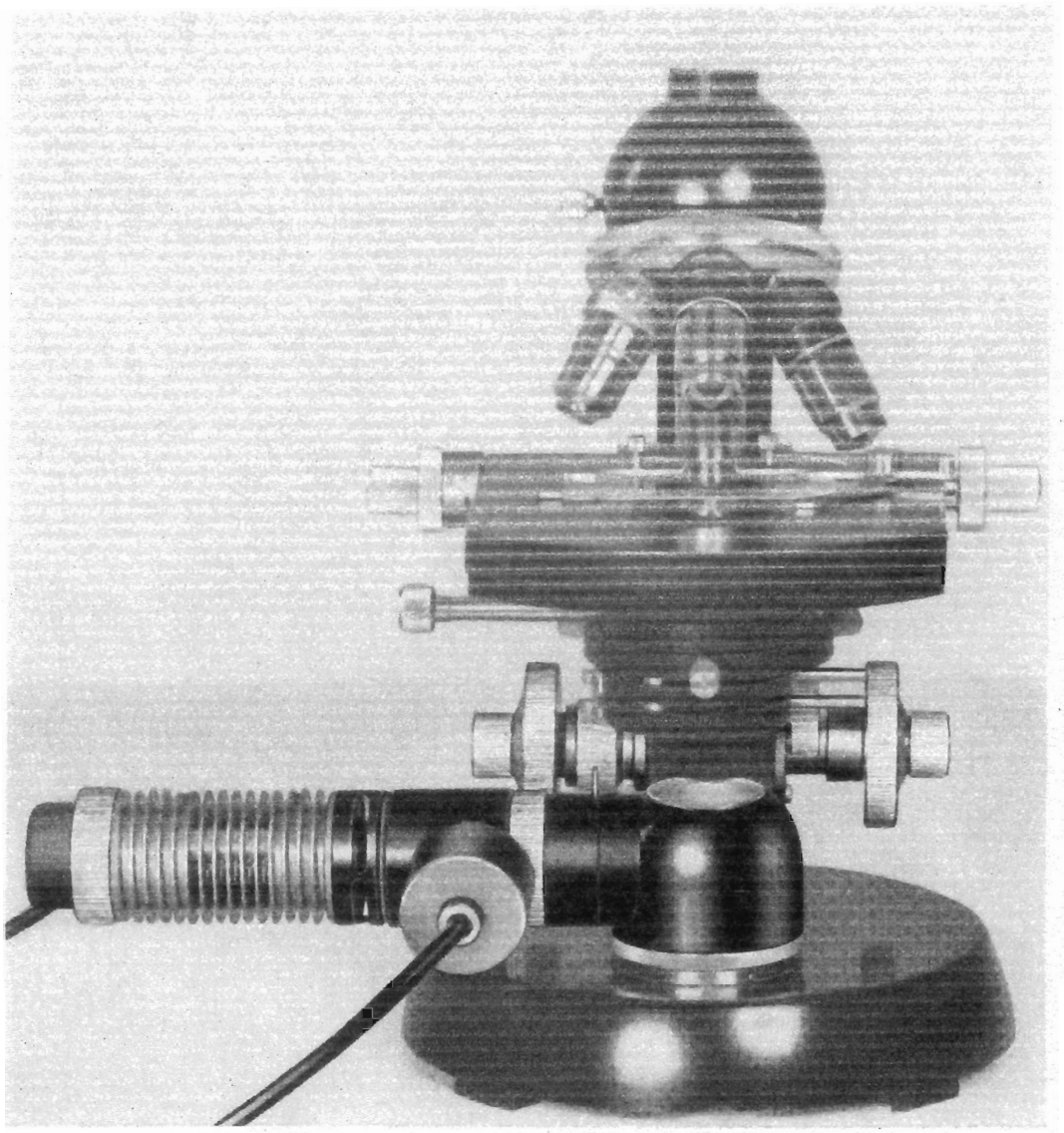
Monochromatic light can be obtained by the use of filters.

There is a **special illuminating apparatus** with a multi-purpose microscope lamp or a carbon arc lamp with similar properties for the STANDARD UNIVERSAL microscope and PHOTOMICROSCOPE.

Connections to the power supply

For the use of built-in lamps, attachable low-voltage lamps and low-voltage microscope lamps, a plug-in transformer 5/6/8/V is generally all that is required. A regulating transformer is also available with which it is possible to regulate the secondary voltage from 2 – 8 V (3.5 A), 30 VA. The multi-purpose microscope lamp is connected either by a transformer 10/12/15 V, 100 VA, by a regulating transformer 3 – 15 V (8 A), 120 VA or by a special connecting device for high-pressure mercury and sodium spectral lamps.

The **micro-flash apparatus** is an excellent light source for the photomicrography of rapidly moving bodies, as for instance suspension with Brownian molecular movement of the smallest mineral particles in suspending fluid.



The micro-flash apparatus has two light sources:

a) the observation light source in prolongation of the optical axis, always burning, and

b) the special flash-tubes for a series of flashes with intervals of only 3 seconds.

The apparatus is hardly any larger than a low-voltage attachment lamp.

By the use of a special flash-tube a very high light intensity can be obtained because of the compressed discharge, in spite of the low electrical energy of 30 or 60 Watt seconds needed.

All of the above-mentioned light sources are described in detail in leaflet 40 - 340.

LIGHT FILTERS

There are **blue glasses** for the assimilation of the light of the incandescent lamp to day-light;

neutral filters for regulating the brightness;

grey filters for regulating the light also in color photomicrography.

The grey filters give an absolutely neutral as to color, and exceedingly even transmission in the entire spectral region that makes them especially suited to polarizing-optical investigation in connection with photomicrography.

A set consisting of 4 grey filters makes possible a weakening of light by degrees 1 : 2, from 50 % up to 0.75 %.

Combination possibilities:

Light transmittance	100 %	50 %	25 %	12 %	6 %	3 %	1.5 %	0,75 %
Filter	–	50	50 + 50	12	12 + 50	3	3 + 50	3 + 50 + 50

As our illumination arrangements follow KOEHLER's method, it is unnecessary to use ground glasses besides.

Interference filters
for generation of monochromatic and nearly monochromatic light are manufactured by Schott & Gen., Mainz

They have a high degree of transmittance and are easy to handle. They can be combined with any microscope lamp to supply a sufficiently monochromatic, bright light source for polarizing microscopic and ore microscopic investigations.

The following are available according to the list:

Interference broad-band filter, green, $\lambda = 546\ m\mu$;
interference band filter, green, $\lambda = 546\ m\mu$;
precision line filter PIL 546 $m\mu$.

The last one is used especially for polarizing-optical and interference-microscopic measurements.

(See leaflet: Schott-Interferenzfilter.)

Continuous Running Filter Monochromator

The continuous running filter monochromator is the easiest and most convenient means by which microscope lamps can be converted into a monochromatic light source. It contains a continuous running interference filter manufactured by the Jenaer Glass factory Schott & Gen., Mainz.

Its transmittance range is changeable without stages between around 400 $m\mu$ and 750 $m\mu$;

its transmittance degree is about 30 %;

its width at half maximum intensity around ~ 14 $m\mu$.

This filter, the monochromasy of which is approximately constant up to an aperture diameter of 5 mm., has a frame calibrated in light-wave lengths which has, besides, an aperture for free passage of light. With this it is inserted into a filter holder with adjustment marks for the microscopes STANDARD GFL POL, STANDARD WL POL, STANDARD UNIVERSAL POL, PHOTOMICROSCOPE POL and ULTRAPHOT II POL, and placed in the base of the instrument.

