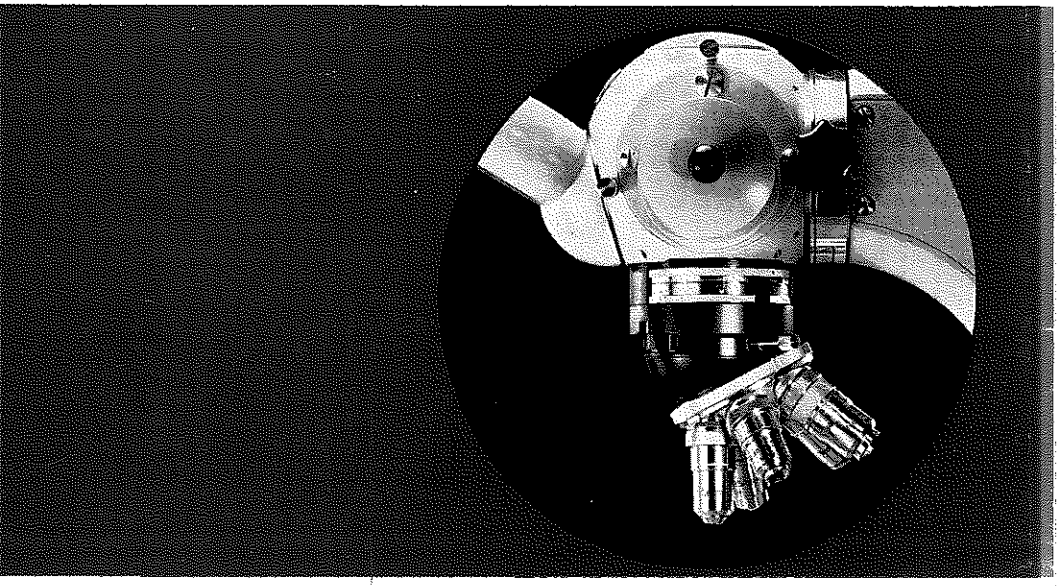
Large UNIVERSAL Research Microscope

Operating Instructions

Micro NEW YORK



CONTENTS

These instructions describe and illustrate the operation and the different models of the Large UNIVERSAL Research Microscope. Please take time to read this booklet very carefully. Only this will enable you to make full use of the countless possibilities which this instrument offers for practical work.

The two basic models of the UNIVERSAL are distinguished by their illuminating system:

a) Microscope stand for centerable and interchangeable condensers. Great versatility, because adaptation to any presently known microscopic technique is possible.

b) Microscope stand with a pancratic condenser. Complete instrument for simplified operation in bright-field and phase-contrast work. Pages 16–17 describe the possibilities offered by this equipment.

The procedures described in these Instructions all refer to transmitted light.

The booklet G 41–100 "Microscopy from the very beginning" being supplied with the instrument, a detailed explanation of microscope terminology has intentionally been omitted from this manual.

The six-digit figures appearing in the text are catalog numbers. Orders for separate components or accessories should always include the serial number on the instrument base. This will avoid unnecessary correspondence or even the shipment of improper parts.

The figures 1 to 15 shown in brackets refer to the illustrations on the folded page.

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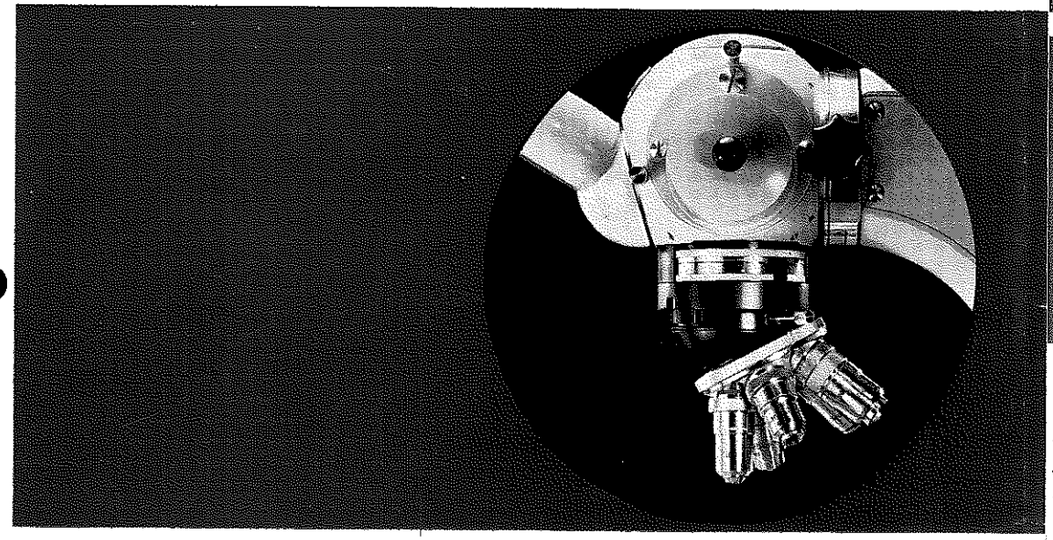
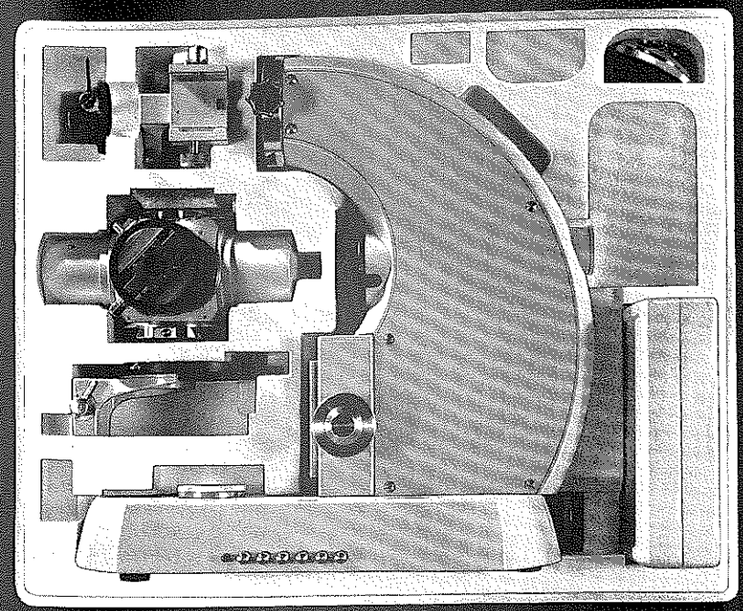
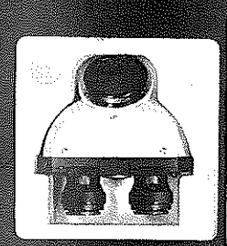
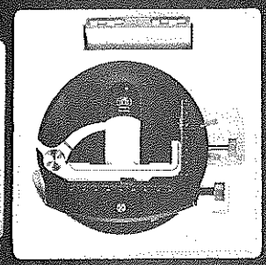
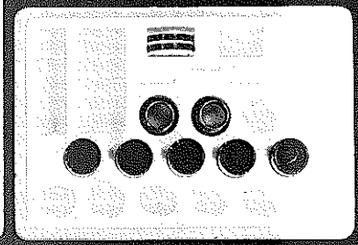






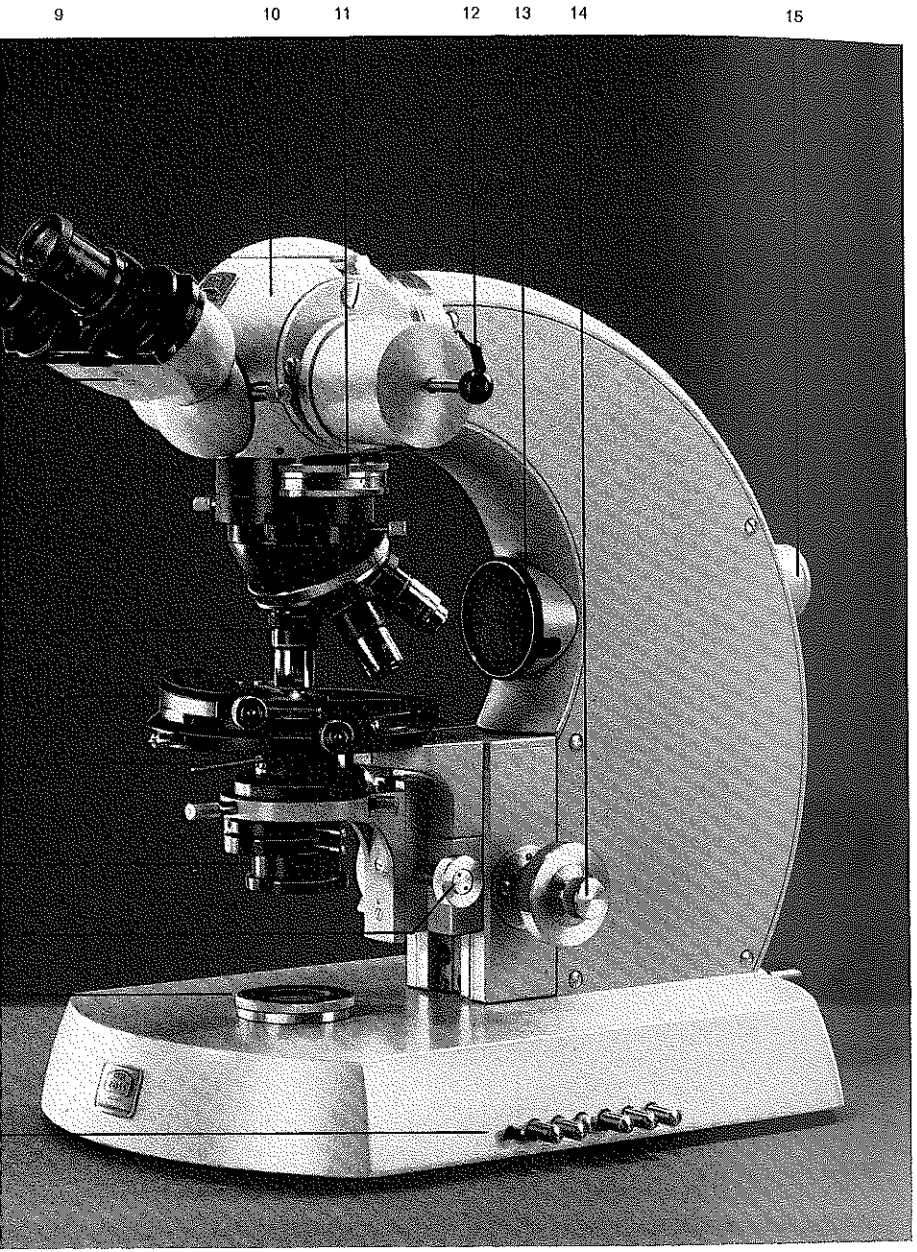




Unpacking the instrument

The UNIVERSAL is supplied in a Styropor case which has accurately shaped compartments for the stand and the different components. Although this case is ideal for shipment, the microscope should not be stored in it for prolonged periods, since the unavoidable humidity of the air would be trapped in the well-insulated case and might act on the instrument. The Styropor case should, however, be kept for later use, should it ever become necessary to ship the instrument again.

Unpack the microscope and its components with the extreme care which is indispensable when handling such a valuable precision instrument. On no account should the various knobs and other controls be used as handles.



1 = Filter control
Six light filters can be introduced into the substage beam with the aid of pushbuttons. The filters may be used singly or in combination. As the black button is pressed, the filters return to their original position. For the insertion of 32-mm filters, see page 7.

2 = Lamp field stop in diaphragm insert.

3 = Vertical adjustment knob of condenser. The stiffness of motion can be varied: turn the two-hole disk with the aid of a two-pin wrench supplied with the instrument. Clockwise rotation results in greater stiffness, counterclockwise rotation in greater ease of motion.

4 = Auxiliary condenser lens serving to illuminate the full aperture. Is permanently in light path.

5 = Condenser aperture diaphragm; for use, see page 9.

6 = Specimen stage, page 26.

7 = Revolving nosepiece, page 19.

8 = Inclined binocular body. The eyepieces of the **inclined binocular body** can be shifted in relation to each other over a range from 55 to 75 mm to allow adjustment to the interpupillary distance of the observer. The small disk between the eyepiece tubes indicates the value set. This adjustment slightly changes the mechanical tube length which is of importance for the parfocalization of objectives. The eyepiece tubes must therefore always be turned to the value indicated on the center disk. Parfocalization of the objectives ensures that the image remains visible after an exchange of objectives.
If the images presented by the two eyepieces should not be equally sharp, turn the eyepiece tube requiring readjustment until both eyes see the image in sharp focus. When exchanging objectives defective eyesight will impair their parfocalization, particularly if they are of low power.

9 = Eyepieces, page 22.

10 = Tube head, page 18.

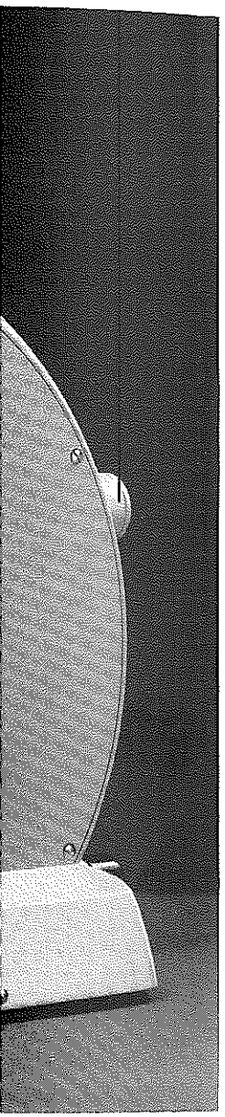
11 = OPTOVAR magnification changer. This has two knurled wheels, the lower one of which holds the 1.25×, 1.6× and 2× optical system as well as a PH system which in conjunction with the eyepiece acts as a centering telescope for viewing the exit pupil of the objective.
In the PH position, the upper wheel serves to focus, for example, on the image of the aperture diaphragm or, in the case of phase contrast, on the image of the annular diaphragm and the phase annulus of the objective.
Like the Bertrand lens used in polarized-light microscopy, it may be used for monocular and binocular viewing of interference figures and for photographing interference phenomena.

12 = Reflecting system; for beam control, see page 18.

13 = For reflected light only:
Opening for aperture diaphragm insert.

14 = Coarse and fine adjustment knobs, page 19.

15 = For reflected light only:
Location for 60-watt illuminator.



