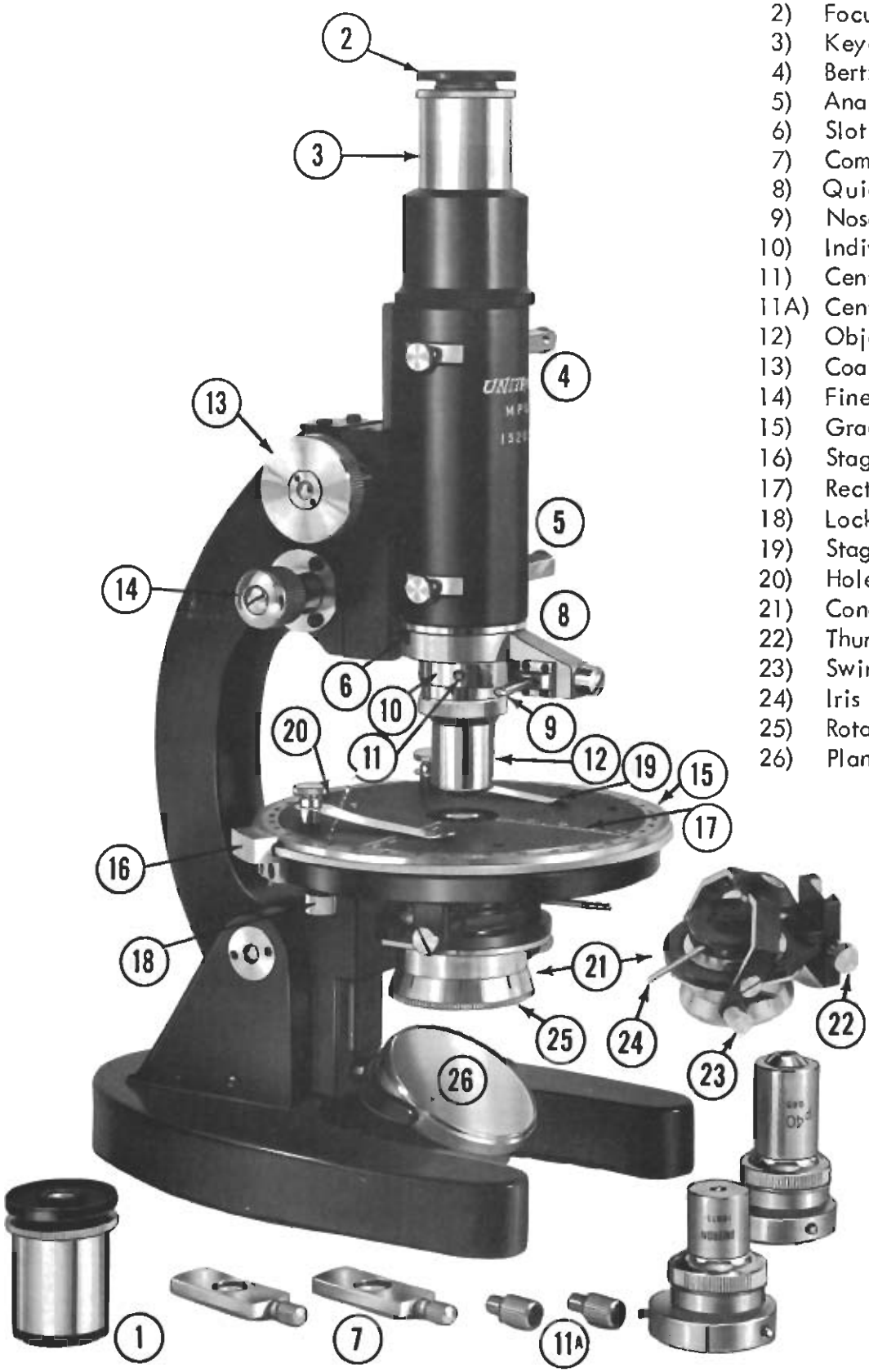
Instructions

UNITRON POLARIZING MICROSCOPE

MODEL MPS



1) Eyepiece
2) Focusing eyepiece collar
3) Keyed eyepiece tube
4) Bertrand lens slideway
5) Analyzer slideway
6) Slot for compensators
7) Compensating plates
8) Quick-change nosepiece
9) Nosepiece lever
10) Individual objective holder
11) Centering screws for holder
11A) Centering wrenches for holder
12) Objective lens
13) Coarse focusing control
14) Fine focusing control
15) Graduated rotatable stage
16) Stage vernier
17) Rectangular stage graduations
18) Lock for rotatable stage
19) Stage clips
20) Holes for mechanical stage
21) Condenser
22) Thumbscrew for condenser focus
23) Swing-out top condenser lever
24) Iris diaphragm lever
25) Rotatable polarizer ring
26) Plano-concave mirror