The fastening of the monochromator in front of the multi-purpose microscope lamp is done with another filter holder; when used in epi-microscopy it can be brought directly into the illuminating path of rays.

(See the leaflet Schott-Interferenzfilter.)

Polarizing filters

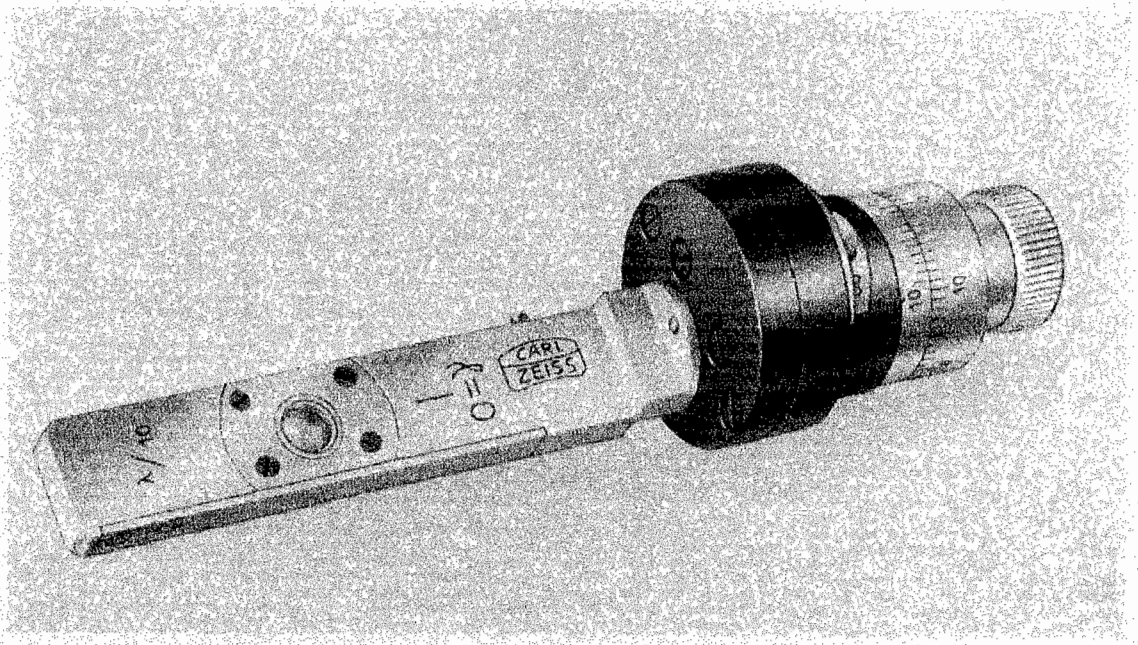
The ZEISS polarizing filters contain a foil neutral in color with a very high polarizing degree (on the average, greater than that of POL prisms!). It is free from disturbing absorption and resistant to dampness and higher temperatures to a considerable extent.

Thus they have essential advantages with regard to the path of rays in the illumination and image-forming space which result in a heightening of contrasts with crossed polarizer and analyzer, and in improved quality of the image. A special device makes possible simultaneous rotation of polarizer and analyzer (see page 43).

AUXILIARY DEVICES

As a help for determining the optical character of birefringent substances, we supply various devices that can be inserted in the slots below the analyzer or above the polarizer.

Auxiliary object 1st order red and auxiliary object λ 4 are for preparations with slight phase differences; the quartz wedge 1st to 3rd order is for preparations with greater phase differences.



Compensators

These are elliptic compensators with rotary mica plates after Brace-Koehler for quantitative measurement of the smallest phase differences up to λ/10, λ/20 or λ/30.

These three compensators, much used for birefringent biological objects, differ externally only by the engravings on their mounts which give the values for each one of the maximum phase difference (λ/10, λ/20 or λ/30) to be compensated. These are nominal values. In the instructions that come with the compensator the number of the instrument is given with the calibration value for each case as measured by us. The calibration values are stated for the wave-lengths of the C, D, E and F lines.

The λ/4 mica plate for compensation by Senarmont's method is used in determining smaller phase differences up to 1 λ.

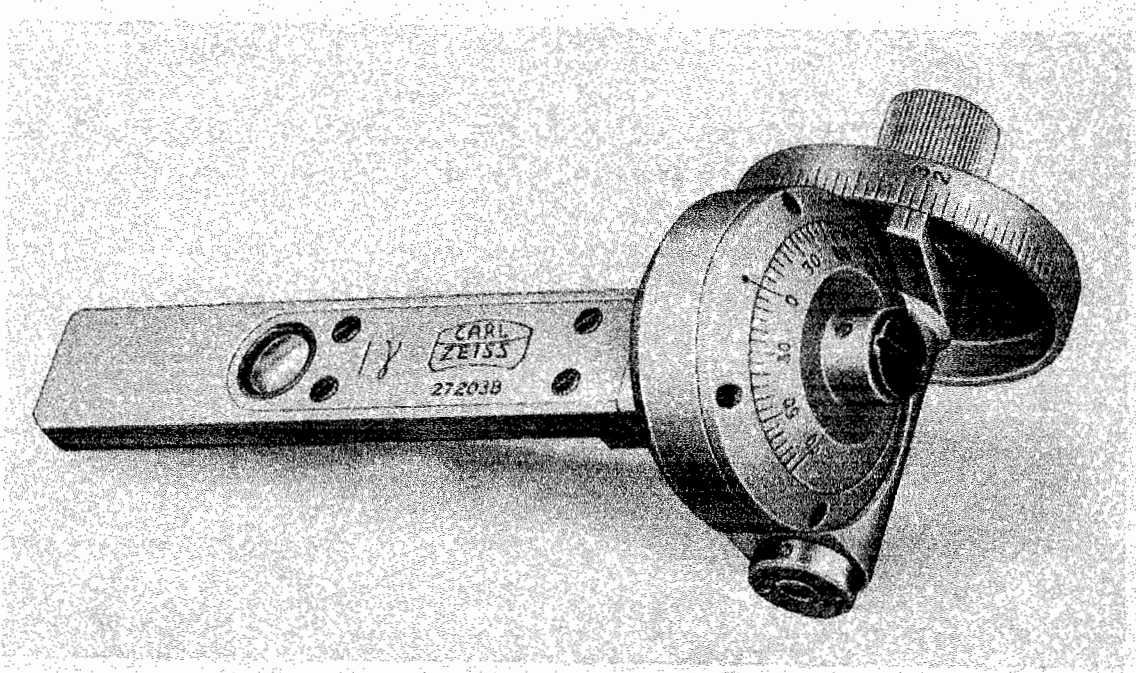
It should only be used on microscopes that have a rotary analyzer.

This mica disk is adjusted in its mount in such a way that the vibration direction

after insertion into the tube slot is either parallel or perpendicular to that of the polarizer. The compensation is based on the transformation of the elliptical vibrations produced by the object into a linear vibration with fixed azimuth. The phase difference is ascertained by rotating the analyzer up to the position of maximum extinction in the specimen.

Compensation by the Senarmont method is only possible in monochromatic light. The $\lambda/4$ value of the mica disk is adjusted to the wavelength of $\lambda = 589\ m\mu$ (D-line of sodium light).

Another quartzer wave plate for the e-line of mercury light $\lambda = 546\ m\mu$. (See



page 66 1 - 6) exists for transmitted-light interference microscopy. Plates for other wavelengths on request.