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Assembling the microscope

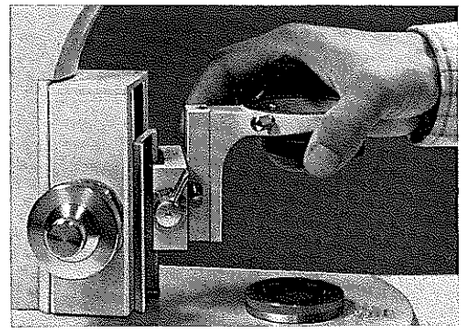
It is advisable to practice the operations described below a number of times until a certain skill has been acquired. This will at the same time serve to familiarize the operator with the design and function of the different mechanical components.

To attach the **condenser carrier** (Fig. 3) or the **pancratic condenser,** move the clamping lever right up and hold its right-hand guide rib against the flank of the dovetail guide. Then pivot it to the left until it snaps into position, push it down to the stop and clamp the lever.

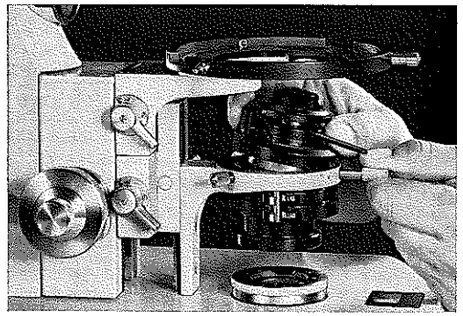
Not applicable to pancratic condenser:
Slightly tilt the **condenser** and with its dovetail ring press the spring bolt of the condenser carrier back until the condenser can be inserted. Then turn the condenser so that its controls are in a convenient position. The notch provided in the dovetail ring of the phase-contrast condensers must be engaged by the spring bolt (if necessary, turn the condenser until it snaps home).

Attaching the specimen stage
Move the clamping lever of the stage carrier up. Slide the stage carrier (without the stage) from above onto the dovetail guide until it rests against the condenser carrier. Then clamp the lever.
Condenser carrier and stage carrier must always be right down in the dovetail guide so that they touch. Otherwise "inexplicable" errors will occur.
Centerable stages are detached from the stage carrier for shipment: Press the dovetail ring of the stage at a slight angle against the spring bolt in the centering piece of the stage carrier (the spring bolt must engage the notch) until it is perfectly seated in the centering piece.
The two-pin wrench supplied with the stage serves for screwing the attachable mechanical stage on and off, the two socket wrenches for centering the stage.

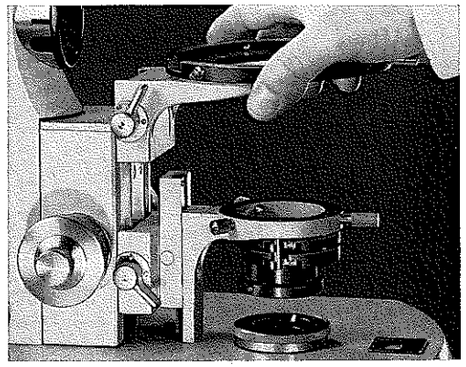
Finally rack the condenser up as far as it will go.



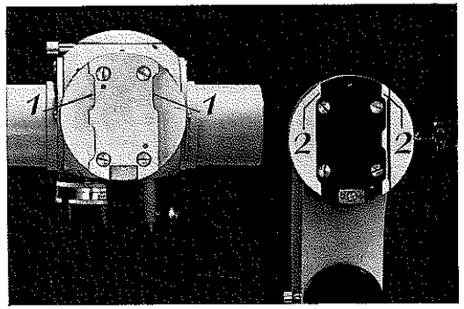
3 Attaching the condenser carrier



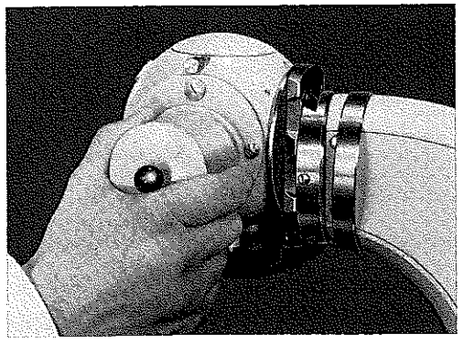
4 . . . the condenser



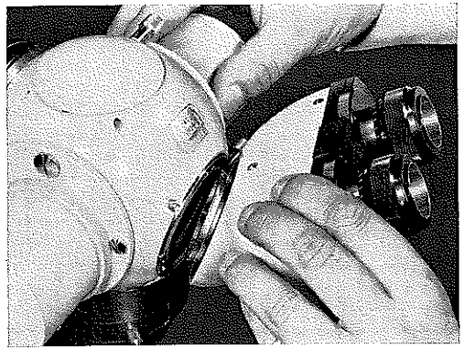
5 . . . and the stage carrier



6 How the tube head engages the stand . . .



7 . . . and how to hold it for correct mounting



8 Attaching the tube

Take the **tube head** in both hands and hold it high enough for the two upper guide edges (2) of the stand to engage the cutouts (1). Then slide the tube head down to the stop and adequately tighten the screw on one side.

To attach the **tube,** slightly loosen the clamp screw in the tube head. Press the dovetail ring of the slightly inclined tube against the spring bolt until the tube snaps into position. Then tighten the clamp screw.
The black plastic pinhole diaphragm supplied with the binocular body is not required in the UNIVERSAL. It should be removed to avoid vignetting of the field of view.

Slip the **eyepieces** into the body and screw the **objectives** into the revolving nosepiece.

Attach the **revolving nosepiece** from the rear left, push it right forward to the stop and tighten it with the clamp screw. The single nosepiece is attached from the front, on the right, like the vertical illuminator.

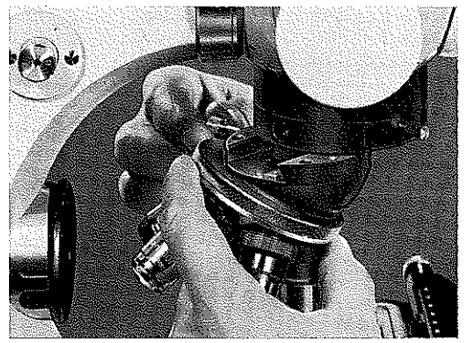
For microscopes supplied with a work table:
For shipment, the **table** is dismantled into the side part with drawers, the table top and the leg portion.
Two people are required to assemble the table.
First pull out the drawers to the stop, lift them slightly and remove them from the side part.
Place the table top in its packing upside down on a table or the floor. Insert four of the clamping members supplied into the opening in the front edge and two into the rear edge. Attach the two legs by their screws, push them out to the left and tighten the screws firmly with the aid of the hexagon socket wrench. Attach the side part so that the sheet-metal projection on the rear engages the rear edge of the table top (Fig. 10). Next, shift the side part out towards the edge and secure the clamping members of the front edge by two screws. Then turn the table round and put it on its feet.
Slip the rails over the lateral angles of the drawers and insert them into the table.

Inserting filters: After unscrewing the bottom cover, filters of 32 mm dia. can be inserted into the different holders where they are secured by means of a circlip.

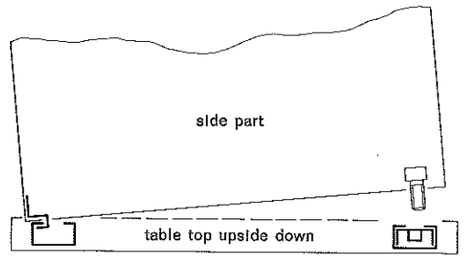
The **transformer** must be set to the correct line voltage. Check setting through the window in the bottom of the transformer.

Insert the **filament lamp,** 38 01 77, under moderate pressure into the socket and turn it when the red dot on the centering ring is opposite the red pin of the socket. Remove fingerprints to avoid their burning in and impairing the illumination.
Insert the lamp socket with the bulb into the collector tube of the microscope base. For this purpose, the red dots of the clamp must be opposite each other. Then clamp it in place.

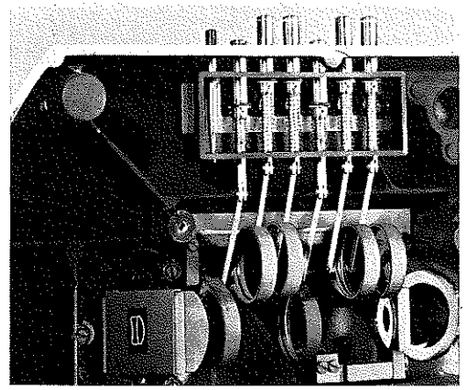
For connecting the 60-watt illuminator, see page 30.



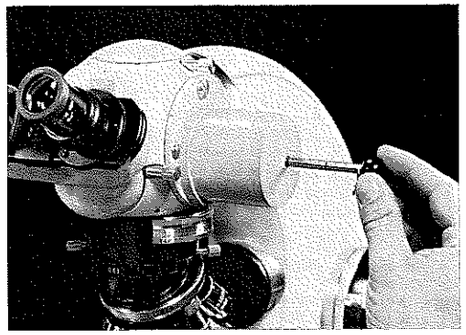
9 . . . and the revolving nosepiece with objectives



10 Table: assembly of table top and side part



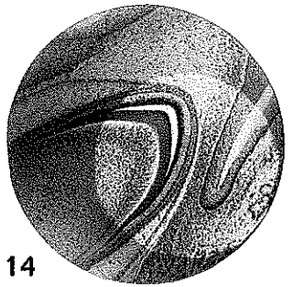
11 Bottom view of filter control with cover removed.



12 Setting the reflecting system (12)

13

Image of lamp field stop unsharp and decentered



14

Image of lamp field stop in focus

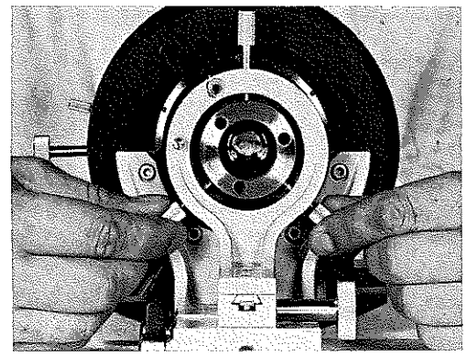
Working with the UNIVERSAL

Centerable condensers

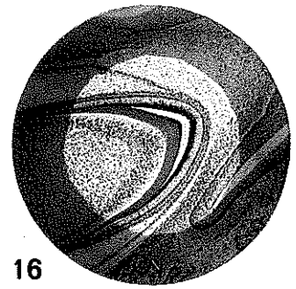
For pancratic condenser, see page 16.

Bright field

1. Place the specimen on the stage (cover glass facing up) and switch on the lamp from the transformer.
2. Turn the reflecting system (12) to the red or white ring.
3. Rack the condenser up to its top position. With phase-contrast condensers set the revolving disk to I (bright-field position).
4. Focus on the specimen with the aid of the coarse and fine adjustments, using a low-power objective.
   To illuminate the large object fields imaged by scanning objectives (up to an initial magnification of about 6.3×), unscrew or swing out the condenser front lens (depending on type of condenser). The auxiliary lens (4) below the condenser is always left in the light path. Open the condenser diaphragm (5) fully and control image contrast and resolution by means of the diaphragm in the microscope base (2). Remove the condenser when using a 2.5× objective with a wide-field system.
5. Close down the lamp field stop (2) in the microscope base and slowly rack the condenser down until the image of the lamp field stop is sharply defined on the specimen (Fig. 14). With condensers which are not of the achromatic-aplanatic type, the color reversal from red to green may serve as an indication in the case of higher magnifications.
6. Turn the two centering screws (Fig. 15) of the condenser until the image of the lamp field stop lies in the center of the field (Fig. 16). The condenser is thus centered.
7. Open the lamp field stop until the entire field of view is evenly illuminated (Fig. 17).
8. Use the aperture diaphragm (5) to control image contrast and resolution.
   A compromise must be sought here because an open diaphragm is equivalent to high resolution and low contrast, while a stopped-down diaphragm means reduced resolution but high contrast.
   First open the diaphragm fully, then carefully close it down until a change in contrast is just noticeable. This is not always easy to determine by the image alone. As a rule of thumb it may therefore be said: Set the OPTOVAR magnification changer to PH and use the upper knurled wheel to focus on the objective aperture (or look into the tube without an eyepiece). The diaphragm image that is now visible should only in exceptional cases be smaller than two thirds of the diameter of the objective aperture. Check items 5 to 8 whenever objectives are changed.
9. With 100× objectives not only these but also the front lens of the N.A. 1.3 or N.A. 1.4 condenser should be optically connected with the underside of the specimen slide by means of immersion oil. Only then will the objective aperture be completely filled with light. The N.A. 1.4 front lens of the achromatic-aplanatic condensers should always be immersed, even when dry objectives are used, to preserve their high correction.
   To facilitate the application of immersion fluid, the mounts of the immersion objectives can be arrested in retracted position by clockwise rotation. However, the 63× N.A. 1.25 NEOFLUAR "oil" must be swung in with the revolving nosepiece from the side so that it penetrates the oil.



15 Centering the condenser

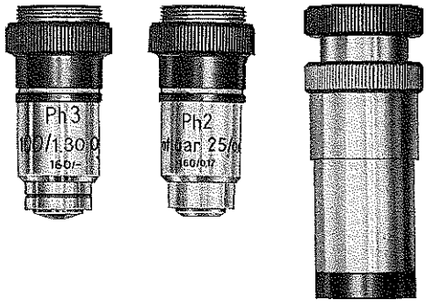


16

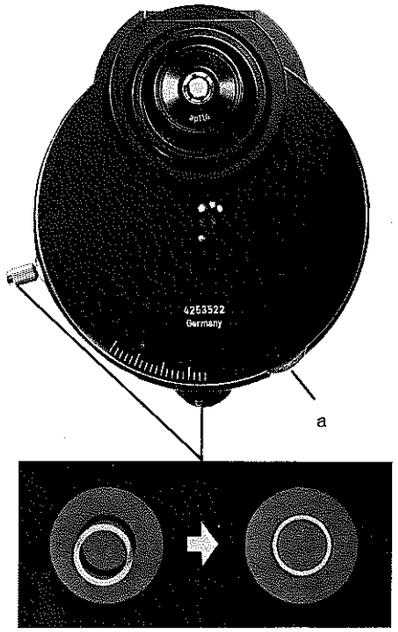
Image of lamp field stop centered

17

Open lamp field stop



18 Phase-contrast objectives, centering telescope, 46 48 20



19 Phase-contrast condenser:
adjusting knobs for centering the annular diaphragm.
a = iris diaphragm for bright-field position J.