UNITRON INSTRUMENT CO. MICROSCOPE SALES DIVISION 66 NEEDHAM STREET, NEWTON HIGHLANDS, MASS. 02161

Instructions

UNITRON POLARIZING MICROSCOPE

MODEL MPS

PART I: THE NATURE OF THE POLARIZING MICROSCOPE

TYPES OF MICROSCOPES

The unique features of the polarizing microscope can best be studied by o comparison with microscopes of other types. A "microscope" can be defined roughly as an instrument which produces o magnified image of object structures which are too small to be seen with the unaided eye. The need for microscopes of different types arises from the fact that the objects have varying properties which require the use af speciol techniques of examination.

One af the fundamental problems of microscopy is making the specimen structure visible. As a first condition for visibility, the specimen must be suitably prepared. In addition, the microscope itself may have to be equipped with special instrumentation beyond the usual objective and eyepiece (the elements which magnify the image).

Biological Microscopes: Specimens generally consist of thin sections cut with a microtome or liquid preparations. In either cose the sample is mounted between a glass slide and cover glass so as to provide a flat layer for viewing. Highly transparent objects of the type studied in biology are usually too thin to modify the amplitude of the light wave and are therefore almost invisible when viewed through the ordinary microscope in an "untreated" state. However, since such objects generally do modify the phase of the light, adjacent structures with differing indices of refraction are clearly distinguished when examined with the phase microscope. Alternately, the specimen itself can be altered in a controlled manner by chemical treatment ("differential staining") so that parts of the specimen with different chemical properties are seen in different colors.

Metallurgical Microscopes: Metal specimens must be ground to provide a flat surface and palished to a high finish ta remove scratches which would otherwise mar an image of the grain and other surface structures. However, a specimen so prepared is essentially o mirror. Since all parts of the object reflect light to an approximately equal degree, an untreoted metal specimen is generally "invisible". By the use of a suitoble etchant, portions of the specimen with differing properties are altered to the extent that part of the light reflected from them is scattered; in this way, details become visible. Therefore, the chemical etching techniques of metallography are onalogous to the differential staining techniques of biology.

Polarizing Microscope: Mineralogical specimens studied with the transmitted-light polarizing microscope generally consist of tiny crystals or thin sections cut and ground perfectly flat. Structural details in highly transporent specimens of this type lack visibility for the same reason noted above for biologicol specmens: they are too thin to modify the amplitude of the light wove. However, most crystalline materials have the important property that they are doubly-refractive and, therefore, change the state of polorization of the light. By viewing the specimen with polarized light, details become visible in a way which is familiar to the user of the polarizing microscope.

SPECIAL PROPERTIES OF THE POLARIZING MICROSCOPE

It was observed above that a microscope is generally used to view an enlarged image of the specimen and that a special property of the polarizing microscope is based on its ability to reveal details in birefringent materials. For this application, oll that is needed in practice is a micrascope fitted with a "polarizer" below the specimen and an "analyzer" above it, oriented so that they are "crossed". Objects which can be examined in this way include not anly mineralogical specimens, but other materials including certain textile and paper fibers and biological tissues.

But the polarizing microscope has an additional application. When suitably equipped, it may be used to identify crystalline material using tests which are not bosed on magnification alone. These tests depend not on viewing the specimen directly ("orthoscopic observation") but, instead, on studying an "interference figure" produced at the rear of the objective ("conoscopic observation"). In practice, an additionol optical element, the Bertrand Lens, is placed in the optical path and in conjunction with the eyepiece, acts as a magnifier to observe on optical pattern, the nature of which is a function of certain crystallographic properties of the specimen and its orientation. The role of the objective lens is to illuminate the specimen with light fram a wide ronge of angular directions, rather than (as in the ordinary microscope) to form a "primory image" of the object which will be further magnified by the eyepiece. Used in this way, the "microscope" is more properly described as a "polariscope", equipped for studying tiny crystals.

If the polarizing microscope is used only for purposes of magnificotion little specialized knowledge is required beyond that needed for efficient use of less specialized microscopes. Only the polarizer and analyzer are needed to increase the visibility of birefringent materials. However, for "polariscope" applications which involve the classification and identificotion of materials, some knowledge of optical crystallography is necessary if the techniques ond accessary equipment are to be used intelligently. It is not within the scope of the present instructions to cover these techniques; the bibliography included in Part VI lists several references where such information con be found. The instructions to follow will describe and explain the operating features of the UNITRON Model MPS Polarizing Microscope and include suggestions which will allow the user to realize the excellent performonce of which this instrument is capoble.