The Ehringhaus rotary compensator with quartz plates is for determining medium phase differences up to 7 orders (7 λ);

the Ehringhaus rotary compensator with calcite plates is for determining large phase differences up to 122 orders (122 λ).

These rotary compensators are becoming more and more popular for measurements of small, medium and larger phase differences because they are so easy to handle. Two plates of equal thickness, cut parallel to the optical axis of a uni-axial crystal and superimposed at right angles, form the compensating element. In comparison with rotary compensators that have only one plate, this arrangement results in a larger measuring range and a higher degree of measuring accuracy. The phase difference can be read directly from the table that comes with the instrument.

Simultaneous use of two auxiliary devices or compensators

In special cases, for example as a means for increasing the measuring range or for compensation of residual strains, in illumination or image-forming optics, it is an advantage to work with two compensators at the same time.

If two $\lambda/4$ plates are placed in the path of rays, one below and the other above the birefringent object, with their vibration direction at right angles they bring out the interference contrasts or interference colors. Thereby in differently placed objects there will be no added intensity variation in like colors due to the azimuth, or position of rotation, of the microscope stage. In such cases one compensator or auxiliary device is placed in the slot of the tube, and the other in the opening that is made in the mount of the polarizer.

All auxiliary devices and compensators come in mounts which fit into the usual 12 x 4 mm. tube slot. The catch of the mount is adjusted to the microscopes of our manufacture unless otherwise requested. In case the compensators are to be used with other makes or older models, we would have to have the distance from the center of the tube to its outer edge, the place for the catch, in order to make the proper adjustment.

If monochromatic light is needed when working with compensators, we recommend the use of interference filters. These can be inserted in the holder in the illuminating unit of the microscope just as any other light filter. The interference monochromator filter can be used in all cases. Its range of light transmission is sufficiently restricted, and it has the advantage when compared with a monochromator that it can be conveniently combined with any light source without effecting additional geometric narrowing of the light path. Moreover, loss of light is far less than with a monochromator. Details concerning light filters are given on page 58.

Phase contrast microscopy with polarized light

A number of recent works*) show the importance of phase contrast microscopy in investigating crystalline and glassy substances, especially if very fine grained. We have therefore made in possible to combine the phase contrast equipment with the polarizing microscope. The ZEISS phase contrast equipment is distinguished for its ease in manipulation and its outstanding phase contrast as well as bright field effect.

A phase contrast equipment is made up of phase contrast objectives and a phase contrast condenser. It contains a revolving disk on which annular condenser diaphragms with graded diameter are arranged which always remain effective in the same way after each switching over. Thus it ensures the reproducibility of the contrast effects, the interpretation of which forms the basis of the crystal-optical identification of the specimen under investigation.

The phase contrast condenser II Z POL (n. A. 0.9) can be used at the same time for the classical polarizing-optical methods including interference image observation.

As phase contrast objectives have no centering mounts they are attached to the microscope stand by means of centerable slide changers or by a centerable changing ring and holder for single objectives.

For centering the annular condenser diaphragms to the phase plates of the objectives, the Bertrand lens must be made effective. This replaces the auxiliary microscope that usually comes with phase contrast arrangements.

ZEISS phase contrast equipment is described in detail in leaflet 40 – 160.

The phase contrast condenser I S in the usual model not free from strain is available for use with the microscope STANDARD JUNIOR POL. A polarizer cannot be used together with it. Phase contrast investigations in polarized light are possible by using the analyzer.

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*) See bibliography at the end of this work.

Dark field microscopy

Dark field microscopy is especially suited to observation of morphological properties of very small objects (inclusions, edges, crevices etc), and for the study of diffraction phenomena of submicroscopic particles, in other words, to ultramicroscopic methods.

ZEISS polarizing microscopes can also be used for these methods by changing the condenser and selecting suitable objectives.

The following are the condensers available:

Ultra-condenser 1.1/1.2 Z,
preferably for objectives with apertures between 0.8 and 1.0

Dry dark-field condenser 0.8/0.95 Z, preferably for dry objectives with apertures between 0.6 and 0.75

Dry dark field condenser 0.65/0.85 Z, preferably for dry objectives with apertures between 0.4 and 0.6

Bright-field phase-contrast and dark-field condenser III Z, which can be used for any of the above three microscopy methods.

If these condensers are to be used on the microscope STANDARD JUNIOR POL, the S model (sliding sleeve) should be taken instead of the Z (centering mount).

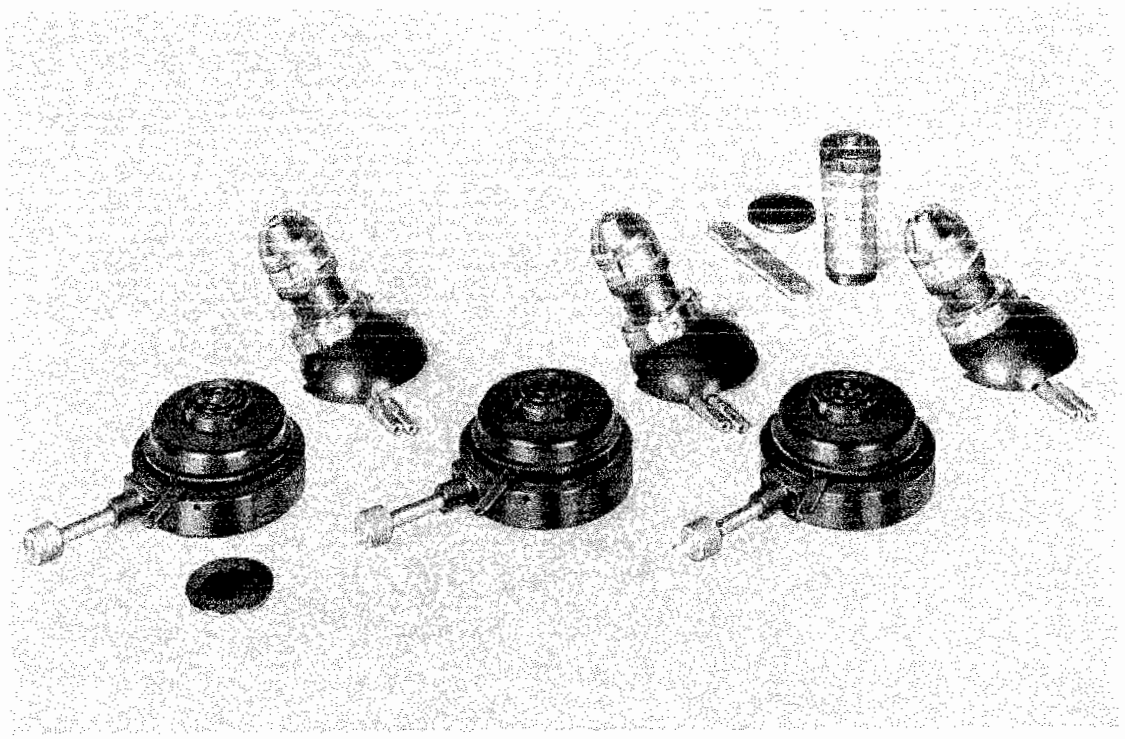
The bright-field phase-contrast dark-field condenser only comes in model Z.

Fluorescence microscopy

In recognition of the fact that contemporary microscopic research calls for the application of the most varied microscopy methods when dealing with a special problem, we have also turned our attention to the development of fluorescence equipment to be used with polarizing microscopes.