Phase contrast

For this technique, phase-contrast objectives (engraved with red Ph) and a phase-contrast condenser are needed. Phase-contrast objectives, above all Ph NEOFLUARS, can also be used for bright-field work if a slightly lower image quality is accepted. However, we do not recommend them for critical bright-field photomicrography.

Achromatic-aplanatic phase-contrast condensers must be equipped with an N.A. 1.4 front lens. Their high optical correction will be utilized only if the underside of the specimen slide is connected with the N.A. 1.4 condenser front lens by means of immersion oil. This holds for any objective, regardless of its initial magnification. The only exception is the dry long-focus achromatic-aplanatic condenser IV Z/7.

1. Proceed as described for bright-field illumination, items 1 to 7, but use a low-power Ph objective. Insert a green filter.

2. To change over to phase contrast, insert the annular diaphragm of the condenser which corresponds to the objective employed.
   The objective with engraved red Ph 2 corresponds to the position 2 of the condenser's revolving disk, the Ph 3 objective to position 3.

3. Set the OPTOVAR to PH and use the upper knurled wheel to focus on the phase annulus and annular diaphragm that are visible in the objective pupil. If the tube head is not fitted with an OPTOVAR, replace one of the eyepieces by the centering telescope, 46 48 20, and focus by turning the two knurled collars in opposite directions.

4. Obtain coincidence between the image of the annular diaphragm and the phase annulus (Fig. 19). To do this use the two adjusting knobs on the condenser. Set the OPTOVAR to the desired magnification factor or reinsert the eyepiece.

5. After every exchange of objectives check the setting of the lamp field stop and set the condenser to the annular diaphragm corresponding to the objective employed. Recentering of the annular diaphragm is required only if the specimen is changed.

Preparation of phase-contrast specimens

To obtain satisfactory results it is necessary to make allowance for the special optical conditions of phase-contrast work in the preparation of specimens. The sensitivity of the method requires particularly careful microtechnique. Special care must be taken to use only optically perfect slides and cover glasses (free of striae and bubbles). In addition, slides and above all cover glasses should be thoroughly cleaned to remove all traces of solvents. It is also indispensable that the specimens be bounded by plane surfaces. Objects in suspended droplets or mounted in cavity slides cannot be examined. Instead of such specimens we recommend the oil chamber (Fig. 20). A few of the plastic rings required for this purpose are supplied with the set of mounting media, 46 29 29. This chamber has proved to be very useful for observing living objects.

Examining biological and medical objects in phase contrast

When using the phase-contrast technique, special attention must be given to the selection of a suitable mounting medium. Some biological specimens will produce optimum contrast even in their native state, i. e. without changing the mounting medium, such as suspensions of cells in ascites, bacteria in a culture medium or blood cells in blood plasma. In many other cases, however, the mounting medium has to be selected so that its refractive index will ensure satisfactory phase contrast in conjunction with the optical properties of the specimen.

It is frequently said that such interference with the specimen – and any modification of the mounting medium constitutes an interference – is incompatible with the phase-contrast method, since this very method was developed to eliminate the necessity of using the fixing and staining techniques normally employed in histological work. However, this is only partly correct. On the one hand, any damage to the specimen should, of course, be avoided. On the other hand, however, it is frequently only by adapting the specimen to the optical conditions of the method that essential structures in the object can be observed.

It should be pointed out in this connection that, while the so-called physiological solutions (Ringer's Tryode's and similiar solutions) usually produce good contrast in living biological objects, the objects as such suffer considerable damage within a relatively short period, or may even die. Instead of these saline solutions, albumin solutions such as ascites, gelatin or other protein solutions have proved more useful. Used as mounting media for biological objects, such albumin solutions of proper concentration have the advantage of being non-toxic, not affecting the structure and functioning of the living cells and not penetrating the cells. In addition, due to the high molecular weight of the disperse phase, they have a low osmotic pressure and, finally, they are soluble in water. Another advantage is that their refractive index is a linear function of concentration and can be varied within the required range without damage to the specimen.

However, the selection of a suitable mounting medium is not only of special importance in phase-contrast microscopy of living biological objects, but also for making permanent preparations, for example, of histological sections.

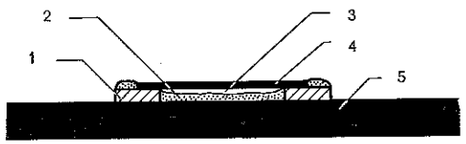
The mounting media normally used in histological work, such as Canada balsam and similar media, are quite useful for mounting stained specimens and examining them in bright field. In phase work, however, they often fail to produce sufficient image contrast unless there is a mixture of positive and negative or even purely negative image contrast*). In order to obtain optimum results with such sections we therefore supply mounting media developed by Th. v. Hirsch with our phase-contrast equipment, the refractive index of which corresponds to the requirements of the technique.

*) **Positive phase contrast:** The light diffracted by the object structures is retarded in phase by means of a phase plate.

Positive image contrast is thus produced: highly refracting object structures appear darker than those of lower refractive power.

Negative phase contrast: The light not diffracted by object structures is retarded by means of a phase plate.

Negative image contrast is thus produced: highly refracting object structures appear brighter in the image than others of lower refractive power.



20 Oil chamber
1 = plastic ring, 0.5–1 mm thick
2 = paraffin oil
3 = culture liquid
4 = cover glass
5 = specimen slide

21 Phase contrast mounting media, 46 29 29

Phase-contrast mounting media, 46 29 29

These include two fundamentally different types, viz.:

L 25 ($n_D = 1.525$) and
L 15 ($n_D = 1.515$)
(corresponding to "Phako 525" and "Phako 515" by Th. v. Hirsch). These mounting media are mixtures of two solvents. Specimens taken from an aqueous liquid must first be dehydrated (either by alcohol or 50 or 100 % methyl glycol) before they are embedded in these media.

L 25 and L 15 harden relatively quickly without changing their refractive index. The choice between the two depends in each case on the properties of the specimen and its preliminary histological treatment. In many cases both may be used for the same specimen. The designation of these mounting media indicates the last two decimal places of their refractive index.

W 15 ($n_D = 1.515$)
(corresponding to "P 50" by Th. v. Hirsch). This is a mounting medium for sections (or other objects) taken directly from an aqueous liquid. Frozen sections, for example, can be mounted on slides and evenly covered with W 15 while they are still wet. Wait a few minutes before putting on the cover glass, until the section has become completely clear, then weight down the cover glass with a small lead weight. Excess W 15 emerging along the edges of the cover glass may be washed off under a fine jet of running water. Contrary to L 15 and L 25, W 15 does not harden. We therefore recommend that the edges of the cover glass be sealed with a special lacquer supplied with the equipment. This lacquer should preferably be applied with a brush which can be cleaned with acetone or alcohol.

For brief, merely orientational phase-contrast examinations of fixed histological specimens, possibly before staining, hydrophobic solvents such as xylol should be selected instead of hydrophilic solvents such as alcohol. In the latter case, there is a possibility of considerable swelling or shrinkage even in fixed specimens, due to the interaction between the hydrophilic solvents and the albumin, and it may be a little while before stability is obtained.

A suitable mounting medium can be found without difficulty for every object to be examined. The time spent in search of the most suitable medium will never be wasted, since the results of the examination largely depend on this. In this manner even specimens normally considered as unsuitable for phase-contrast observation will make very worthwhile subjects of phase-contrast examination.

Examining transparent solids in phase contrast

For phase-contrast observations, crystals, plastics, fibers or small inclusions therein should be well separated from each other in the specimen, for example, in the form of inclusions in a homogeneous substance. In this case, a thin polished specimen or a thin section may be prepared. Minute particles are observed as pulverized solids in an embedding liquid.

Details on microtechnique and its application to phase-contrast microscopy with fine-grain material will be found in an article by Correns-Piller, published in the Handbuch der Mikroskopie in der Technik, edited by Dr. H. Freund, Umschau-Verlag, Frankfurt a. M., 1953, Vol. IV, Part 1.

Nomarski differential interference contrast (DIC)

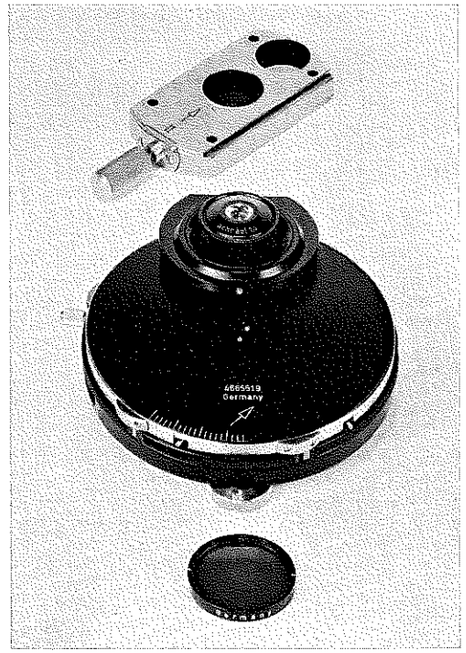
CNRS licence

Differential interference contrast*) shows structures of unstained transparent objects with an optical path difference (thickness × refractive index) in relief. Objects having optical path difference from about $^1/_{10}\lambda$ to 1λ are specially suited. The method is characterized by an azimuth effect which is comparable to unilateral oblique illumination. With the aid of the rotary stage any structure can easily be moved to the most favorable position.
A Wollaston prism in the condenser splits the light beam. The two partial beams then penetrate the object at a distance which is just short of the resolving power of the optical system. In the object the optical path difference gives rise to differences in path length. The two beams are then recombined by a Wollaston prism in the DIC slide. By shifting this Wollaston prism out of its center position, an additional path difference is superimposed on the object path difference. This lights up the background field (in color) and is responsible for the brightness of the object structures – which is accompanied by interference colors. However, these two changes in brightness do not occur in the same direction, but vary the contrast.

In the case of color contrast, identical structural elements appear in the same color in the image and can therefore be recognized at a glance.

The equipment comprises a polarizer (e. g. the polarizing filter 47 36 00), the strain-free DIC condenser, 46 52 84, with N.A. 1.4 front lens (for immersion only!) and the type II DIC slide, 47 44 31. Normal bright-field objectives, the 6.3×, 16×, 40× and 100× Planachromats, are used for observation.

*) in the following called DIC



22 DIC equipment for transmitted light:
Pol filter, 47 36 00, DIC condenser, 46 52 84,
type II DIC slide, 47 44 31.

Orienting the polarizer

1. Insert the polarizing filter into the microscope base or the filter holder below the condenser so that the vibration direction, which is marked by two lines, is from right to left (east-west) when the filter holder is in the light path.
2. Insert the Inco slide instead of the dust plug into the wide opening in the tube head as far as it will go. Then retighten the screw at the side.
3. Remove the condenser, auxiliary condenser lens, objective and eyepieces and carefully rotate the polarizer until the interference fringes are imaged with optimum sharpness. If the dark fringe does not appear in the middle of the field, center it with the aid of the knurled screw of the Inco slide.
4. Do not turn the polarizer thus oriented any further. Check the orientation at intervals while working.

Adjusting the DIC image

5. Insert the condenser, auxiliary lens, objective and eyepieces. Withdraw DIC slide to the stop.
6. Use an objective of lower power (see table below). Focus bright-field image (page 8).
7. Insert the DIC slide and turn its knurled control until the object image shows optimum relief or until satisfactory color contrast is achieved.
   Areas of greater optical density may be imaged either as valleys or hills. This depends on the imagination of the observer which varies individually and is influenced by physiological factors. Which is actually the case can easily be distinguished by focusing on an impurity or a scratch somewhere else on the slide.
8. When changing objectives, open or close down the lamp field stop and aperture diaphragm as usual.

Objective	Condenser position	Condenser front lens
Plan 6.3	IIII	0.63
Plan 16	I	1.4 with oil immersed
Plan 40	II	
Plan 100	III	

Dark field

Dark-field illumination can be achieved with one of the special dark-field condensers (page 25) or the achromatic-aplanatic condenser V Z (in D-position, with N.A. 1.4 front lens).
The light emerging from the condenser does not enter the objective directly. The image is formed only by the light reflected or diffracted by the specimen. The field of view remains dark wherever there are no object structures. The dark-field condensers illuminate the specimen by a hollow cone of light, the interior limit of aperture of which must be larger than the numerical aperture of the objective. The designation of the condensers reveals the interior and exterior limits of aperture of the illuminating cone of rays.
Ordinary bright-field objectives are used, the numerical apertures of which must, however, lie within certain ranges. Immersion objectives must always have an iris diaphragm to enable their high aperture to be reduced for dark-field work. This illuminating technique calls for a high-power light source such as the base illuminator. If particularly exacting demands are made, we recommend use of the 60-watt illuminator or the lamps of the multi-purpose microscope illuminator. The objects to be studied are embedded in a medium of higher refractive index than air between meticulously clean specimen slides and cover glasses.

Procedure with Ultracondenser or achromatic-aplanatic condenser V Z

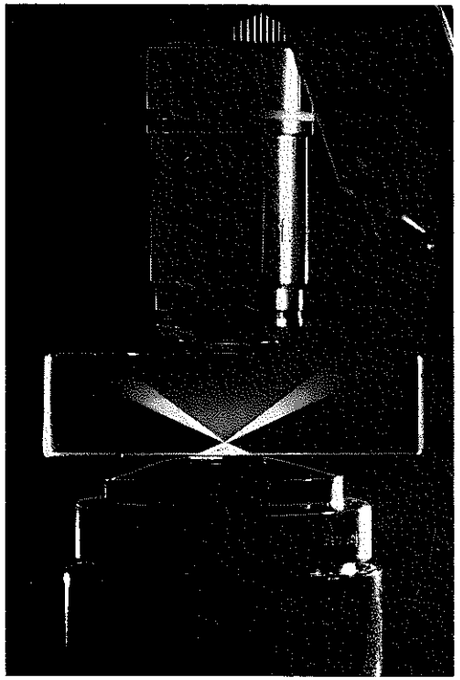
1. Immerse the condenser (use V Z condenser in D-position with N.A. 1.4 front lens):
   Apply a sufficient quantity of immersion oil without bubbles to the condenser front lens to cover the entire lens surface.
   Place the specimen in position and rack the condenser up until perfectly bubble-free connection with the specimen slide is achieved.
2. Center the field illuminated by the condenser with respect to the optical axis of the objective:
   First focus the specimen with a low-power objective (6.3× to 16×), using the coarse and fine adjustment. The field of view will appear only partly illuminated. With closed lamp field stop, slowly vary the vertical adjustment of the condenser until the spot of light is as small as possible and almost sharply defined (image of lamp field stop).
   Use the centering screws of the condenser carrier to move this spot of light into the center of the field.
   When changing the focus of the microscope, small punctiform objects in the center of the field must remain radially symmetric. If they move laterally, the illumination needs readjustment.
3. Dark-field adjustment with viewing objective:
   Move the viewing objective into position and focus on the specimen. If an immersion objective is used, immerse it beforehand and close down the diaphragm to the stop. Center the image of the closed lamp field stop by means of the centering screws on the condenser carrier. Do not open the lamp field stop further than is necessary to make its image disappear beyond the edge of the visual field. In the case of immersion objectives slowly open the iris diaphragm but only far enough to keep the background sufficiently dark.