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PART II: COMPONENTS AND CONTROLS OF THE UNITRON MODEL MPS

Further details on the method of use of many of the components and controls are given in later sections of these instructions.

OBJECTIVES: Three objectives (12) are included as standard equipment: 4X(N.A. 0.10), 10X(N.A. 0.25), and 40X(N.A. 0.65). In addition, accessary objectives of magnifications 60X and 100X are available at extra cost for specialized applications.

Each objective is provided with an individually centerable objective holder (10). To install the holder on the "quick change" nosepiece (8), pull the nosepiece tension lever (9) backward, carefully insert the holder into the fitting, rotate the holder so thot the slot faces the spring-loaded contoct pin, and release the lever. Moke certain that the pin engages the slot. The method of centering the objectives is described in Part III below.

EYEPIECES: Two eyepieces are included as standard equipment: Cross 10X and Micrometer 5X.

The Cross 10X contains an accurately centered crossline which establishes the locatian of the center of the field of view far reference purposes. This is the eyepiece which is used for most applications.

The Micro 5X eyepiece contains on accurately centered micrometer scale 5mm in length, graduated in 50 divisions. The scale is used to measure dimensions on the specimen ond in this application the absolute value of each division depends on the objective being used, as follows: 0.05mm for the 4X, 0.02mm for the 10X, 0.005mm with the 40X, 0.0033mm with the accessory 60X, and 0.002mm with the accessory 100X objective. The micrometer eyepiece may also be used to measure the optic axial angle.

Each eyepiece has a lacation pin which fits into the keyed slot in the rear of the eyepiece tube (3). In addition, each eyepiece is fitted with a helical focusing collor (2) which ollows the reticle pattern (crossline or micrometer) to be facused for individual vision. To focus the reticle, turn the collar until the pattern is seen in sharpest focus.

STAGE: The circular stage (15) is rotatable thraugh 360°, graduated in degrees, and reads to 6 minutes of arc using the vernier (16). The top of the stage is calibrated (17) in millimeters in two directions at right angles; the distance measured is from the center of the stoge. To lock the stage against rotation, tighten the thumbscrew (18) on the bottom lefthand of the stage.

A set of stoge clips (19) is furnished as stondard equipment. In additian, the top of the stage is drilled ond tapped (10) to accept the occessory mechanical stages listed in Part V below.

FOCUSING CONTROLS: Coarse focusing is done using the controls (13). To vary the focusing tension, turn the control knobs in opposing directions in such a way that the body tube itself does not move. This adjustment changes the friction on nylon bushings located within the knobs.

To refine the focus of the image, use the fine focusing adjustment (14). The position of the fine focusing slideway within its 2mm travel may be estimated by referring to the index on the righthand side of the microscope arm (adjacent to the control knab).

POLARIZER: The polarizer is locoted below the condenser (21) and is rotatable using the knurled ring (25). Each of the calibration lines corresponds to a rotation of 45°. When the red line is aligned with the fixed red index mark the polarizer is "crossed" with the analyzer. In practice, the polarizer may be crossed with respect to the analyzer without reference to the index: with no specimen on the stage, rotate the polorizer until the field of view is darkest.

ANALYZER: When the analyzer (5) is pushed all the way to the left the analyzer is in the optical path for polarized-light observations. For opplications which do not require polarized light, move the slideway all the way ta the right. In-between positions of the slideway have no operational significance.

CONDENSER & IRIS DIAPHRAGM: The three-lens condenser (21), N.A. 0.65, has a fixed lawer element and a top element which can be remaved or inserted from the optical path using the swing-out lever (23). To facus the condenser, loosen the thumbscrew (22) and move the complete unit along the dovetoil slide to the desired height. The lever (24) odjusts the opening in the iris aperture diaphragm.

BERTRAND LENS: To place the Bertrand Lens in the optical path for conoscopic observations, push the slideway (4) all the way to the right.

COMPENSATORS: Two compensating plates (7) are included as standard equipment: a quarter wave and a first order red plate. These fit inta the slot (6) located above the objective holder and are inserted from the front with the engraved side facing upward.

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PART III: USING THE MICROSCOPE

ADJUSTMENT OF ILLUMINATION: Proper illumination is essential with any microscope in order to achieve optimum results. Far polarizing microscopy a high intensity illuminator is required, especially if weak birefringence is to be detected. In addition, the illuminator must be carefully aligned with respect ta the microscope in order to obtain highest resolution of the specimen image for orthoscapic observations and full illumination of the objective rear focal plane for conoscapic observations.

The UNITRON Model LKR Koehler Illuminator is an ideal and popular light source to use in conjunction with Model MPS. Detailed instructions for its use are included below in Port IV.

The general questian af illumination includes not only the lamphouse alone, but also the adjustment of condenser and mirror. These, in turn, depend on the objective lens being used. The following general remarks apply to most illuminators.