This equipment is for visual observation and for photomicrography in transmitted light. It is used for investigation of fluorescing substances and for the identification, to give another example, of particles which show specific fluorescences when stained with fluorescent dyes. The STANDARD GFL and STANDARD WL microscopes have an intermediate filter tube with eight suppression filters instead of the intermediate analyzer tube. In fluorescence investigation with the STANDARD UNIVERSAL, PHOTOMICROSCOPE and ULTRAPHOT II, two suppression filter slides each holding 4 suppression filters are used instead of the intermediate filter tube.

Fluorescence equipment is described in detail in leaflet 40 – 215.



Interference equipment for transmitted-light

The ZEISS polarizing microscopes, excepting the STANDARD JUNIOR, can be fitted with transmitted-light interference equipment which gives still further possibilities in polarizing-optical investigations and measuring procedures. In principle, these effects and their application go back to the works of Jamin (1868) and Lebedeff (1935). At that time, however, there was not yet the technical perfection in optical calculation and achievement necessary for the development of the means to meet the highest demands in quality of image, contrast and magnification, together with convenience in manipulation and utmost accuracy in measurements.

The range of application includes: measurement of the smallest optical thickness differences in the object or between it and its surroundings; measurement of phase differences in inorganic and organic live or lifeless substances; increasing the contrast in the microscopic image; focusing of a specific density or color in fixed object elements. The measurements can be used as a basis for ascertaining the refractive indices or thicknesses of single object elements as well as their gradual or continuous alteration.

The essential parts of a transmitted-light interference equipment are:

Interference attachment I = Achromat Int. POL I, 10/0.22, Condenser Int. POL I;

Interference attachment II = Achromat Int. POL II 40/0.65, Condenser Int. POL II;

Interference attachment III = Achromat Int. POL III, 100/1.0 Oil, Condenser Int. POL III.

These are interchangeable on the microscope just as all the other objectives and condensers.

For phase difference measurements in the usual manner as done by simple polarizing-optical methods with condensers see page 60.

For interference color filters for measurements with monochromatic light and spectral lamps see pages 56 and 58.

Details on transmitted-light interference equipment will be found in leaflet 40 – 560.

Additional devices for photomicrography

Any one of the ZEISS polarizing microscopes, if not already fitted with an automatically controlled built-in camera, can be converted by supplementary equipment into a photomicrographic apparatus.

The most usual supplementary equipment is the ZEISS attachment camera.

Micro-photos in combination with a compound microscope (using objective and eyepiece), and

survey photographs in combination with a simple microscope (using LUMINARS, but without eyepiece)

can be made with it.

For micro-photos, the basic unit I or basic unit II is placed on a straight tube and connected to a camera attachment. The following can be used:

camera attachment 24 x 36 mm. with shutter (for miniature film 24 x 36 mm.);

camera attachment 6.5 x 9 cm. with shutter (for plates and 6.5 x 9 cm. plane film);

roll-film plate holder 6 x 6 cm. (for 6 x 6 cm. roll-film);

Contax camera-housing or a similar make with a corresponding attachment piece (for miniature film 24 x 36 mm.).

Focusing of the image is done by means of an adjusting eyepiece on the basic unit.

Although basic unit I has a solidly built-in optical system, basic unit II has an adjustable beam-splitting prism which makes it possible to deflect the rays in five different manners. Since its beam-splitting prism can be made ineffective and depolarizing phenomena can be prevented, the use of basic unit II is recommended for polarizing-optical investigations. When photographing conoscopic interference images, an auxiliary microscope should be inserted instead of the eyepiece.

For survey photographs, the camera attachment 6.5 x 9 cm. with shutter (for plates and 6.5 x 9 cm. plane film) is to be placed directly on the tube carrier, in other words instead of the tube, of the microscope. Focusing of the image is done by the adjusting eyepiece on the ground glass with clear cross of the camera attachment. The objectives to be used are LUMINARS in conjunction with the corresponding spectral-glass condensers.

especially useful in color photomicrography can be used with any of the camera arrangements just decribed. A vacuum photo cell is attached to the basic unit of the camera or to the camera attachment 6.5 x 9 cm. and connected to a 4-stage amplifier which contains the amplifying system and indicates the photo-electric current. The exposure time is gotten from a table. The sensitivity of this device is greater than that of a barrier type cell, and is accordingly also sufficient for work with crossed polarizer and analyzer.

Leaflet 40 – 410 gives further information on the ZEISS attachment camera.

The projection attachment with 9 x 12 photo inset makes possible photomicrographic work with plates or 9 x 12 cm. plane film. For this purpose it is used instead of the tube, except on ULTRAPHOT II. Smaller formats can be marked off with appropriate reduced enclosures. The projection attachment has a built-in projective with a 10 x magnification factor which takes over the functions of an eyepiece, thus permitting photographs to be made only with the compound microscope.

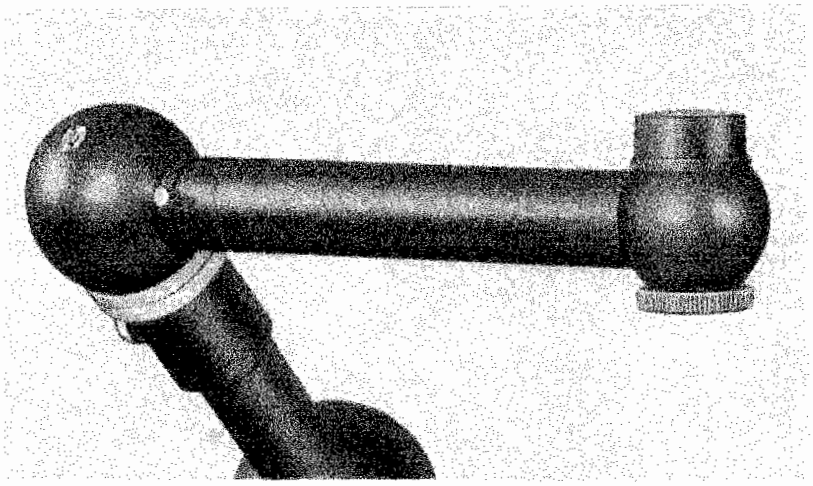
The scale of the image depends on the magnification of the individual objective and can lie between 10 : 1 and 1000 : 1. With the PHOTOMICROSCOPE POL and STANDARD UNIVERSAL POL the factors 1.25, 1.6 or 2.0 of the solidly built-in OPTOVAR are likewise to be considered, as they effect correspondingly greater image scales.

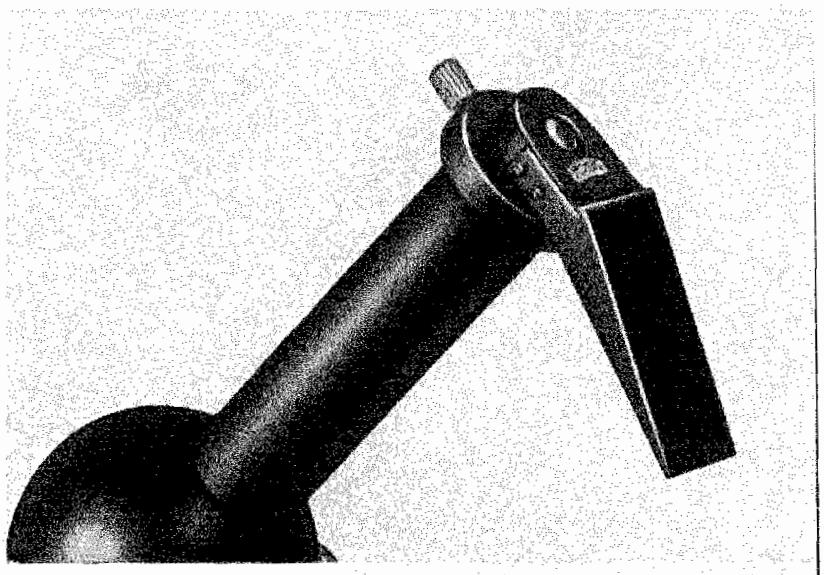
The projection attachment is mentioned on page 47 and described in leaflet 40 – 360.