Procedure with dry dark-field condenser

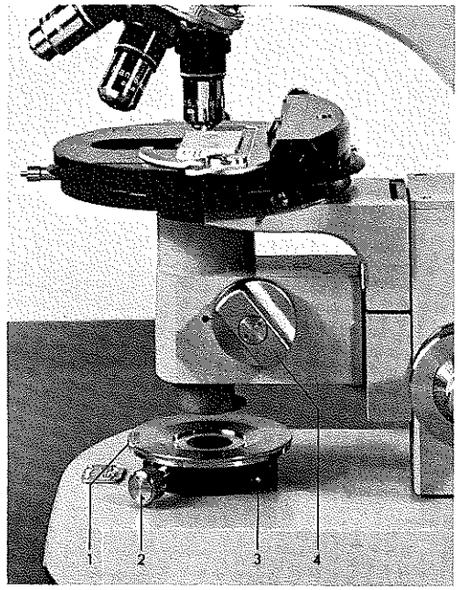
To adjust for dark-field illumination, proceed as above, but do not apply any immersion oil between the condenser front lens and the specimen slide.

Procedure with phase-contrast condenser

With objectives up to N.A. 0.32 (16× magnification) use the annular diaphragm 3 of the phase-contrast condenser for dark-field illumination. Fully open the lamp field stop. The annular diaphragm must first be adjusted as usual in phase work.



23 Dark-field illumination shown in an opal-glass model. The object is normally located in the vertex of the hollow cone of light.



24 Pancratic condenser
1 = Aperture diaphragm. The engraved figures are a mesure of the opening obtained. 1 = full aperture, 4 = ¼ aperture, etc. Lever 2 serves as an index.
2 = Knob for shifting aperture diaphragm. Lateral movement of the lever shifts the aperture diaphragm in azimuth.
3 = If necessary, the image of the lamp field stop can be readjusted here by means of socket wrenches.
4 = Condenser control knob with engraved aperture values.

Pancratic condenser

The pancratic condenser solves the problem of microscope illumination in a neater manner than any other, by means of a single control knob. An optical system of variable focal length images the aperture diaphragm in the focal plane of the condenser. At the same time, an image of the lamp-condenser opening is formed on the specimen as a constantly centered field stop. If the illuminating aperture is increased by rotation of the knob, the illuminated field is reduced at the same time. With any objective from 2.5 to 100× the field reproduced by it is thus automatically illuminated as the condenser is adjusted for the objective aperture. The product of field diameter and aperture remains constant.

As usual, the illuminating aperture can be reduced by means of an aperture diaphragm which in this case is located in the microscope base. The requirements of Köhler illumination are thus fully satisfied.

The correction of the pancratic condenser is of the achromatic-aplanatic type.

If illuminating apertures higher than 0.9 are required, the front lens can be unscrewed and replaced by the N.A. 1.3 condenser head, 46 52 91. In this case, the aperture values engraved on knob 4 of Fig. 24 are no longer applicable.

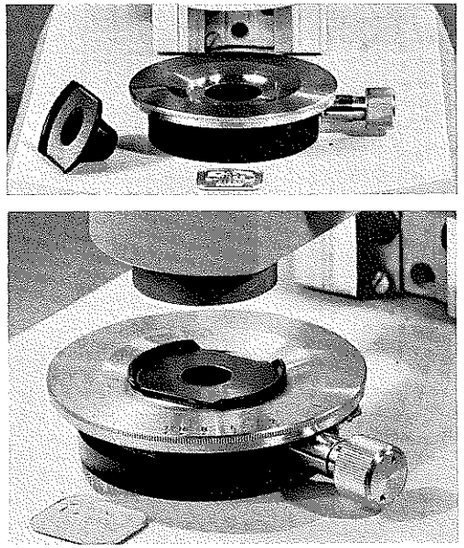
Bright field

1. Place the specimen on the stage (cover glass facing up) and switch on the lamp from the transformer.
2. Return the reflecting system (12) to the red or white ring.
3. Focus on the specimen with the aid of the coarse and fine adjustments, using a low-power objective. If image is too bright, swing in filter (1) or reduce lamp voltage.
4. Set condenser control knob to aperture value of objective. The two terminal stops for low and high-power objectives and a central notch for medium-power objectives facilitate the setting.
   The field of view is now evenly illuminated.
5. Use the aperture diaphragm (1, Fig. 24) to control image contrast and resolution as is usual with any condenser.
   Here a compromise must be sought, because an open diaphragm is equivalent to high resolution and low contrast, while a stopped-down diaphragm gives good contrast, but reduced resolution.
   First open the diaphragm fully, then carefully close it down until a change in contrast is just noticeable. This is not always easy to determine by the image alone. As a rule of thumb it may therefore be said: set the OPTOVAR magnification changer to PH and use the lower knurled wheel to focus on the objective aperture (or look into the tube without an eyepiece). Only in exceptional cases should the diaphragm image now visible be smaller than two thirds of the diameter of the objective aperture.
   The aperture diaphragm is centered if the edge of the diaphragm insert is opposite the index of lever 2 in Fig. 24.
6. After every change of objectives, repeat items 4 and 5.
   If in the case of low-power objectives the image of the lamp field stop should be decentered in relation to the field of view, readjustment is possible at the diaphragm insert (3, Fig. 24) with the aid of two socket wrenches.

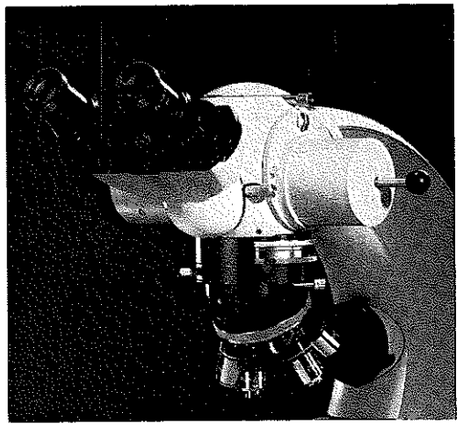
Phase contrast

The pancratic condenser is supplied with an annular diaphragm that can be inserted in the plane of the aperture diaphragm. Its image can be adapted to the size of the phase annulus of any PH phase-contrast objective thanks to the zoom optical system.

1. Proceed as for bright-field illumination, items 1 to 3, but use a low-power Ph objective. Insert green filter.
2. Insert annular diaphragm into diaphragm insert (plane of aperture diaphragm). Set OPTOVAR to PH and use the lower knurled wheel to focus on phase annulus and annular diaphragm which are visible in the objective pupil.
   If the tube head does not include an OPTOVAR, replace one of the eyepieces by the centering telescope, 46 48 20, and focus by turning the two knurled collars in opposite directions.
3. Turn the condenser control knob until the image of the annular diaphragm corresponds to the size of the phase annulus. Obtain perfect coincidence between annular diaphragm and phase annulus. For this purpose move lever 2, Fig. 24, while turning the knob. Set the desired magnification factor on the OPTOVAR or re-insert the eyepiece.
4. After every change of objectives, repeat item 3.



25 a) Annular phase-contrast diaphragm removed
b) in place in diaphragm insert



26 Tube head with binocular body, OPTOVAR and revolving nosepiece.

Details of the microscope

unless described on page 4

Tube head

All image-forming components are combined in the tube head which is thus the microscope proper.
The tube head for the UNIVERSAL is available in two different versions:

Tube head with OPTOVAR	47 16 45
Simplified tube head without OPTOVAR	47 16 40

The openings accept special-purpose inserts, the wide opening on the left, which is normally closed by a dust plug, the analyzer slide for polarized-light microscopy, the barrier-filter insert for fluorescence microscopy or the differential interference-contrast slide;
the narrow opening on the right (below the OPTOVAR), retardation plates or compensators for polarized-light microscopy.

Beam control by reflecting system (12)

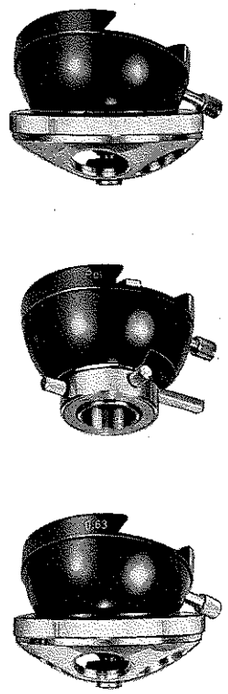
Slide position:

white	red	black	colorless
Normal viewing position,	**Viewing position** if image is too bright in position I,	no light	**For special purposes**
all light used for observation	1/3 of light transmitted to observer's eyes, 2/3 vertically upwards; photomicrography, photometry, television camera, etc.		all light reflected vertically upwards, for projection, photomicrography, cine camera, photometry, etc.

The standard quintuple revolving nosepiece, 47 31 59, may be replaced by the quintuple nosepiece with wide-field system or the single nosepiece.

The **single nosepiece,** 47 31 16, is useful for special-purpose work, for instance with heating stages or universal-stage objectives. In addition, it is used if more objectives are needed than can be mounted on a revolving nosepiece or if each objective must be separately centered.
Objectives screwed into centerable change rings, 46 62 56, can be quickly and easily attached to the single dovetail nosepiece and centered with the aid of two socket wrenches.

The quintuple revolving nosepiece with wide-field system, 47 31 55, in conjunction with the 12.5× Kpl-W wide-angle eyepieces results in extremely wide object fields. By means of a fixed 0.63× optical system the object image produced by the objective is first formed at a reduced scale (thus covering a larger area) in the plane of the eyepiece field stop. Viewed through 12.5× Kpl-W wide-angle eyepieces, this aerial image covers a 2.5× larger area than with a conventional nosepiece in conjunction with 8× Kpl eyepieces. In spite of this increase in coverage, however, there is no change in total magnification.
Flat-field objectives are required for wide-field observation.

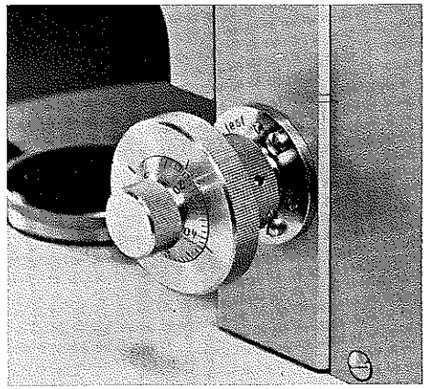


27 Nosepieces
From top to bottom:
Standard quintuple revolving nosepiece, 47 31 59,
Single nosepiece, 47 31 16, with centerable change ring, 46 62 56,
quintuple revolving nosepiece with wide-field system, 47 31 55

Controls

The coarse and fine adjustments are coaxial. The coarse adjustment displaces the specimen stage vertically by about 34 mm, the fine adjustment by 2 mm. The excursion ranges are limited by stops.

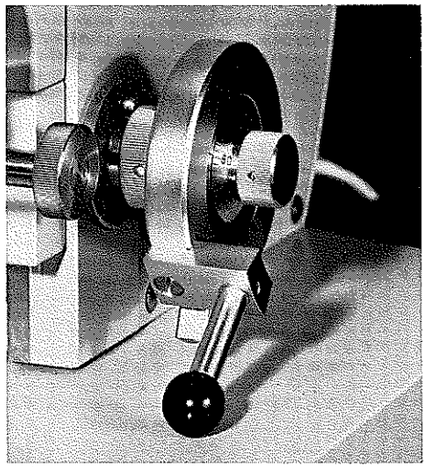
The fine-adjustment range is marked by two lines at the side of the rack and pinion (Fig. 28). The fine adjustment should initially be set to the middle of its range. One interval on the fine-adjustment scale is equivalent to a vertical displacement of 2 μ = 0.002 mm.



28 Coarse and fine adjustment

Regulating the motion: The stiffness of the coarse adjustment can be increased by turning the knurled collar behind the right-hand coarse-adjustment knob towards "fest". The motion of the knob should neither be too easy nor too stiff.
Should the fine-adjustment knob turn too easily, this can be corrected by turning both knobs clockwise.

The focusing lever, 471018, attached to the coarse-adjustment knob allows the rapid relocation of the focusing plane after lowering the specimen stage by simply returning the lever to a stop which is in this case the top of the microscope base.



29 Focusing lever, 47 10 18

Total magnification

is determined by multiplying the initial magnification of the objective by the OPTOVAR factor and the eyepiece magnification.
If the revolving nosepiece with wide-field system is used, allowance must in addition be made for the factor 0.63×.
Tube heads without an OPTOVAR have the factor 1.25.

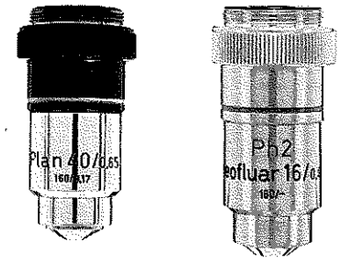
Example a:
16× objective, OPTOVAR 1.25, 10× eyepieces – magnification M?
$M = 16 \cdot 1.25 \cdot 10 = 200\times$

Example b:
40× objective, 0.63× wide-field system, OPTOVAR 1.6, 12.5× eyepieces – magnification M?
$M = 40 \cdot 0.63 \cdot 1.6 \cdot 12.5 = 500\times$

Objectives

The meaning of the values engraved on the objective mount may be explained with the aid of the accompanying illustrations:
Plan = Planachromat (type of correction)
40 = initial magnification
0.65 = numerical aperture (N.A.)
160 = objective computed for a mechanical tube length of 160 mm
0.17 = optimum image quality with cover glasses of 0.17 mm thickness

Ph 2 = phase annulus Ph 2
Neofluar = type of correction
16 = initial magnification
0.40 = numerical aperture (N.A.)
160 = same as above
– = variations in cover-glass thickness without effect on correction.