1) 4X objective: used only for orthoscopic observations, either as a scanning lens or for observing lorge oreas. Swing the top condenser lens out of the optical poth. If the illuminator is of the non-Koehler type, with a very large effective source of illumination, the concave mirror may often be used to odvantage in preference ta the plane mirror.

2) 10X objective: used only for orthoscopic observations. If the observed field of view cannot be illuminated fully with the top condenser lens in pasition, swing the lens out of the optical path. In general, however, the plane surface of the mirrar should be used.

3) 40X objective and accessory higher-powered objectives: may be used for both orthoscopic and conoscopic observations. It is essential that the top candenser lens remain in the optical path and that the plane surface of the mirror be used.

4) Condenser focus: Whatever the objective, it is impartant that the condenser be focused so as to completely fill with light the rear lens of the objective. To achieve this, it is necessary that the illuminator be of a suitable type and that both it and the mirror be correctly aligned with respect to the micrascape. The alignment method for the UNITRON Model LKR Koehler Illuminator, as described below, may serve as a guide to the use of other illuminators of the same general type.

If the rear lens of the objective is not evenly and completely filled with light, aptical resalution will be reduced for orthoscopic observations and the complete interference figure will not be visible when making conoscopic observations. With the UNITRON Model MPS Polarizing Microscope, it is easy to check the light distributian at the rear of the objective. First, focus an image of a specimen slide and then, without changing the focus, remove the slide from the stage. Move the Bertrand lens into the optical path: the image seen through the eyepiece is that of the rear lens of the abjective. As the condenser is focused, note how the illuminated area changes in diameter. Adjust the condenser height and the mirror angle ta achieve complete and even illumination.

USE OF THE CONDENSER IRIS DIAPHRAGM: As a preliminary experiment the effect of the condenser iris on the objective aperture may be abserved by moving the Bertrand lens into the optical path and opening and closing the iris. The primary function of this diaphragm is to adjust the angular aperture of the cone of illumination to the requirements of the abjective being used and to the nature of the specimen under examination.

Now, move the Bertrand lens out of the optical path (the correct position for orthoscopic observations). While observing the specimen, note that as the iris is closed, depth of field and image contrast increase. However, if the diaphragm is closed too far image resolutian is reduced. The iris should never be opened beyond the point needed to illuminate the full abjective aperture: otherwise, unnecessary glare will be introduced. In practice, the diaphragm is usually closed so as to reduce the aperture somewhat in order to gain increased contrast and field depth, especially when abserving specimens with a high degree of transparency.

For certain types of observations the iris is purposely closed to a very small opening: for example, to accentuate the "Becke line" at the boundary of a mineral when performing the Becke Line Test. Here, image resolution is not an important consideration.

As the iris is closed the intensity of illumination is necessarily lowered because of the reduction in lens aperture. However, never use the iris as a means of controlling illumination intensity. Instead, use the illuminator variable intensity cantrol or, alternately, place neutral-density filters in front of the lamphause.

OBSERVING INTERFERENCE FIGURES (CONOSCOPIC OBSERVATIONS): In order to observe interference figures it is essential that certain conditions be fulfilled. The following steps may be used as a "check list".

1) Specimen: The specimen must be correctly prepared and the portion abserved must include a well-formed crystal. An "arbitrary" specimen will nat produce an interference figure. As an experiment, try observing the interference figures produced by flakes of mica varying fram sectians which are very thin to sections about 0.5 to 1.0mm thick. Alternately, the beginning student may find it instructive to purchase a set of commercially prepared reference slides which exhibit the most common type of interference patterns. Excellent slides of this type may be obtained from: R. P. Cargille Laboratories, Inc., 117 Liberty Street, New York 6, New York.

2) Objective: The 40X (or higher) powered objective must be used. (Interference figures cannot be produced with the 4X or 10X objectives).

3) Objective Focus: The objective must be focused on the top surface of the specimen.

4) Polarizer and Analyzer: The polarizer must be rotated to "cross" the onolyzer: that is, polarized light is essentiol.

5) Bertrand Lens: The Bertrand Lens must be in the optical path.

6) Mirror and Illuminotor: The plone mirror must be used in conjunction with a suitable illuminator.

7) Condenser: The condenser must be focused so os to completely fill with light the rear lens of the objective: otherwise, the outer portion of the interference figure will be cut off.

8) Condenser iris: The iris diaphragm of the substage condenser must be completely open: otherwise, port of the interference figure will be cut off.

Reference to the following hints will oid in ochieving best results.

1) Eyepiece: Unless speciol micrometer measurements ore being made, always use the Cross 10X eyepiece. This choice will produce the largest image of the interference figure.