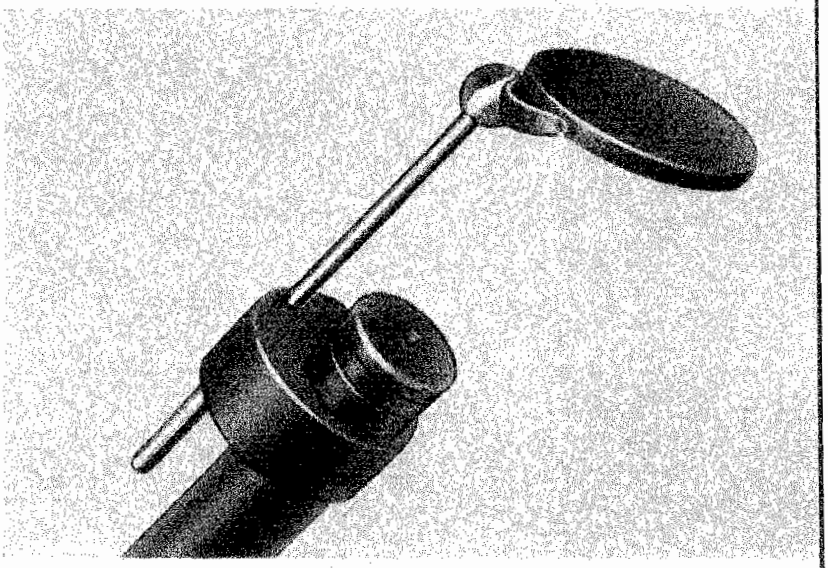
The large apparatuses for photomicrographic work are

PHOTOMICROSCOPE POL (described on page 10) and

ULTRAPHOT II POL (described on page 7).



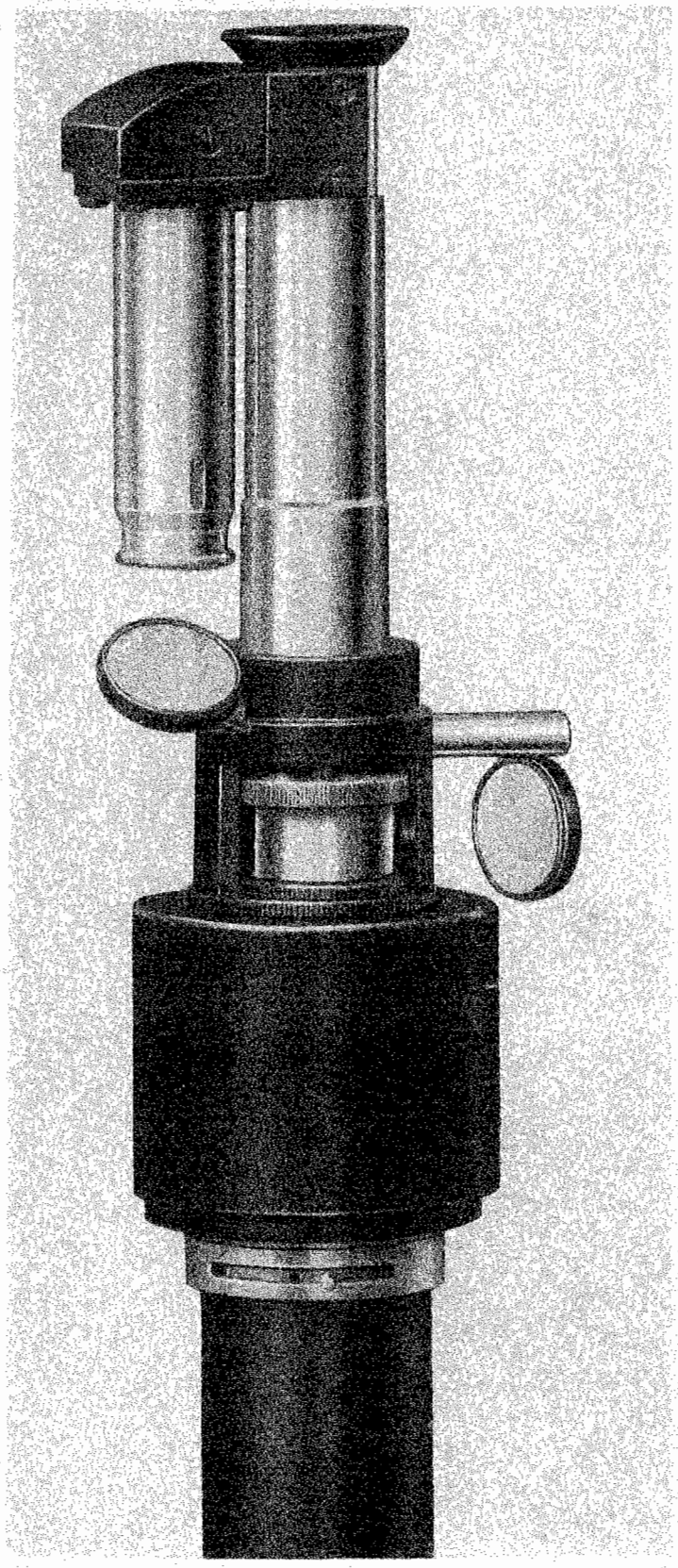




CARL ZEISS also manufactures

drawing apparatuses,
drawing attachments
and projection drawing-mirrors for tubes with the standard outer diameters of 25 mm. or 33 mm.