30 Objectives
Left: 40× Planachromat
Right: 16× Ph NEOFLUAR

To facilitate identification, every objective is provided with a colored ring which can be clearly seen from all sides.
Our objectives are parfocalized. As a result, the image remains visible after an exchange of objectives and need only be refocused with the fine adjustment for optimum sharpness. This, however, is only the case if the tube length is properly adjusted, which can be done by setting the eyepiece tubes of the binocular body to the same value as that indicated by the central interpupillary-distance disk.

All objectives guarantee perfect specimen protection. For this purpose, high-power systems for short working distances are provided with resilient mounts.

Special mention should here be made of the **numerical aperture as** a measure of the resolving power of the objective. This numerical value is a convenient means of computing the "useful magnification" of the microscope. By this, microscopists understand a total magnification (initial magnification of objective × eyepiece magnification × OPTOVAR factor, if applicable) which lies between 500 and 1000 times the numerical aperture.

Example: Numerical aperture = 0.65 – useful magnification = 325× to 650×.

If this range is exceeded by the use of too powerful eyepieces, so-called empty magnification is obtained which will not yield any further information. In addition, empty magnification will reduce image brightness and degrade contrast.

The resolving power depends on the light wavelength λ, the aperture of the objective A_{obj} and the aperture of the condenser A_{cond} which in the most favorable case is identical. The shortest distance d between two lines which can still be resolved (imaged as two separate lines) is, in microns,

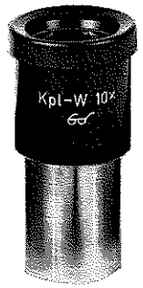
$$\frac{\lambda\,(\mu)}{A_{obj} + A_{cond}}$$

Example a: Planachromat, 40×, 0.65 N.A., $\lambda = 0.55\ \mu$

$$d = \frac{0.55}{0.65 + 0.65} = \frac{0.55}{1.3} = 0.42\ \mu$$

Example b: NEOFLUAR, 100×, 1.3 N.A., $\lambda = 0.55\ \mu$

$$d = \frac{0.55}{1.3 + 1.3} = \frac{0.55}{2.6} = 0.21\ \mu$$



31 10× Kpl-W wide-angle eyepiece

Eyepieces

The UNIVERSAL is always supplied with eyepieces of the Kpl type. These can be combined with all our objectives.

The engraving on the eyepiece in Fig. 31 indicates the following:

Kpl = compensating flat-field eyepieces (correction category)
Lateral chromatic aberration is compensated. Kpl eyepieces reproduce flat aerial images perfectly flat.

W = wide-angle eyepiece

10× = eyepiece magnification

= (Br) also suitable for eyeglass wearers. Long eye relief. The rubber spectacle-lens guards, 46 49 01, supplied with the eyepiece prevent scratching of eyeglasses and are best stuck on with a suitable general-purpose glue.

The so-called field stop incorporated in every eyepiece limits the object portion presented to the observer's eye. The diameter of this stop in millimeters is called the **field-of-view number.**

Eyepiece	Field-of-view number	Cat. No.
Kpl 8×	18	46 39 20
Kpl 8× Br	18	46 39 22
Kpl 10×	16	46 40 20
Kpl-W 10× Br	18	46 40 42
Kpl 12.5× Br	12.5	46 41 20
Kpl-W 12.5× Br	18	46 41 42
Kpl 16×	10	46 42 20
Kpl 20×	8	46 43 20
Kpl 25×	6.3	46 44 20

These field-of-view numbers also apply to the micrometer-disk eyepiece of identical specification.

The field-of-view number determines the **size of the object image.** Two examples are given below to show how the object-field diameter is computed.

Example a:
40× objective, OPTOVAR 1.25, 10× Kpl-W eyepiece – object-field diameter d?

$$d = \frac{18}{40 \cdot 1.25} = 0.36 \text{ mm}$$

Example b:
40× objective, **0.63× wide-field system,** OPTOVAR 1.25, 12.5× Kpl-W eyepiece – object-field diameter d?

$$d = \frac{18}{40 \cdot 0.63 \cdot 1.25} = 0.56 \text{ mm}$$

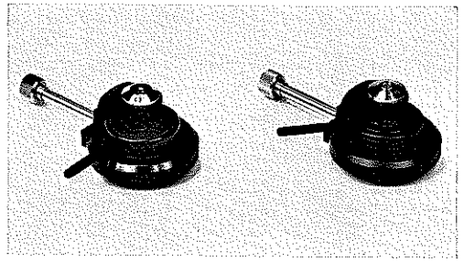
Mention should here be made of our brochure No. 41-101 entitled "Optical Systems for the Microscope", which covers our complete line of microscope optics. All essential data of objectives, eyepieces and condensers are summarized in the form of tables with a detailed discussion of the different correction categories.

Condensers

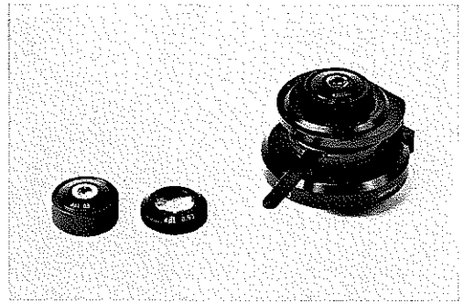
Condensers serve to illuminate the specimen with the correct aperture. In the case of high-power objectives, the condenser ensures that the resolving power of the objective is fully utilized. In order to enable the lamp field stop to be imaged on the specimen to satisfy Köhler's rules, the condenser carrier is vertically adjustable and also permits centration of the condenser.

Bright-field condensers
Pancratic condenser p. 16.

Condensers for bright-field illumination are equipped with an iris diaphragm (aperture diaphragm) to permit variation of the illuminating aperture. Swing-out or interchangeable front lenses allow larger object fields to be illuminated in conjunction with low-power objectives. **Achromatic-aplanatic condensers** contain a high-quality optical system of excellent spherical and chromatic correction. This guarantees a largely aberration-free image of the lamp field stop – and thus rigorous adherence to Köhler's rules – even with the highest apertures. Achromatic-aplanatic condensers are given preference for very critical work. They are practically indispensable for color photomicrography.
In addition to the N.A. 1.4 front lens, front lenses of N.A. 0.63, 46 52 55, and N.A. 0.9, 46 52 56, are available for achromatic-aplanatic condensers (with the exception of the condenser IV Z/7 – see page 24). If no front lens is used, the N.A. of the condenser is 0.32. In bright field, the illuminating aperture and the illumination of different object fields can thus be varied within extremely wide limits.
To change the front lens, the condenser need not be removed but only racked down to the stop. Then the front lens can be screwed on and off.

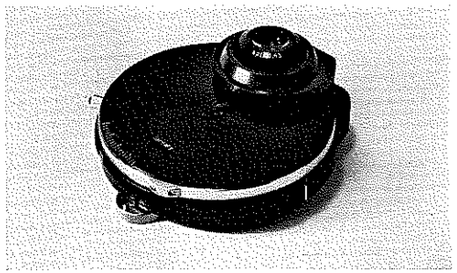


32 Left: Bright-field condenser Z, 0.9 N.A., 46 52 52
Right: Bright-field condenser Z, 1.3 N.A., 46 52 53

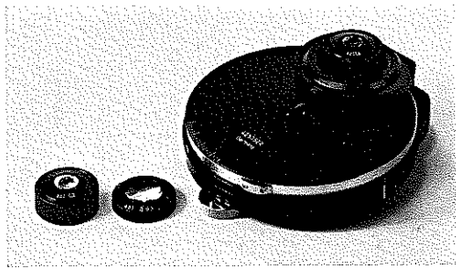


33 Achromatic-aplanatic bright-field condenser Z, 1.4 N.A., 46 52 57; N.A. 0.63 front lens, 46 52 55; N.A. 0.9 front lens, 46 52 56

34 Condenser II Z, 46 52 70



35 Condenser IV Z/7 46 52 72



36 Condenser V Z, 46 52 77

Phase-contrast condensers

Bright-field phase-contrast condenser II Z, 46 52 70

Bright field in J position – N.A. 0.9
Phase contrast with swung-in front lens and annular diaphragms 1, 2, 3
Dark field in position 3 with objective apertures up to 0.32
The phase-contrast condenser II Z POL (red engraving) has a strain-free optical system in the bright-field position J. Strain-free POL objectives must be used for polarized-light microscopy under orthoscopic or conoscopic observation.

Achromatic-aplanatic bright-field phase-contrast condenser IV Z/7, 46 52 72

Bright field in J position –
N.A. 0.63 with front lens
N.A. 0.32 without front lens
Phase contrast with screwed-in front lens and annular diaphragms 1, 2, 3
Dark field with front lens in position 3 with objective aperture up to 0.32
Illumination of thick specimens and objects in sample chambers and Petri dishes due to its object distance of 7 mm (in air) and 11 mm (in glass).

Achromatic-aplanatic bright-field phase-contrast dark-field condenser V Z, 46 52 77

Bright field in J position –
N.A. 1.4 with immersed front lens,
N.A. 0.32 without front lens,
N.A 0.9 with front lens, 46 52 56,
N.A. 0.63 with front lens, 46 52 55
Phase contrast with immersed N.A. 1.4 front lens and annular diaphragm 2 or 3
Dark field with immersed N.A. 1.4 front lens in D position with objective apertures of 0.65 to 1 and maximum specimen-slide thickness of 1.2 mm
Dark field with N.A. 1.4 front lens in position 3 with objective apertures up to 0.32

Achromatic-aplanatic phase-contrast fluorescence condenser, 46 52 78
This corresponds in all details to the V Z-type condenser, but in addition has annular diaphragms 2 and 3 made of polarizer sheet. In these positions, which are engraved in blue, a phase-contrast image can be superimposed on the fluorescent images produced by transmitted light, and continuously varied.

Achromatic-aplanatic phase-contrast interference-contrast condenser, 46 52 84 with strain-free optics
Bright field in positions I, II, III or IIII
N.A. 1.4 with immersed front lens,
N.A. 0.32 without front lens,
N.A. 0.63 with Pol front lens, 46 52 56
Phase contrast with immersed N.A. 1.4 front lens and annular diaphragm 2 or 3
Dark field with N.A. 1.4 front lens in position 3 with objective apertures up to 0.32
Interference contrast in positions I, II, III, IIII (Wollaston prism + iris diaphragm – full aperture can be utilized).

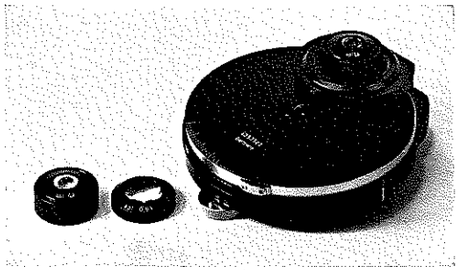
Dark-field condensers

In addition to the aforementioned phase-contrast condensers, which may also be used for dark-field illumination (central dark-field stop D or annular diaphragm 3), special dark-field condensers are likewise available. They can be screwed onto the condenser holder Z.

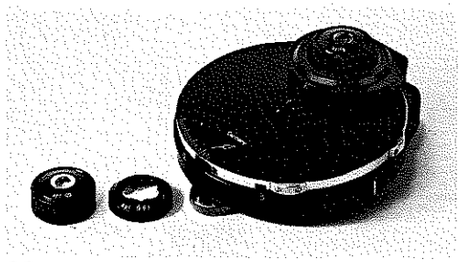
Dry dark-field condenser, 0.7/0.85 N.A., 46 55 06
For objectives of N.A. 0.4 to 0.6 and maximum specimen-slide thickness of 6.5 mm

Dry dark-field condenser, 0.8/0.95 N.A., 46 55 05
For objectives of N.A. 0.6 to 0.75 and maximum specimen-slide thickness of 6 mm

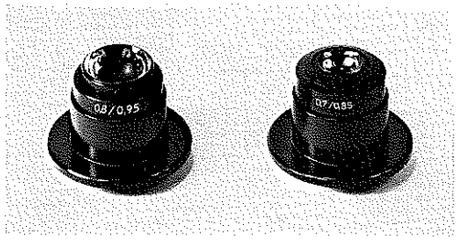
Ultracondenser, 1.2/1.4 N.A., 46 55 00
Immersion condenser for objectives of N.A. 0.75 to 1.0 and maximum specimen-slide thickness of 1.2 mm



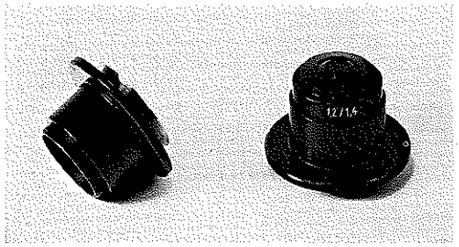
37 Phase-contrast fluorescence condenser, 46 52 78



38 DIC condenser, 46 52 84



39 Dry dark-field condensers, 0.8/0.95 N.A., 46 55 05, and 0.7/0.85 N.A., 46 55 06



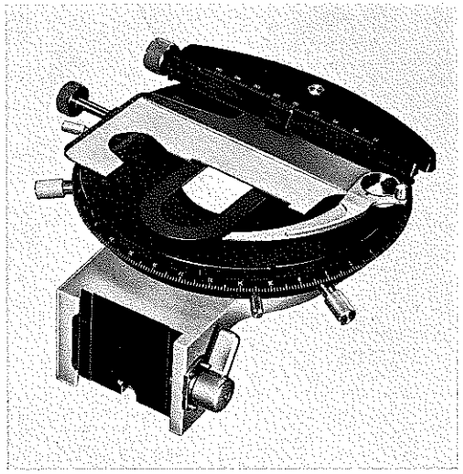
40 Ultracondenser, 1.2/1.4 N.A., 46 55 00
Left: condenser holder Z alone, 46 55 42

Specimen stages

The catalog numbers of stages include the stage carrier. The circular mechanical stage and the glide stage can be removed from the centering piece of the stage carrier, while the large mechanical stages are screwed on.