2) Sharpness of image: For normolly-corrected vision, the interference figure will appear in sharpest focus when the eyepiece collar has been focused to produce the sharpest image of the crossline. (If you normally wear eyeglasses, be sure and use them when observing interference figures.) When there are slight errors in vision correction, the sharpness of the pattern can be increased by changing the focus of the collar (but at the expense of blurring the image of the crossline). Alternotely, in some cases a sharper image can be obtained by roising the eyepiece slightly from the eyepiece tube.

3) Objective focus: Unlike the case with orthoscopic observations, the focus of the objective is not too critical. However, if the objective is too high with relation to the specimen the outer portian of the interference figure will be cut off. In no case can a change in objective focus be used to change the sharpness of the observed interference pattern.

4) Evenness of illumination: For Koehler illumination, an image of the bulb filament is focused in the plane of the condenser iris and is re-imaged and seen at the rear of the objective. The resulting filament lines are in no way detrimentol to image quality for orthoscopic observations but the lines may prove distracting for conoscopic observation of interference figures. To remove these lines ond produce more even illumination of the interference figure, place a ground glass filter in the lamphouse holder or directly in front of the light source.

5) Color of illumination: Illumination of the correct color is required in order to judge "interference colors" correctly. To remove the normal yellow coloration of tungsten-filament bulbs use a doylight-blue filter in front of the lamp.

6) Use of 60X objective: This accessory objective is useful for conoscopic observations not because of its higher magnification, but because of its higher numerical aperture. Thanks to the greater aperture, a larger interference pottern can be seen than is possible with the standard 40X objective. Frequently, the additional pottern details permit a more extensive analysis of the crystal structure. Since the numerical aperture of the 60X objective is 0.80 and that of the condenser 0.65, it might seem theoretically impossible for the condenser to completely illuminate the objective aperture. However, in practice sufficient light is scattered to fill the aperture provided that the illuminator and condenser are adjusted properly.

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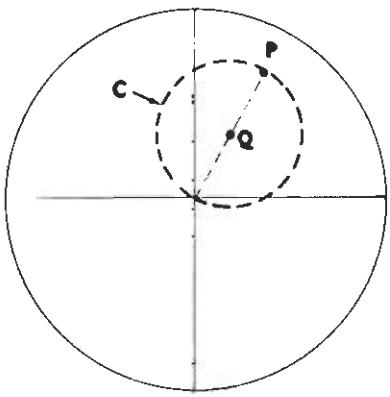
METHOD FOR CENTERING THE OBJECTIVES: Each of the individual objectives has been centered before shipment of the microscope. Should subsequent recentering be required, or if additional objectives are purchased at a later date, use the following method to achieve centrotion.

While looking through the microscope using the Cross 10X eyepiece, move the specimen slide so as to place a small but praminent specimen detail in the exact center of the eyepiece crosslines. This detoil will serve as a paint of reference. Now, rotate the microscope stage and observe the motion af the reference point. If the objective is nat perfectly centered, the point will not remain superimposed on the crasslines but, instead, will move in a circular path like that shown by C in the accompanying figure. In such a cose, rotate the stage ta the position where the distance from the reference point to the center of the crosslines is greatest: position P in the illustration. Attach the two centering wrenches ta the objective holder. Turn the wrenches so as to move the reference point to a new pasition, Q, halfway along the imaginary line jointing the original position P and the center of the crosslines.



Next, move the glass slide so os to recenter the reference point an the crosslines and again rotate the stage. The point will probably still not be perfectly centered but the error will have been reduced by the previous step: that is, the point will mave along the circumference of a circle of smaller diameter. Repeat the centering process until the required accuracy af centratian has been obtained.

In the case af objectives of higher power, an objective in a holder which has not previously been centered may be sufficiently out of centrotion so as to cause the reference point to move completely out af the observed field when the stage is ratated a full 360°. This makes the centering procedure for high pawered objectives slightly more difficult. It is suggested that yau practice centering the low power 4X objective as a means af becaming familiar with the general procedure.

Once centered, objectives will remain so unless the centering screws are accidentally turned while handling or installing the objectives.

CARE OF THE MICROSCOPE: Dust is the enemy of optical equipment. When nat in use, cover the microscope with the plastic dustcover which is pravided. The extra objectives and eyepieces should always be kept cavered in the accessories box which farms part af the microscope cabinet.

Spots which are seen in the field of view and which rotate when the eyepiece is raised (fram its keyed slat) and turned are caused by dust an the eyepiece lenses. Wipe the tap and the bottam lenses with a high grade of lens tissue or a clean handkerchief. Do not disassemble the eyepieces; the chances far dust within the eyepieces are negligible.