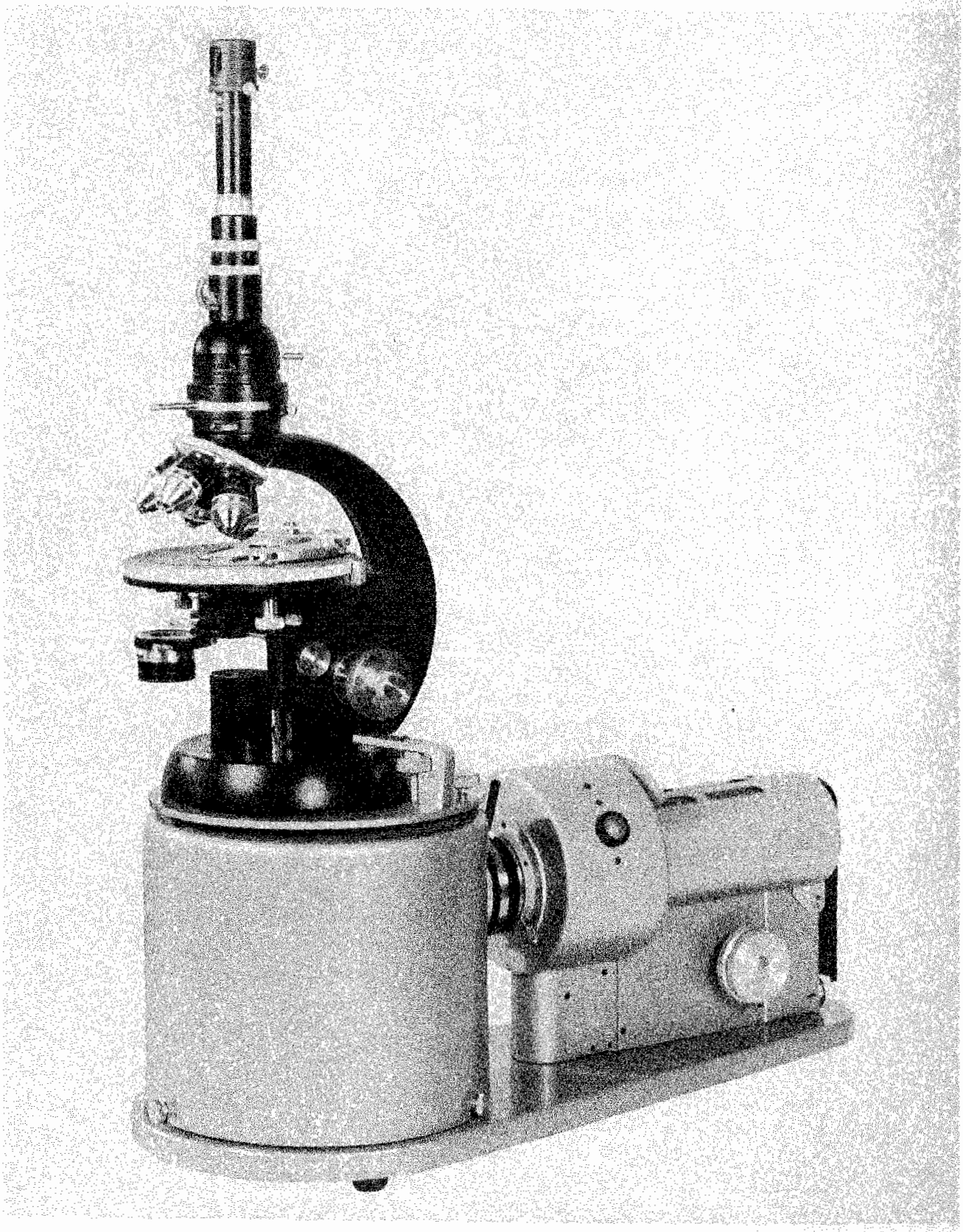
Even though photographic techniques and the quality of photographic materials have undergone considerable development, it is often an advantage to have a drawing of the microscopic image. This is especially true when calling attention to certain essential characteristics in a mass of similar forms. There may also be the need of reproducing objects with a large depth of field in which very fine details must be brought out. The large objective aperture which this would require would work against the desired sharpness and depth of field. The only possibility left is a composite photograph or a drawing.



Pupillary spectroscope

The pupillary spectroscope is used in determining the spectral light transmission of colored objects and the composition of interference colors. It is inserted with its Ramsden eyepiece in the tube of the microscope in place of the usual observation eyepiece. The spectroscope can also be used without eyepiece as an ordinary hand spectroscope, in qualitative chemical analysis, for example.

For details see leaflet 40 – 520.



Micro-projection equipment POL for the STANDARD GFL POL polarizing microscope. This is an especially reasonably priced and widely usable supplementary equipment for instruction purposes in auditoriums or class rooms. It is easy to operate, with focusing as in visual observation. Thus special adjusting, centering and focusing, as often necessary with special micro-projection apparatuses, is done away with.

By the Bertrand lens and, if necessary, with adjustment of the iris diaphragm and length of the tube, conoscopic images of all (including smaller) objects can be projected just as they are seen by visual microscopy. The projection of objects on the Universal Stage is possible in both the orthoscopic and conoscopic path of rays, and is especially to be recommended for courses in microscopy. As all the lens surfaces are coated and because of the application of the KOEHLER illumination method, the brightness of the image is increased considerably. With use of the Achromat 40/0.85 POL, for example, it is sufficient for an image of about 2 m. in diameter in a medium sized auditorium.

The light source of the micro-projection equipment POL is a carbon arc lamp. Its light generates the best possible brightness for projection of polarizing-optical phenomena, and with high intensity is most suited to showing the spectral composition. The use of spectral lamps makes sense only when density variations are to be demonstrated without regard to color phenomena. The carbon feed, automatically controlled by relay, effects even burning of the carbon sticks and makes the operation of the arc lamp a very simple matter. The arc lamp burns brightest on direct current. In case only alternating current is available a converter should be used. The relay, however, is only to be used on alternating current.

The collector diaphragm and a system of collector lenses are placed in front of the arc lamp. The heat emission of the lamp is kept from causing harm by a water cell with protecting-filter for reflected heat. The cell is covered by a metal hood with a built-in reversible mirror and a light aperture. On top of the hood there are adjusting pegs and clamps for fastening to the polarizing microscope STANDARD GFL.

The following are to be recommended for the optical image-forming equipment:

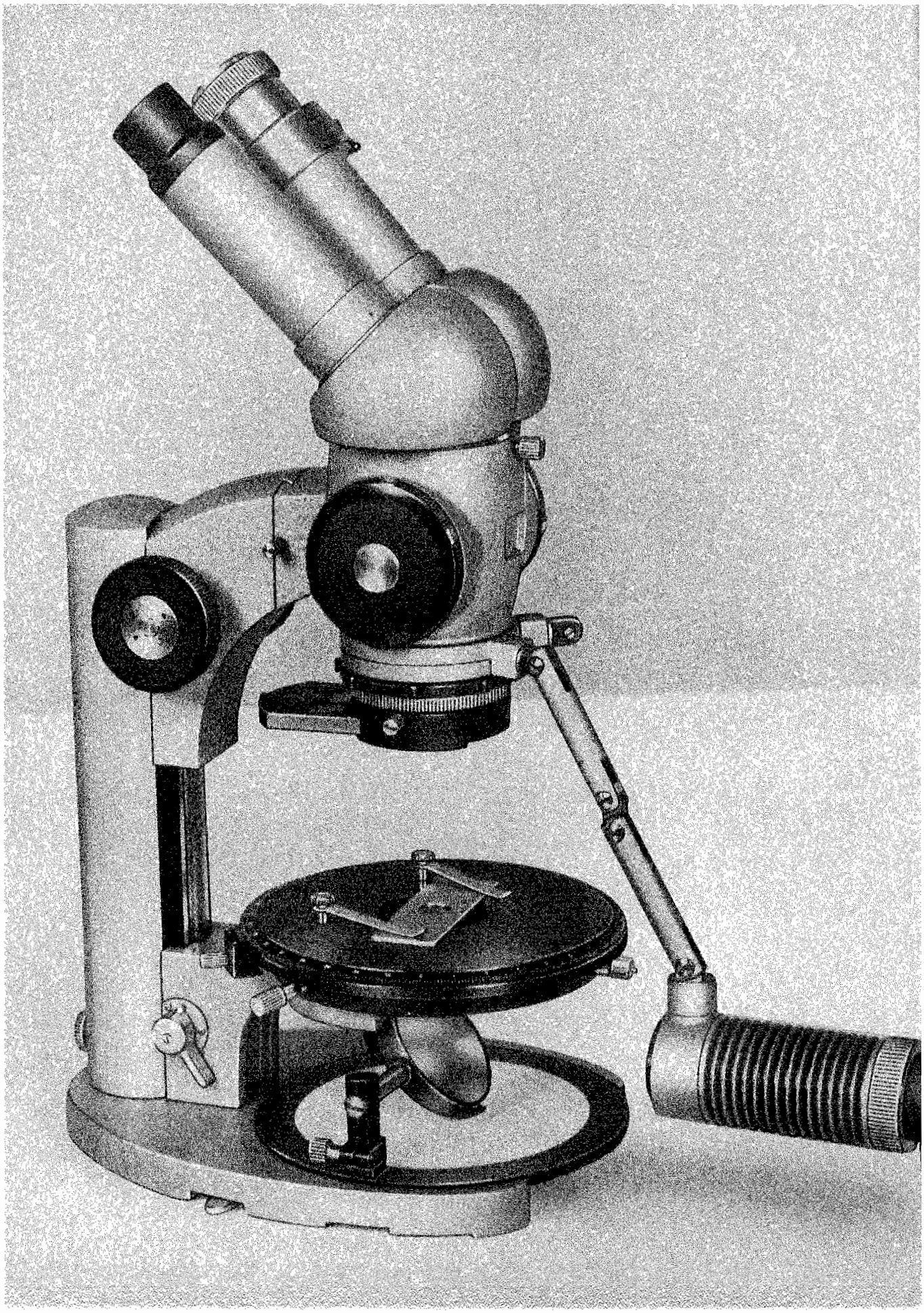
Objectives	Planachromat	2.5/0.08 "POL" Z
	Achromat	6.3/0.16 "POL" Z
	Achromat	16/0.32 "POL" Z
	Achromat	40/0.85 "POL" Z
Objectives for survey projection	Planachromat 1.0/0.04 with illumination lens	
Eyepieces	Micro-projection eyepiece f = 63 mm. (about 4 x)	
	Micro-projection eyepiece f = 80 mm. (about 3 x)	