Circular mechanical stage
ungraduated: 47 35 56
graduated: 47 35 57 (Fig. 41)
Motion range 50×75 mm

The rotating stage can be centered in relation to the optical axis of the microscope to ensure that the specimen remains in the field of view during rotation. For this purpose we supply a centering cross with the individual coordinates of every stage: Place this centering cross on the stage and set the scale of the mechanical stage to the coordinates indicated. If a low-power objective is used, focus on the cross lines. To facilitate recognition of the cross, close the aperture diaphragm down as far as possible. Insert two socket wrenches into the centering piece (Fig. 43) and move the cross lines to the center of the field. Since a cross-hair eyepiece is not generally available, the center of the field can be marked by the centered, closed lamp field stop (Fig. 16). Finally, proceed in the same manner with an objective of higher power.
The graduated scales allow any point on the specimen to be quickly relocated. With the aid of verniers, this can be done with an accuracy of 1/10 mm. The two coordinates applicable to a certain specimen point (e. g. 14.1/112.7) may then be noted down on the data card. This point will again be in the field of view as soon as the scales have been set to the above values.
The rotary and back and forth motions can be clamped by means of lateral screws.



41 Circular mechanical stage with graduation, 47 35 57

Glide stage, 47 34 54
Motion range 28×32 mm

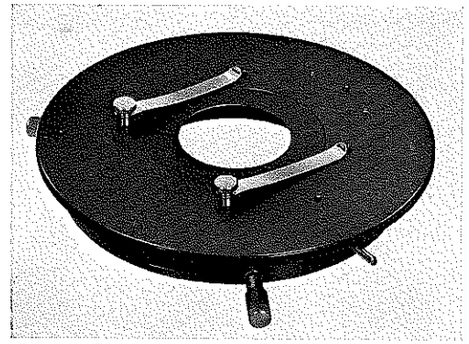
The stage top follows the pressure of the hand. It can be rotated by means of two grips. The rotary motion can be clamped by a screw.

The stage can be centered in relation to the optical axis of the microscope to ensure that the specimen will remain in the field of view while the stage is rotated: turn the stage under observation with 10× or 16× objective. The approximate position of the center of rotation can be easily recognized. Move this center into the middle of the visual field with the aid of two socket wrenches. For more accurate centering, use a cross-hair eyepiece to mark the center of the field.

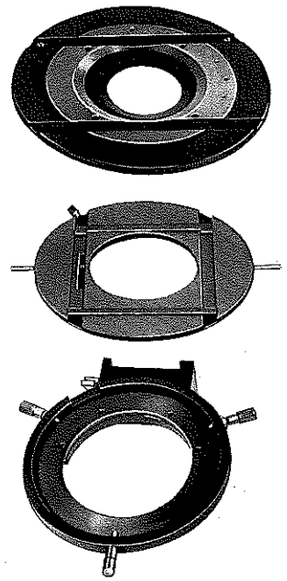
Specimen slides are held down by two stage clips. In additon, the stage top is provided with holes for mounting an attachable mechanical stage to guide the specimen. If the stage has not been used for some time, shift it several times in all directions to ensure smooth motion of the top.

To preserve the gliding properties of the stage and to ensure perfect results at any magnification, the stage should be lubricated at intervals of about six months. 10 cc of suitable oil, 47 33 91, are supplied with the stage.

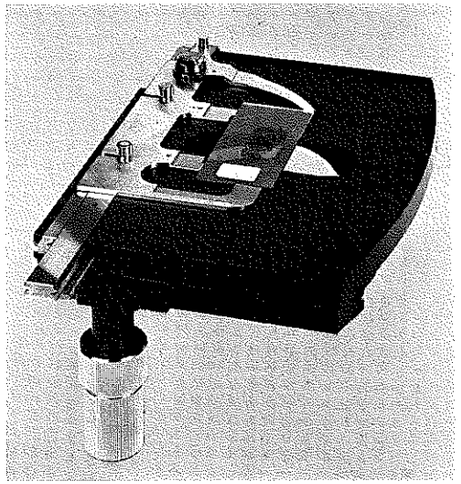
Lubrication of glide stage
Turn stage centering screws back. Press base plate with stage top against the relieved spring bolt and lift it off. Separate base plate from stage top by pushing them apart. Now make a note of the position of the guide frame, which is important for assembly. Clean all gliding surfaces carefully with xylol. With your finger apply a very thin film of oil to the gliding surfaces of stage top and guide frame. The less oil is used, the better. Then reassemble the stage. Be sure that the spring bolt lies in the cutout of the base plate.
After reassembling the stage, move the stage top several times in all directions to distribute the oil uniformly. The top must not move too easily. This would indicate that there is too much oil between the gliding surfaces. It is advisable then to center the stage at least approximately.



42 Glide stage, 47 34 54



43 Glide stage disassembled for lubrication. From bottom to top: centering piece, base plate, stage top turned upside down.



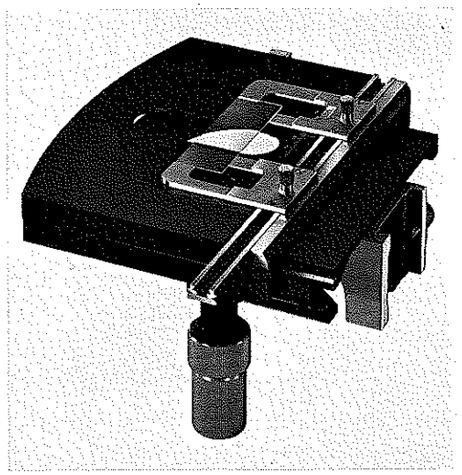
44 Large mechanical stage, 47 34 23

Large mechanical stage
Motion range 35×75 mm
The low, coaxial controls for stage displacement are located on the right-hand side of the instrument. If it is desired to operate the shift control with the left hand, it is only necessary to rotate the body tube through 180°. However, there is also a version of the stage featuring left-hand controls (Fig. 44). The specimen holder can be removed for cleaning. At the same time, this produces a large stage surface for special applications.

Two different models of this stage are available:

Stage 47 35 23 with specimen holder for ordinary 76×26 mm and 76×52 mm slides, without graduation. When immersion objectives are used, "lifting off" of specimens can be prevented by two stage clips.

Same as above, with left-hand controls: 47 35 24.



45 Large mechanical stage, 47 34 25, with adjustable specimen holder

Stage 47 35 25 with adjustable specimen holder, for guiding up to 180 mm wide plates. The two holders can be adjusted and clamped as required.

The graduated scales of this stage allow any point on the specimen to be quickly relocated. With the aid of a vernier, this can be done with an accuracy of 1/10 mm. The two coordinates applicable to a certain specimen point (e. g. 96/24.7) may then be noted down on the data card. This point will again be in the field of view as soon as the scales have been set to the above values. It is then, of course, necessary that the right-hand holder carrying the index be left unchanged.

Same as above, with left-hand controls: 47 35 26.

Illumination

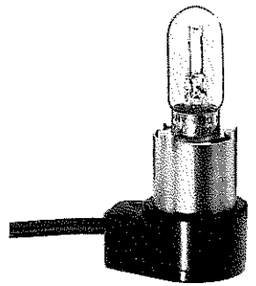
Base illuminator
The instrument is generally used with a 6-V, 15-W lamp incorporated in the base. The light output of this lamp is entirely sufficient for ordinary microscopic work. If special requirements are made of the light intensity or the spectral characteristics of the radiation, suitable accessory light sources may be used (page 31).
In the majority of cases it will be sufficient to operate the lamp at lower than rated voltage. This will considerably increase its burning life. The lamp should only be overrun, i. e. operated on more than 6 volts, for brief periods because overvoltage will reduce its life excessively. See the table opposite.

Lamp data

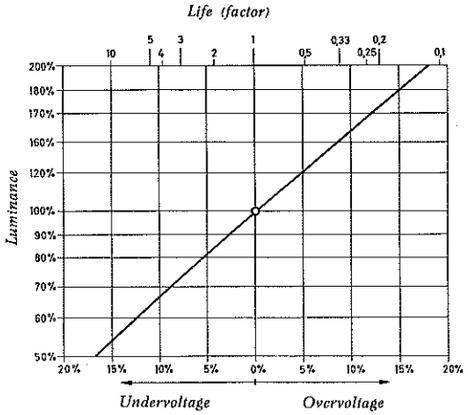
	Base illuminator	60-W illuminator
Rated voltage	6 volts	12 volts
Current	2.5 amps	5 amps
Luminance	850 stilbs	1250 stilbs
Color temperature	2850° K	3050° K
Luminous area	1.6×1.8 mm	3.2×3.2 mm
Catalog No.	38 01 77	38 02 16

Transformers for

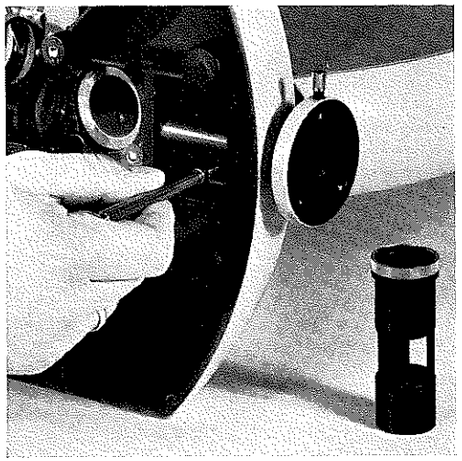
6-V, 15-W illuminator	60-W illuminator
39 25 21 110-127-220-240 / 2.5-3.5-4.5-5.5-8 volts 50 . . . 60 Hz, 15 VA	39 25 27 100-110-127-220-240 / 10-12-15 volts, 50 . . . 60 Hz, 135 VA
39 25 24 100-110-127-220-240 / 0 . . . 8 volts, 50 . . . 60 Hz, 30 VA with ammeter and outlets for two illuminators	39 25 33 100-110-127-220-240 / 3 . . . 15 volts, 50 . . . 60 Hz, 120 VA with ammeter and outlets for two illuminators



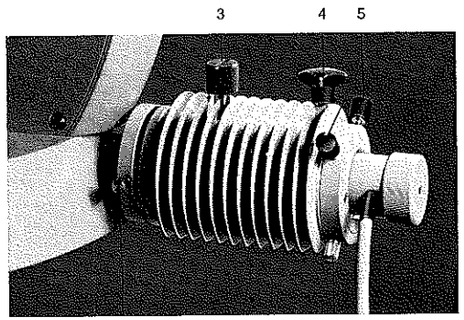
46 6-V, 15-W lamp in socket



47 Relationship between voltage, luminance and life of low-voltage lamps



48 60-watt illuminator; mounting the connecting tube; on the right, the collector tube of the base illuminator.



49 60-watt illuminator on UNIVERSAL
1 = clamp screw of illuminator
2 = clamp screws of spring bolts (counterparts of 5)
3 = knob for controlling diffusion disk which is usually in the light path during work with the microscope
4 = clamp screw of lamp socket
5 = centering screws of lamp socket

Further accessories

60-watt illuminator

Instead of the 6-V, 15-W base illuminator, the 60-watt illuminator for transmitted light may be firmly connected to the microscope stand. For this purpose, the collector tube with lamp condenser, 46 70 50, must be removed after unscrewing the bottom plate and replaced by the connecting tube, 46 70 41 (Fig. 48). The 60-watt illuminator is mounted in the usual manner with the aid of a dovetail ring, like a body tube, for example.

For vertical illumination, the 60-watt illuminator is mounted directly to the back of the stand (15). In this case, the connecting piece, 46 70 42, is used instead of the cover.

The relationship between voltage, luminance and burning life is illustrated in Fig. 47.

Centering the 60-watt illuminator

1. Switch lamp on. Swing out diffusion disk 3 and slightly loosen both clamp screws 2 of the spring bolts and screw 4.
2. Place a sheet of paper on the diaphragm insert in the microscope base and shift the lamp socket until the lamp filament is imaged on the paper, varying the diaphragm setting as required.
3. Turn the centering screws 5 until the filament is exactly in the center of the light exit opening. Tighten both screws 2. The lamp is thus centered.
4. For perfect illumination, the lamp filament should be imaged in the plane of the aperture diaphragm of the condenser. To check this, hold a sheet of paper as close to the condenser as possible (swing out filter holder and auxiliary lens) and slightly shift the lamp socket. Then tighten the screw 4 and swing in the diffusion disk.

Special-purpose illuminator

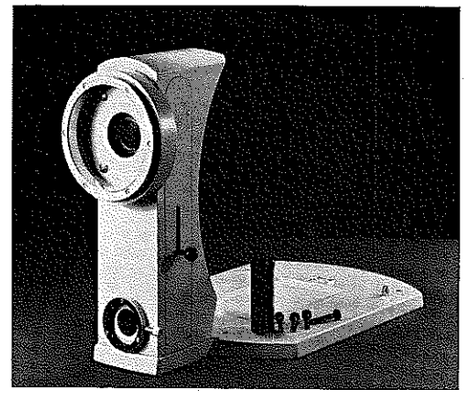
The special-purpose illuminator, 47 20 17, allows the multi-purpose microscope illuminator to be firmly connected to the UNIVERSAL microscope. As a result, all the gas-discharge lamps generally used for special microscopic work can also be employed in conjunction with this instrument.
Moreover, an additional 60-watt illuminator can be connected.
The knob on the left-hand side of the special-purpose illuminator serves to operate a reflector system:

Knob	Special-purpose illuminator set for	60-watt illuminator set for
Up	Reflected light	Transmitted light
Down	Transmitted light	–

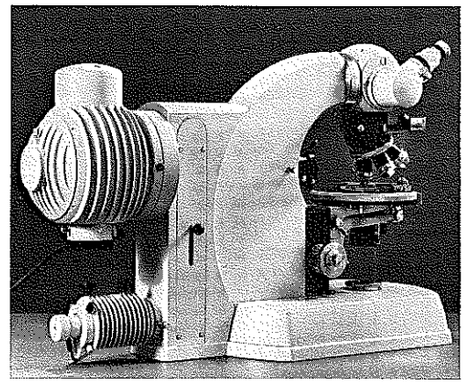
Assembly

1. Tilt the UNIVERSAL to one side, unscrew the bottom plate and remove the collector tube normally housing the 6-V, 15-W illuminator, after loosening one screw with the aid of a screwdriver (Fig. 48). Then mount the orienting tube supplied with the special-purpose illuminator in the microscope base in the reverse order.
2. Unscrew the four rubber feet of the microscope and place the instrument on the base plate so that the orienting tube slightly projects into the opening of the special-purpose illuminator. Then insert the four fixing screws from below through the base plate into the tapped holes from which the rubber feet were removed, thus connecting the microscope firmly to the special-purpose illuminator.