When using the coarse facus contral care should be taken to prevent facusing the objective dawnward ta the point where it cantacts the specimen. When changing ta the 40X and objectives af higher power, it is advisable to raise the bady tube to allow ample space for easy insertian.

Keep the front surfaces af the objective and condenser clean. Fingerprints and foreign matter moy nat prevent the formation af an image but they will often cause a noticeable reduction in image cantrast.

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PART IV: ADJUSTMENT OF ILLUMINATION USING THE UNITRON MODEL LKR KOEHLER ILLUMINATOR

ADVANTAGES OF KOEHLER ILLUMINATION: Illumination by the Koehler method offers the following practical advantages:

1) Field Diaphragm: For Koehler illumination, an image of the lamp iris diaphragm is brought to a sharp focus in the visual field of view using the microscope condenser. In use, the lamp diaphragm is opened just enough to illuminate the observed field and no more. By restricting the illuminotian in this way, glare is kept to a minimum and image contrast is highest. For this reason, Koehler illuminatian is especially valuable for photomicrography.

2) Evenness of illumination: In a Koehler system the bulb filament is focused in such o way that the specimen is illuminated with parallel rays of light. Since the filament lines do not intrude in the observed field, the field is evenly illuminated.

3) Highest intensity: The system is such that illuminating efficiency is highest. Therefore, the full lamp intensity is available for detecting weak birefringence with polarized light.

STEP-BY-STEP PROCEDURE FOR ADJUSTMENT: Adjustment of the illuminating system for optimum results is not difficult. The procedure is described in detoil to insure correct results.

1) Adjustment of the Microscope: Incline the orm of the microscope to a comfortable angle for viewing.

2) Adjustment of the Distance between Illuminator and Microscope: Position the Model LKR Koehler Illuminator so that the distance between the front of the circular base and the front edge of the Model MPS Microscope is 3". "Square up" the illuminator directly in front of the microscope.

3) Preliminary Adjustment of Lamphouse and Mirror: A rough adjustment of the lamphouse inclination ond of the angle of the substage mirror is needed to provide enough light to focus a specimen image. Turn on the illuminotor to a relatively low intensity and open both the lamphouse iris diaphragm and the condenser iris diaphragm all the way. Using the extension-locking lever, adjust the lamphouse inclination so as to direct the beam of light to the approximate center of the plane (flat) side of the mirror. Then, incline the mirror so as to reflect light into the microscope condenser.

4) Focusing an Image of the Specimen: Verify that both the Bertrand lens and the analyzer ore out of the optical path. Install the 10X objective and the Cross 10X eyepiece. Place a specimen slide on the microscope stage and focus a sharp imoge of the specimen. (For this step no effort need be made to obtain even illumination.) Do not change the focus of the microscope during the succeeding steps.

5) Adjustment of Lamphouse and Mirror Orientation: The substage mirror is rotatable about two axes in its fork mounting. Two independent rotations are also possible for the illuminator, as follows:

   i) Chonge of Lamphouse Inclination: achieved by using the extension-locking lever.

   ii) Rotation of the Illuminator about its Base: leaving the relotion between the base and the microscope unchanged.

Alignment of the optical axes of the microscope and the illuminator requires adjustment of the orientotions of both the substage mirror and the illuminotor. This is easily achieved using the following steps which, when completed, will refine the rough adjustment made in 3) above.

a) Close the lamphouse iris diaphragm to the setting "10". Verify thot the swing-out condenser lens is in the optical path. Starting with the microscope condenser at its highest position, gradually lower the condenser to focus a shorp image of the lamphouse iris diaphrogm in the field of view. This image will, in general, not be centered (Fig. 1). Adjust the mirror ongle to move the iris image to the center of the field, as shown in Fig. 2.