Because of thei· small angle of image these micro-projection eyepieces make projection on greater distances possible and avoid too great an extension of the image diameter. For the axis image projection of larger objects, let us say the demonstration of specific optical directions, the use of a stronger eyepiece is advisable. A choice could be made between Kpl 12.5 x and Kpl 16 x in combination with the achromat 40/0.85 "POL" Z.

For micro-projection with the polarizing microscope STANDARD GFL POL we have a **micro-projection tube POL** with an analyzer that can be swung in and out, correction lens slots for auxiliary preparations, Bertrand lens that can be swung in and out, tube iris diaphragm and adjustment possibilities for the length of the tube. In order to keep away disturbing light from reflection on the specimen holder and on parts of the specimen, the object area is closed off by a curtain placed on the projection tube.

Because of the strong absorbtion of heat radiation by polarizing filters and the high intensity of the light from the arc, the micro-projection equipment POL has a calc-spar polarizer. This is placed with its mount in the base of the microscope, and can be rotated around the microscope axis. The parallel or crossed positions to the analyzer a e marked. A **Foucault type polarizing prism** under which a plane-parallel glass plate is placed in inclined position for compensation of the shift in beam is used.

A filter is generally used as analyzer, but the analyzer itself is used when a specimen is to be observed with crossed polarizer und analyzer. In this case stronger absorbtion in comparison to that of a prism does not play as decisive a role as with the polarizer which is always in the path of rays. The regular filter polarizer always remains on the instrument in order to have it ready at any time for visual observation. It should be swung out of the beam path during micro-projection.



STEREO-Microscope II POL

gives a plastic, sharp-outlined, non-reversed image.

The technical details are as follows:

magnification range,

6 x to 200 x;

diameter of field of view,

between 33 mm. and 1 mm.;

working distance remains fixed at

about 80 mm. up to 100 x and

about 40 mm. up to 200 x;

rapid magnification changer

works simply by turning a drum, without change of objective and eyepiece and without change of working distance;

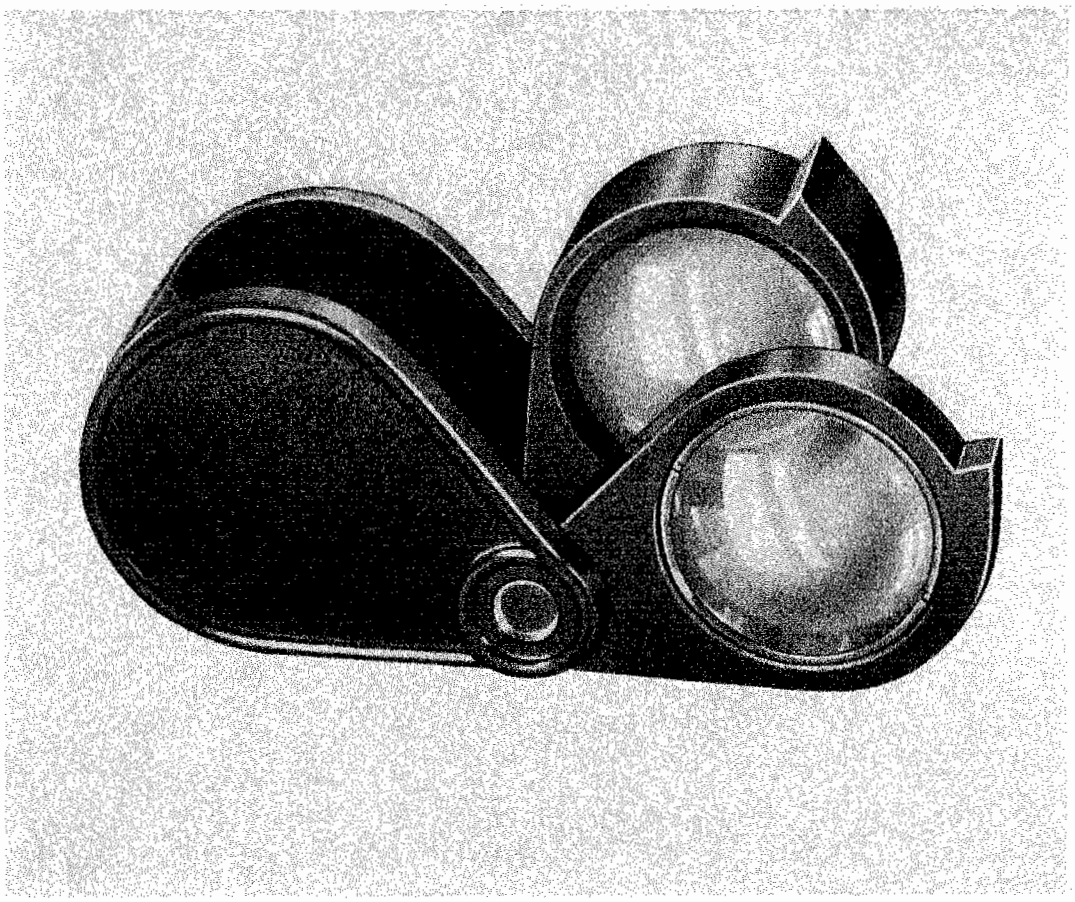
there are four different magnification stages between 6 x and 100 x without special objective 2 x,

and four different stages between 12 x and 200 x with special objective 2 x.

The image-forming path of rays consists of two partial beams with a common main objective. This results in a uniform sharpness across the entire field of view and a large diameter of the object field.

The 6 V – 15 W low-voltage lamp
in the illumination unit can be used both for incident as well as transmitted light.