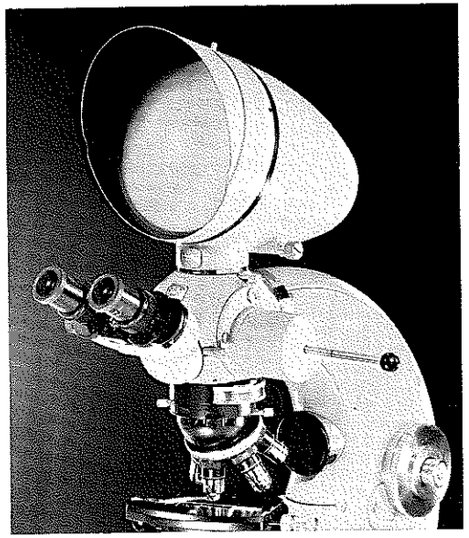
For **inserting and centering** the lamp, see Operating Instructions G 41–320 for the Multi-purpose Microscope Illuminator.



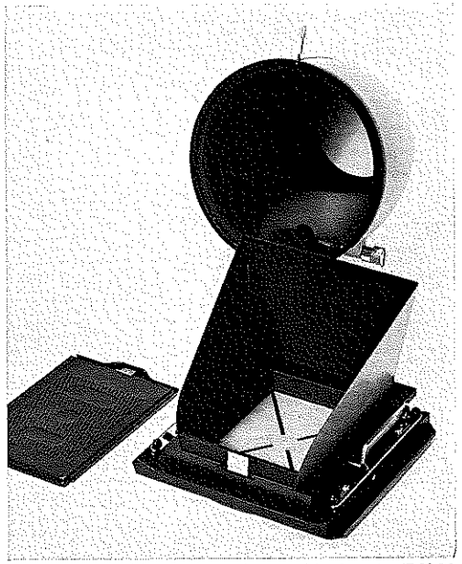
50 Special-purpose illuminator, 47 20 17, with orienting tube and fixing screws



51 Multi-purpose microscope illuminator and 60-watt illuminator on special-purpose illuminator



52 Projection attachment, 47 30 85



53 9×12 cm / 4×5" photomicrographic insert, 47 30 84, and 9×12 cm sheet-film and plate holder, 47 61 29

Projection attachment

The projection attachment, 47 30 85, is mounted directly on the top of the tube head like a body tube. The 15 cm Fresnel lens used as ground glass provides uniform illumination right out to the edge of the field. The 6-V, 15-W base illuminator is entirely sufficient for bright-field work with low and medium-power objectives. In the case of illuminating techniques involving a certain loss of light, with strongly absorbing specimens and high-power objectives, preference should, however, be given to the 60-watt illuminator.
The viewing screen should be set up so that no bright surroundings or windows are in the viewing direction. Best results are obtained in subdued room light.
The image scale on the ground-glass screen is the product of the initial magnification of the objective, the OPTOVAR factor (or, otherwise, 1.25×) and the factor 10. In other words, the aerial image produced by the objective is magnified 10× by the optical system in the projection attachment.

The ground-glass screen 47 30 81 may be exchanged for two other inserts:

Ground-glass insert, 47 30 83, with rotating and sliding scale. The transparent millimeter scale allows any object point to be measured on the ground glass.

9 × 12 cm / 4 × 5" photomicrographic insert, 47 30 84, for use in conjunction with:
9×12 cm sheet-film and plate holder, 47 61 29,
LINHOF 9×12 cm double sheet-film and plate holder,
Polaroid 4×5" sheet-film holder, type 545.

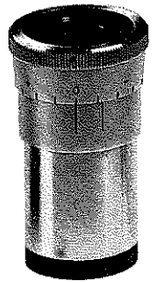
With this negative size, of course, longer exposure times are required. The capping shutter may therefore be operated by hand without danger of blurring. The shutter is closed when the red line on the shutter knob is in a vertical position.

Length measurements under the microscope

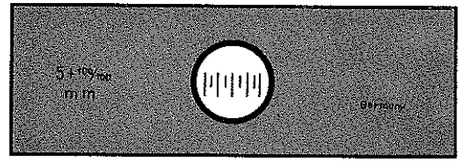
These can be effected with the aid of an eyepiece designed to take micrometer disks. In addition, a stage micrometer is required for the initial calibration of the disks.
Eyepieces for micrometer disks are available with the most widely used eyepiece magnifications. Their eyelens can be focused on the measuring scale. With the micrometer disk in place, the red line serves as index for the diopter scale of the eyepiece. This compensates for the dislocation of the image plane produced by the disk. If used without a micrometer disk, the black line serves as an index.
With some eyepieces the ends of the micrometer scale are cut off by the eyepiece field stop. However, this will never be the case with the 8× Kpl eyepiece.
Eyepiece micrometers are circular glass disks of 17 mm diameter provided with a scale. They are located close to the field stop in the eyepiece. With the 10:100 micrometer disk, 47 4011, 10 mm are divided into 100 intervals.
The **stage micrometer 5+100/100,** 47 40 20, is a glass plate mounted in a metal slide of normal size. Its scale consists of 5 whole millimeters and 1 mm subdivided into 100 intervals (1 interval = 10 µm). As is usual for transmitted-light work, the scale has a coverslip.

Measurement

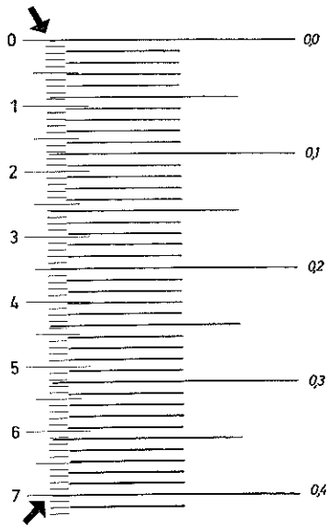
When measuring microscopic specimens it is impossible to place a scale in direct contact with the specimen. The scale of the micrometer disk is therefore seen together with the specimen in the intermediate image plane. However, the eyepiece micrometer is not used for measurement in the original sense of the word, but a certain object length is transferred to a true scale. This true scale is the stage micrometer which is now exchanged for the specimen. In order to avoid having to exchange the specimen for the stage micrometer all the time, the eyepiece micrometer may be **calibrated** once and for all so that it can



54 Eyepiece for micrometer disks



55 Stage micrometer 5+100/100, 47 40 20



56 Calibrating the eyepiece micrometer.

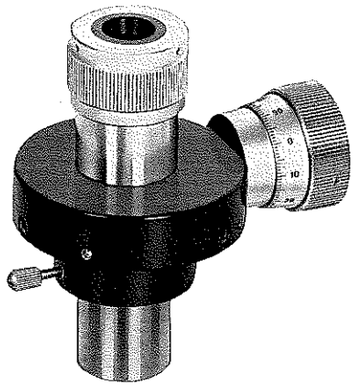
Scales of eyepiece micrometer (left) and stage micrometer (right) side by side in the field of view.

be employed for direct measurement. For this purpose, proceed as follows:

1. Insert micrometer disk into eyepiece (which must be designed to take reticules). To do this, unscrew the lower, black part of the eyepiece. Remove the ring above the field stop and replace it after inserting the micrometer disk (scale facing up). Screw eyepiece together again.
2. Point eyepiece towards a bright surface and turn focusing eyelens counterclockwise until the scale is in sharp focus. Then slip the eyepiece into its tube.
3. Place stage micrometer on specimen stage and use coarse and fine adjustment to focus on the scale. Turn the eyepiece in its tube until the two scales are parallel and side by side.
4. Determine the number of micrometer-disk divisions corresponding to a certain length of the stage micrometer. In Fig. 56, 70 intervals of the micrometer disk correspond to 0.4 mm (400 µm) on the stage micrometer.
5. Determine the micrometer value, i. e. the true length corresponding to an interval of the micrometer-disk scale.
   Example: 400 µm : 70 = 5.7 µm.
   If the micrometer value is close to a round figure it may be rounded off, provided that the body tube of the microscope permits the tube length to be varied (binocular body). This tube length must then be used for all future measurements.

To determine the length of an object distance, it will henceforth only be necessary to multiply the number of divisions by the micrometer value. The stage micrometer is no longer required. The micrometer value applies only to the objective-OPTOVAR-eyepiece combination used for calibration. Separate calibration is required for every objective. Since the micrometer value is also a function of tube length, special care should be taken always to use identical settings on the eyepiece tubes.

For special applications, contrast, line contrast and net micrometer disks can be supplied (see booklet 41-101, Optical Systems for the Microscope).



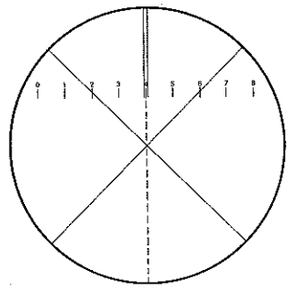
57 K 8× screw micrometer eyepiece, 46 39 72, or K 16×, 46 42 72

Precision measurements

The K 8× or K 16× screw micrometer eyepiece permits even more accurate length measurement and can be used in monocular tubes. This eyepiece has its graduation on a measuring drum with 100 intervals per revolution. After every revolution, a measuring line (and a crosshair) shift by one full interval in the field of view (divisions in the field of view = 0–8).

a) Turn eyelens down until the double lines at one end of the broken measuring line appear just sharply separated. Now calibrate the screw micrometer eyepiece as described before with the aid of a stage micrometer.
b) Set micrometer to 0 (measuring drum at 0, measuring line in field of view at 0). Use coarse and fine adjustment to focus on the scale of the stage micrometer, turn eyepiece until the two scales are parallel to each other and clamp eyepiece in position.
c) Turn micrometer screw to guide the measuring line over a certain distance of the stage micrometer. Read number of the intervals covered (e. g. 769) and compare with the distance covered on the stage micrometer (e. g. 0.5 mm).

   Example: 500 µm : 769 = 0.65 µm.
   The micrometer value found for one interval of the measuring drum is 0.65 µm.



58 Field of view offered by screw micrometer eyepiece

59 Luminar holder, 47 25 51, with rectangular stop in place. 16 mm, 25 mm and 40 mm LUMINARS.

60 Luminar holder, 47 25 52, and 63 mm LUMINAR

61 Spectacle-lens condensers and auxiliary lens 4 for spectacle-lens condenser 4.

Image scales as referred to the film negative:

LUMINAR	Image scales	Object field size in mm
16 mm	14:1 – 22:1	2.6×1.7 – 1.6×1.1
25 mm	8:1 – 14:1	4.5×3 – 2.6×1.7
40 mm	4:1 – 8:1	9×6 – 4.5×3
63 mm	2:1 – 4:1	18×12 – 9×6

Low-power photography with LUMINAR objectives

The LUMINAR equipment may be used on the UNIVERSAL in conjunction with a 35 mm single-lens reflex camera equipped with a focal-plane shutter. Image scales in the film plane are between 2:1 and 22:1. Transparent specimens are illuminated by means of the illuminator incorporated in the microscope and a suitable spectacle-lens condenser.

The Luminar head, 47 20 50, attached to the stand instead of the tube head, supports the objective and the camera. The telescopic extension provided for variation of the camera extension can be clamped in any desired position with the aid of two screws. It is normally supplied with a bayonet thread suited for attachment of the CONTAREX camera. However, single-lens reflex cameras of other manufacture can also be attached, provided that their lens is interchangeable. If a special adapter is desired in the Luminar head, the required details should be specified in the order.

LUMINARS are high-performance photomicrographic objectives designed for single-stage image formation. To ensure that the focusing movement of the microscope stage is sufficient for satisfactory focusing of the specimen, LUMINARS are supplied with holders of different height.
The iris diaphragm of LUMINAR objectives must be fully opened for photography by transmitted light. It serves to increase the depth of field if three-dimensional objects have to be photographed by reflected light. The diaphragm is engraved with factors by which the exposure time determined for full aperture must be multiplied.

Every LUMINAR has a **spectacle-lens condenser** of its own. A clip-on stop, which is located directly beneath the specimen when the condenser is properly set, serves as a fixed field diaphragm. In the spectacle-lens condenser 4 for the 63 mm LUMINAR the clip-on stop is replaced by an auxiliary clip-on lens 4.

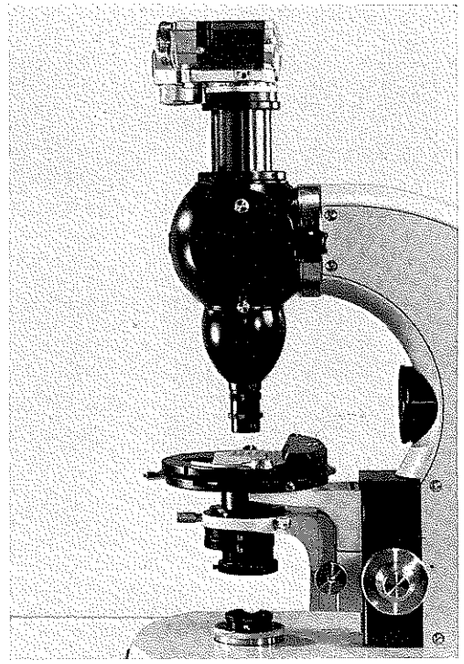
With all LUMINARS, the **BL illuminating lens,** 46 70 90, is inserted into the light-exit opening in the microscope base. It may only be omitted if the microscope is equipped for use of the pancratic condenser.

Assembly

1. Remove the tube head of the microscope and replace it by the Luminar head, 47 20 50.
2. Screw the LUMINAR into the corresponding Luminar holder and attach the latter in the usual manner with its dovetail ring to the Luminar head. Then clamp it.
   With the LUMINARS from 16 to 40 mm first insert the rectangular stop, 47 25 53, from above into the Luminar holder. Its correct position may be checked by looking from above into the telescope tube: turn the Luminar holder until the two visible rectangular stops are properly located.
3. Remove the lens of the CONTAREX and attach the camera – red dot facing red dot – with the aid of the bayonet mount to the telescope tube.
4. Insert the spectacle-lens condenser corresponding to the LUMINAR used (identical color of engraving) and rack it fully up by means of the condenser movement.
5. Insert the BL illuminating lens, 46 70 90, into the light-exit opening of the microscope base. This does not apply if the microscope is equipped for use of pancratic condenser.