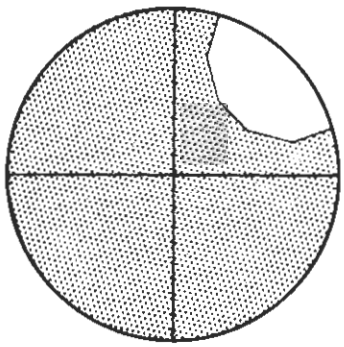

Fig. 1

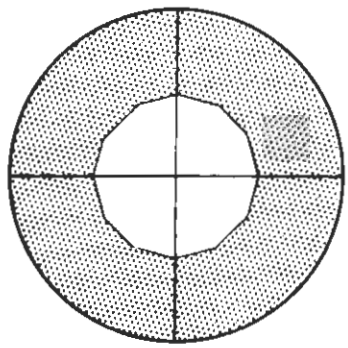

Fig. 2

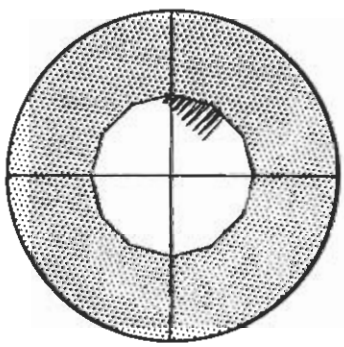

Fig. 3

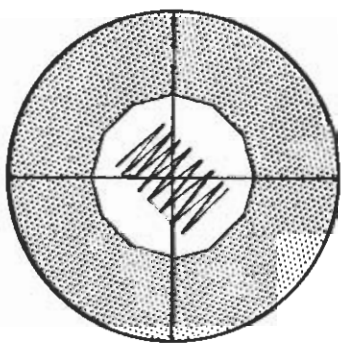

Fig. 4

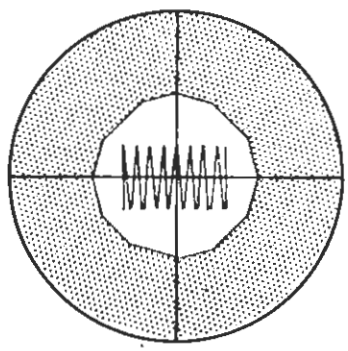

Fig. 5

b) Turn the lamp condenser focus knob so os to move the condenser out all the woy (the position closest to the microscope). Without changing the microscope focus, move the specimen slide to a place where no specimen detoils are present (for exomple, towards the edge of the cover gloss), so as to obtain an "empty" field of view. You will see on image of the bulb filament which is slightly out of focus and, in general, displaced from the center of the field of view as shown in Fig. 3.

c) Alignment will be achieved when both the image of the bulb filament and the imoge of the lamphouse iris are centered in the observed field (Fig. 4). This is accomplished by adjusting both the mirror and the illuminator, using the two types of rotation possible for each. By moving first one, ond then the other, mutual centratian con be obtained by successive approximation. (Note: for purposes of judging centration, it may be easier to observe o configuration such as shown in Fig. 5. To rotate the crosslines, lift the eyepiece so that the location pin disengages from the slot and rotate the eyepiece slightly.)

6) Adjustment of Bulb Filament Focus: Open the lamphouse iris diophragm all the way. As the lamp condenser knob is focused to move the candenser inword, the filoment image will be seen to enlarge. Adjust the focus so that the entire field of view is completely filled with light.

The adjustments to achieve the Koehler methad for illumination have naw been completed. Close the lamp field operture diophragm and an image of the iris diaphrogm will be seen in the center of the field. While loaking through the microscope, open the field diaphragm just enough to illuminate the complete field of view, and no more. To assure continued conditions for Koehler illumination care shauld be token not to disturb the relative positions of illuminator, microscope and substage mirror.

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ADJUSTMENTS FOR INDIVIDUAL OBJECTIVES: The following remarks apply to the use of each of the individual objectives.

1) 4X objective: Koehler-type illumination is not appropriate for this lower power scanning lens. For the 4X, swing the top condenser lens out of the optical path to provide full-field illumination for both the 5X and 10X eyepieces. If filament lines appear in the field of view, or if the outer edges of the field are cut off with the 5X eyepieces, change the filament focus.

   Because of the nature of the scanning objective, the outer edges of the field may darken slightly when the condenser iris is closed all the way (especially when using the 5X eyepiece). However, for the 4X objective this extreme iris setting has no operational significance.

2) 10X objective: The step-by-step adjustment method previously described is designed to permit optimum results when using the Cross 10X eyepiece, the one customarily used for work with the polarizing microscope. When the Micro 5X is used in its place, there will be a ring around the edge of the field which is not illuminated. This condition is normal and results from the large field of view encompassed by this low powered ocular.

   If illumination of the complete field is desired when using the 5X eyepiece, swing the top condenser lens out of the optical path. Resolution will be reduced slightly, and depth of field increased, in a manner similar to that which takes place when the condenser aperture diaphragm is closed down. For this method of use the field diaphragm serves no purpose and it should be opened all the way. Since the field diaphragm loses its significance the resulting illumination is, of course, no longer of the Koehler-type.

3) 40X and accessory 60X objective: The adjustments made for the 10X objective will serve equally well for these objectives of higher power. However, a slight change in condenser focus may be needed to obtain the sharpest image of the lamp field diaphragm. After making this adjustment recenter the image of the closed iris, if necessary, using the substage mirror. With the higher powered objectives the field of view is completely illuminated for both eyepieces.

OBSERVING INTERFERENCE FIGURES: For Koehler illumination the bulb filament is focused in the plane of the condenser iris diaphragm and is re-imaged at the rear focal plane of the objective. This method of focus insures that the specimen is illuminated with parallel rays of light with the result that the filament lines do not intrude in the field of view for ordinary (orthoscopic) observations. To remove these distracting filament lines for conoscopic observations, place a square of ground glass in the filament holder when observing interference figures. In addition, open the lamp iris diaphragm all the way.