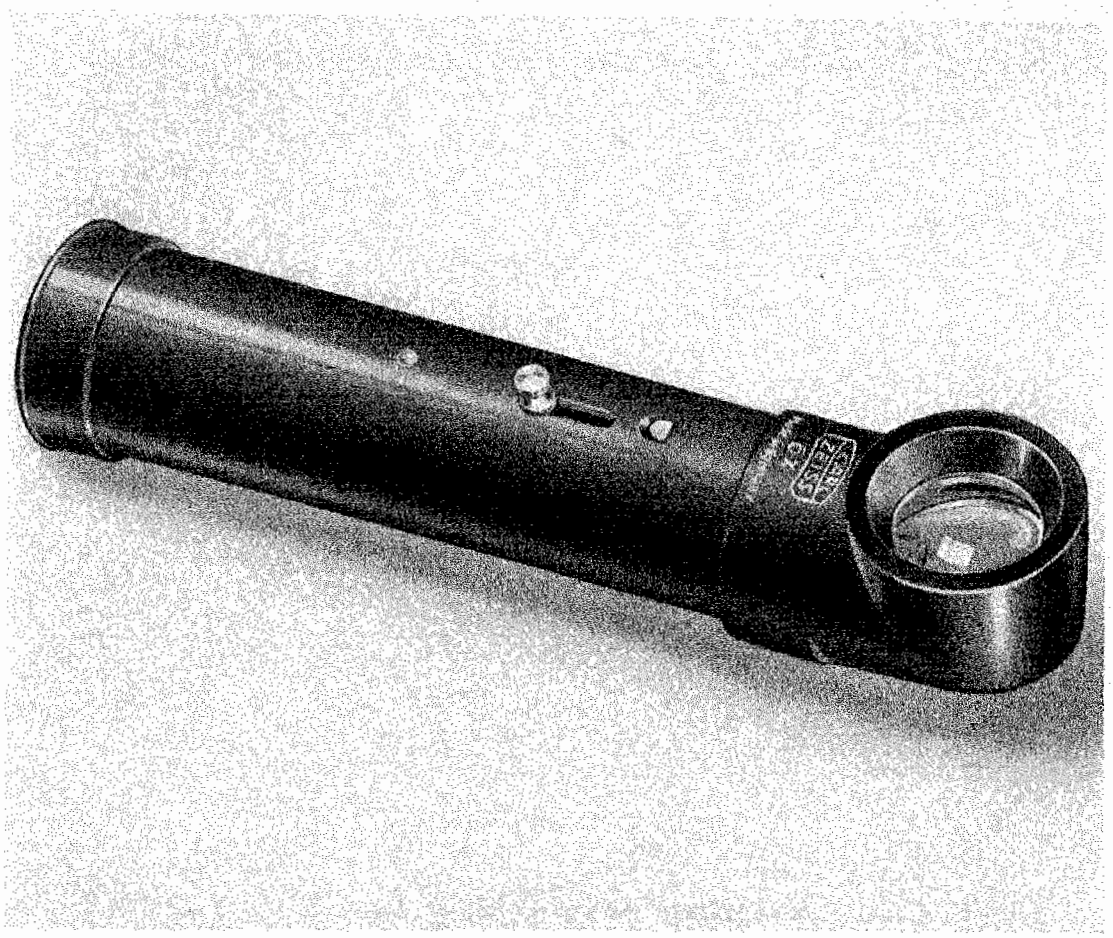
Stereoscopic photomicrography of stationary objects in polarized light is also possible with the STEREO-Microscope II POL.



MAGNIFIERS

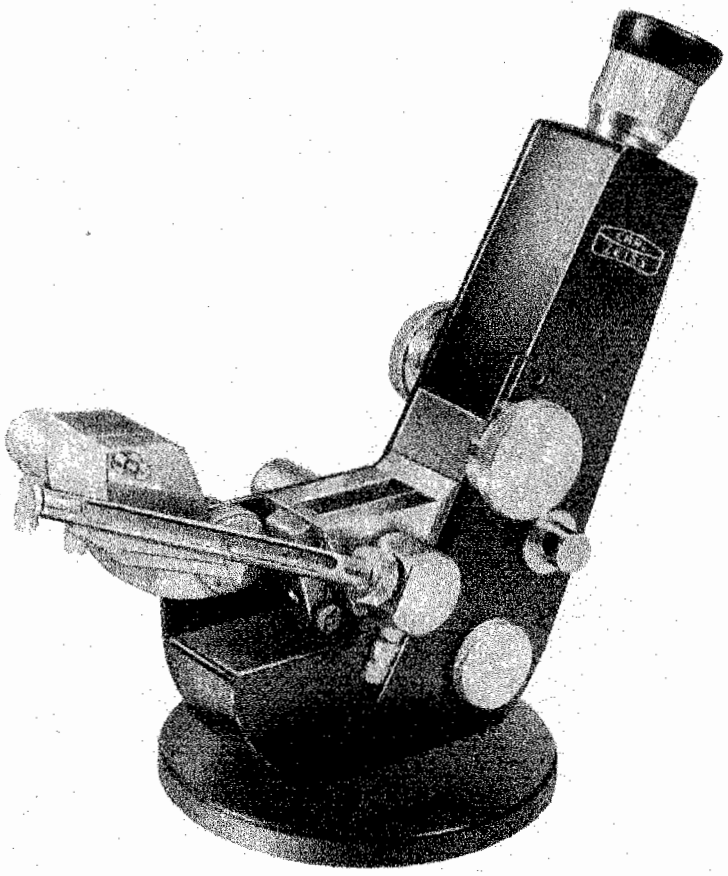
Folding magnifiers have spheric and chromatic correction and multilens magnifying systems. They give exceptionally sharp and color-clean images. The case and mounting are made of plastic material, and therefore are acid-resisting and also lighter than metal handles. These magnifiers are made in 6 x, 8 x or 10 x magnifications. We also can supply a twin folding magnifier with the three magnification values 3 x + 6 x = 9 x.

The **map-reading magnifier** has proved its value as an aid in map reading, for instance in geology map making. It consists of a hand-stick which contains all the parts such as battery, bulb and illuminating lens, attachable reading glass, essential for the illumination. A large field of view can be surveyed with it at a magnification of 1.7 x without distortion.



The **illuminating pocket magnifier** is for magnifying observations that have to be carried out under unfavorable lighting conditions. The battery is in its handle. A special miniature incandescent lamp projects a bit into the field of view and illuminates the objects directly from above. Interchangeable magnifier heads with magnifications of 3 x, 6 x, or 10 x can be used as desired.

The **Telupan** can be put to varied purposes and is especially valuable for field work in geology or minerology as well as on field trips. It consists of a 6 x well-corrected magnifier and a supplementary lens which, when screwed on, produces a Galilean telescope with a 2.25 x magnification. Thus this handy little instrument is also practical for distance use. The Telupan comes in a leather case. When screwed together it is only 3 cm. in height, and it is no trouble at all to carry around.



ABBE REFRACTOMETER

With a measuring range from n_D 1.3 to n_D 1.7 (or if desired, also up to 1.85), this instrument is designed for measurements in grazing and reflected white and monochromatic light. The fact that the surface of the measuring prism always remains in a horizontal position makes it especially convenient to work with.
In order to determine the index of refraction of crystals all that is needed is to grind and polish one or two surfaces that are perpendicular to each other.
Liquids, as for instance embedding media, are spread between two prisms so as to form a thin plane-parallel layer. For exact measurements it is essential that the standardized temperature (for example 20°) be kept constant. For this purpose the attached thermostat will be of great value.
From the determined n value and the reading of the refractometer's compensator graduated scale, the mean dispersion ($n_F - n_C$) can be ascertained even when using white light with the nomogram that comes with the instrument. This is important in applying the immersion method according to the wavelength variation system.

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