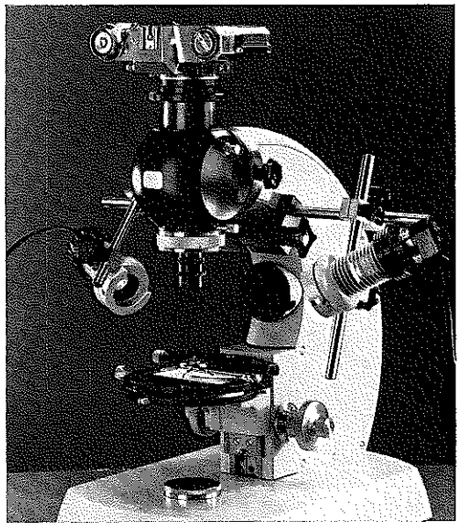
Procedure

6. Switch on the base illuminator and (if necessary) also the light filters.
   With 16 to 40 mm LUMINARS swing auxiliary condenser lens (4) in, with 63 mm LUMINAR swing it out.
7. Look into the camera viewfinder and focus on the specimen using the coarse and fine adjustments of the microscope. Obtain the desired image scale by varying the camera extension (drawing out the telescope tube) and refocus.
8. Control image contrast and resolution by means of the lamp field stop (2) acting as aperture diaphragm.



62 LUMINAR equipment on UNIVERSAL

LUMINAR	Luminar holder	Spectacle-lens condenser Diameter of clip-on stop
16 mm 46 25 11	47 25 51 with rectangular stop 47 25 53	**1** 3.5 mm
25 mm 46 25 13		**2** 6 mm
40 mm 46 25 15		**3** 9 mm
63 mm 46 25 17	47 25 52	**4** without clip-on stop, but with auxiliary lens 4, 46 55 80



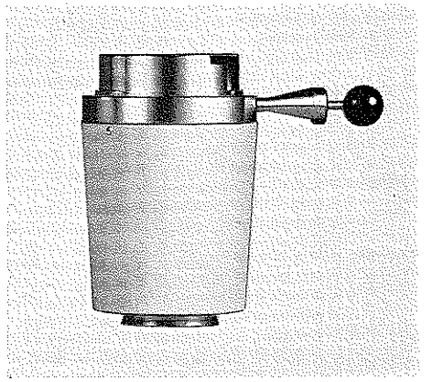
63 Incident illumination using two low-voltage illuminators on holder 47 20 65.

A compromise must be sought here, because a wide open diaphragm means high resolution and low contrast, while a stopped-down diaphragm reduces the resolution but enhances contrast.

Always open the iris diaphragm of the LUMINARS fully.

9. If the camera used does not have a through-the-lens light metering system, determine the required exposure with the aid of a series of calibration exposures.
   The exposure determined with a hand-held meter through the camera viewfinder or, with the camera removed, through the telescope tube at f/2 may serve as a guide.

The holder for reflected-light illuminator, 47 20 65, supports two low-voltage lamps, the position of which can be varied within wide limits. The holder is clamped to the stand from below (Fig. 63).



64 Microscope tube with pointer, 47 79 15, for Siemens & Halske television camera

The microscope tube with pointer, 47 79 15, serves to attach a Siemens & Halske television camera. It is fitted on the tube head in place of a cover.

The television camera tube (Vidicon) is located in the plane of the aerial image produced by the microscope. The movable pointer, the tip of which is imaged together with the specimen, is located in the same plane. Any object detail in the field of view can thus be pointed out without difficulty.
In order not to fall short of useful magnification, it is advisable to use the OPTOVAR for additional magnification.
In monochrome television, certain colors of the object can be stressed or subdued with the aid of color filters. Particularly well suited for this purpose is the continuous interference-filter monochromator (page 40).

Simple polarizing equipment

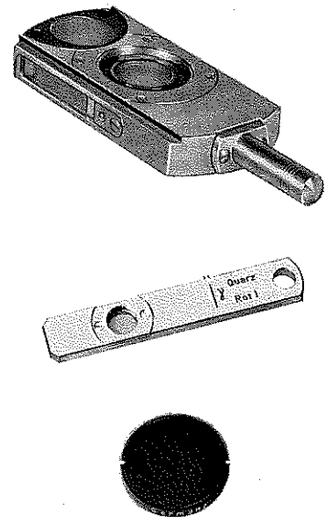
The polarizing equipment, 49 36 01, if used on the UNIVERSAL, serves for simple polarized-light work with moderately to strongly refracting objects and for qualitative work, such as determining optical characteristics. A rotary stage is indispensable here as it is for polarized-light work in general.

The polarizing filter, 47 36 00, is used as polarizer in the lower swing-out filter holder of the condenser carrier. The two white lines on the edge of its mount indicate the vibration direction and should lie in right–left (east–west) direction, like the grip of the filter holder.

The simple analyzer slide, 47 36 63, which has a fixed polarizing filter, is inserted into the wide opening in the tube head instead of the dust plug. It is secured in the tube head by means of the screw on one side. When the slide is pulled out all the way, a quartz plate is in the light path, which eliminates the analyzer effect of prisms.

Accurate crossing of analyzer and polarizer with the resulting optimal darkness of the background field is achieved by slightly turning the polarizer. Only birefringent elements will then light up if the stage is rotated.

The first-order red retardation plate, 47 37 00, is inserted into the narrow opening in the tube head. It has two vibration directions oriented at right angles to each other, in which the light is transmitted at different speed. These two directions make a 45° angle with the vibration directions of polarizer and analyzer. The direction marked γ on the mount indicates the plane of vibration of the light passing at lower speed.
In "plus position", the specimen appears in a 550 nm (first-order red) higher interference color, e. g. blue. The vibration direction of the slower wave train in the specimen is then parallel to the γ-direction of the retardation plate.



65 Simple polarizing equipment, 49 36 01:
Polarizing filter, 47 36 00,
first-order red retardation plate, 47 37 00,
simple analyzer slide, 47 36 63.

In "minus position", the interference color is correspondingly lower, e. g. yellow (vibration direction of faster wave train parallel to γ-direction).
On request, we shall be pleased to supply the Michel-Lévy color chart SE 40–554.

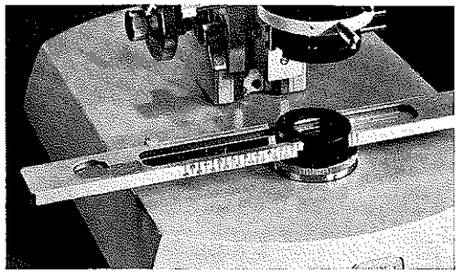
Continuous interference-filter monochromator

The continuous interference-filter monochromator, 47 43 10, is attached via the filter carrier, 47 43 16, to the diaphragm insert in the microscope base.

This filter is a glass strip of continuously varying transmittance from approx. 400 to 700 nm and thus replaces a large set of filters. Monochromasy is constant up to an aperture of 5 mm. This holds for the entire spectral range. The transmission is about 25 %. At a slit width (width of light bundle) of 5 mm the half width is about 13 nm and the tenth width about 34 nm. A displacement of the filter by 0.4 mm corresponds to a wavelength change of 1 mμ. An adjustable stop allows rapid relocation of a certain filter position. The wavelength is read off at the outer edge, not in the incision.

If the filter is located close to the lamp field stop, the diameter of the latter will represent the "slit width" of the filter. A home-made slit diaphragm placed on the filter will serve the same purpose.

The filter is, of course, sensitive to humidity and heat. It is advisable to keep the filter in its case where it is protected against excessive moisture by its dessicant cartridges.

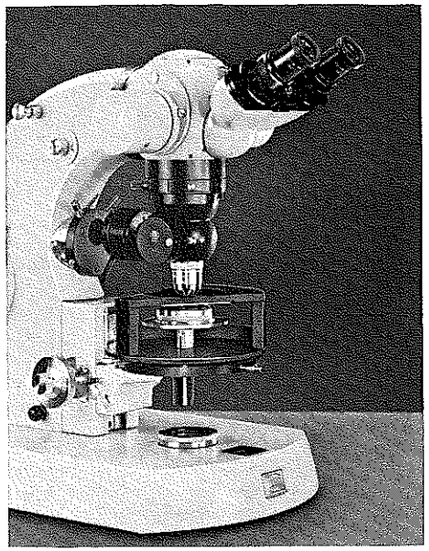


66 Continuous interference-filter monochromator, 47 43 10

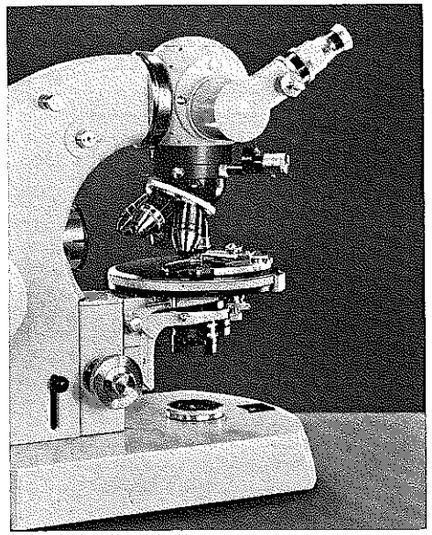
Care of microscope

Your microscope is a valuable precision instrument. It should be properly treated to ensure perfect functioning and long life. Please observe the following rules:

- Protect the microscope against its enemy number one: dust. Use the dust cover, 47 93 01, whenever the instrument is not needed.
- See to it that the eyepieces are always in place. All other openings through which dust may enter (e. g. the intermediate tube) should likewise be closed.
- Remove dust from optical elements exclusively by blowing or by dabbing them with a damp cotton wad. Rubbing may produce tiny scratches.
- All glass surfaces, lenses and mirrors should be cleaned with a dust-free linen rag or cotton wad – never with leather.
- Optical elements should be treated with solvents only if breathing on them (or distilled water) does not do the trick. Small quantities of acetone, xylol or pure benzene may be used as solvents. Never use alcohol, which will destroy the cement between the optical elements.
- In no case must solvents come into contact with guides, for they will destroy the film of grease ensuring smooth and easy motion.
- Residues of immersion oil, fingerprints and traces of grease – above all on objective front lenses and eyepiece eyelenses – impair the performance of the microscope. Check frequently for cleanliness.
- Never oil the precision guides, rack and pinion movements, screws or other moving parts. This would definitely cause damage.



67 UNIVERSAL set up for reflected light



68 UNIVERSAL set up for polarized light

Further possibilities of adaptation

Reflected-light microscopy

The UNIVERSAL is equally well suited for transmitted and vertical illumination. The following four vertical illuminators can be supplied:

a) Type III D vertical illuminator for bright-field illumination (standard metallographic magnifications). With revolving nosepiece.
b) Type II C vertical illuminator for bright field, dark field, differential interference contrast. With single nosepiece.
c) Type III C vertical illuminator for bright field, dark field, differential interference contrast. With revolving nosepiece.
d) Type II E vertical illuminator for photometric work, but also for bright field, dark field and differential interference contrast. With single nosepiece.

The EPIPLAN objectives, which are practically free from flare, have an optimally flattened field. The 60-watt illuminator is a high-power light source which, attached to the back of the stand, transmits the light via the aperture-stop insert directly into the vertical illuminator, without any deflection. The stage for polished specimens holds objects up to 40 mm thick in a perfectly horizontal position and at the same time prevents damage to both the object and the objective.

Parts and procedures for reflected-light work are described in the Operating Instructions G 41–655.

Polarized-light microscopy

Any UNIVERSAL can be converted into a polarizing microscope. For this purpose, the following accessories are required: POL condenser carrier with polarizer, rotary polarizing stage, analyzer, slide, polarizing tube or inclined binocular POL body, crossline eyepiece and compensators. In addition, strain-free optics are needed between polarizer and analyzer (auxiliary lens, condenser, objectives, nosepiece with POL telan system).

In this case, the present instruction manual is supplemented by the Operating Instructions G 41–500 for polarizing microscopes.

Photomicrography

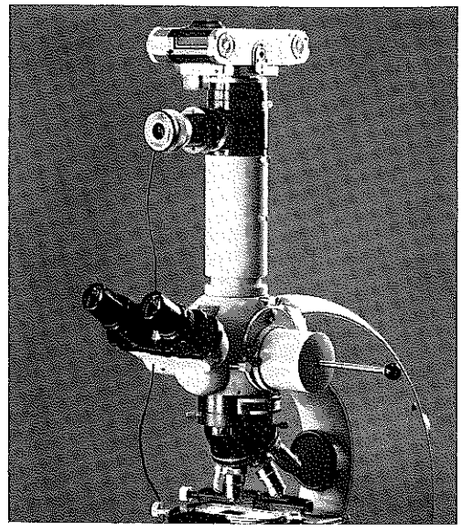
Photomicrographic cameras of different formats are available.

The straight photo tube, 47 30 23, on the tube head supports the basic unit serving as focusing system and a camera attachment for one of the following formats:

24×36 mm,
56×72 mm (LINHOF),
6.5×9 cm,
3¼×4¼″ (Polaroid),
4×5″ (Polaroid) or 9×12 cm.

Exposure is metered photoelectrically. In addition, micrographs can be obtained with the aid of the 9×12 cm photomicrographic insert of the projection attachment (page 32).

Work with the photomicrographic camera is described in the Operating Instructions G 41–410.



69 35-mm photomicrographic camera

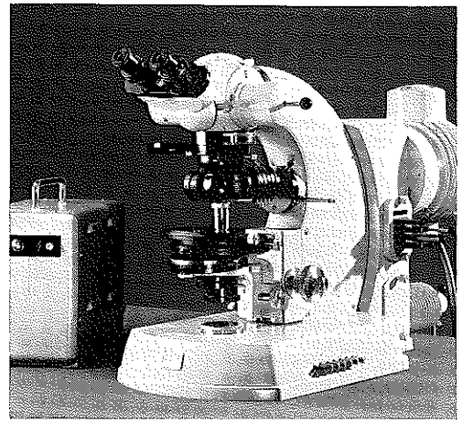
Fluorescent microscopy

The Large Fluorescence Microscope based on the UNIVERSAL offers optimum operator comfort. Apart from conventional excitation of fluorescence in transmitted light, fluorescence with superimposed phase contrast is just as easy to obtain as the special dark-field illumination required for the fluorescent-antibody technique. Special advantages can be secured for the excitation of fluorescence in reflected light, using the type II FI vertical illuminator.

Required for conversion of an existing UNIVERSAL microscope: special-purpose and fluorescent illuminators (HBO 200) with exciter filters, barrier-filter insert, a condenser with a numerical aperture of at least 1.3 suitable for the type of illumination used, and NEOFLUAR objectives.

The possibility of making spot measurements guarantees fully automatic exposure control in this case also.

Detailed information on fluorescence microscopy in connection with the UNIVERSAL and the properties of the filters will be found in the Operating Instructions G 41–350.



70 Large Fluorescence Microscope

The illustrations are not binding in every detail for the design of the instruments.

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