To provide light of the correct coloration for interpreting interference colors use the accessory Daylight-blue Filter, Type F-KB, in addition to the ground glass.

When using the 60X objective for interference figure observations, a larger illuminated field can generally be obtained by raising the condenser slightly from the position which produces the sharpest focus of the field diaphragm. In practice, with the field diaphragm open all the way, observe the rear of the objective with the Bertrand Lens in place and adjust the condenser height until the illuminated area at the rear of the objective is largest. As usual, use a ground glass filter in the lamp holder to even out the illumination.

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PART V: ADDITIONAL ACCESSORIES FOR UNITRON MODEL MPS

1) KOEHLER ILLUMINATOR, MODEL LKR: Provides the correct type and intensity of illumination needed for polarized light microscopy. Complete with variable intensity transformer. (Refer to the catalog sheet on "Microscope Illuminators" for complete information)..... $99.00

2) BLUE FILTER FOR LKR ILLUMINATOR, TYPE F-KB: Daylight type. Recommended for providing light of the correct color for interference color determination, for color photomicrography, etc..... $4.00

3) GREEN FILTER FOR LKR ILLUMINATOR, TYPE F-KG: Recommended for orthoscopic observations with unpolarized light..... $6.00

4) GRADUATED MECHANICAL STAGE, MODEL STC: For precise control of specimen motion. Designed especially for Model MPS to allow full 360° rotation. Graduated in degrees, reads to 0.1mm by verniers..... $40.00

5) UNGRADUATED MECHANICAL STAGE, MODEL STA: A budget-priced mechanical stage suitable for applications which require neither full stage rotation nor graduated motions..... $14.75

6) PHOTOMICROGRAPHY SET, MODEL ACA: For convenient photomicragraphy with a variety of cameras. (Refer to the catalog sheet an this model for complete information.)..... $39.95

7) 60X OBJECTIVE WITH CENTERABLE OBJECTIVE HOLDER: N.A. 0.80, coated, achromatic. Supplied with Type MPS-OH abjective holder, ready to use with Model MPS..... $37.00

8) 100X OBJECTIVE WITH CENTERABLE OBJECTIVE HOLDER: N.A. 1.25 ail immersion, coated, achromatic. Supplied with Type MPS-OH objective holder, ready to use with Model MPS..... $48.00

9) INDIVIDUAL OBJECTIVE HOLDER, TYPE MPS-OH: Permits use of accessory objectives with Model MPS..... $4.50

The following Micrometer Eyepieces have provision for accommodating interchangeable reticles which screw into the rear of the eyepiece tube. The focusing eyelens insures a sharp image of the reticle pattern. The Ke15XR and WF20XR types are useful for obtaining higher magnifications. These eyepieces are not specifically designed for use with Model MPS and therefore must be raised slightly when observing interference figures. They may, however, be used in the narmal fashion for ordinary (orthoscapic) observations. Prices include the reticle cell but not the reticle itself. For special reticles (including nets, etc.) refer to the special catalog sheet on "UNITRON Special Eyepieces and Measuring Accessories".

10) Ke10XR MICROMETER EYEPIECE..... $16.25

11) Ke15XR MICROMETER EYEPIECE..... $17.25

12) WF20XR MICROMETER EYEPIECE..... $19.25

13) QUARTZ WEDGE: To be offered. Write for details.

Prices f.o.b. Newton Highlands, Mass.

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PART VI: SELECTED BIBLIOGRAPHY

Information on the use of the polarizing microscope may be found in books specifically devoted to this type of instrument, in texts dealing with optical crystallography, and in general references devoted to the microscope and its applications. In the bibliagraphy which follows no attempt has been made to include a complete listing. Instead, we have indicated a few of the more popular references which the reader is likely to find both informative and readily available at most technical bookstores and libraries.

1) E. M. Chamot and C. W. Mason, "Handbook of Chemical Microscopy", Volume 1, Wiley, New York, 1958.

Volume 1 covers "Principles of the Use of Microscopes and Accessories" and "Physical Methods for the Study of Chemical Problems". First published in 1930, this book has become a classic reference on the use of the microscope in general because of the completeness of the material and the clarity with which it is presented.

2) F. D. Bloss, "An Introduction to the Methods of Optical Crystallography"; Holt, Rinehart and Winston, New York, 1961.

An excellent introductian to the subject with illustrations of outstanding merit.

3) T. R. P. Gibb, Jr., "Optical Methods of Chemical Analysis", McGraw Hill, New York, 1942.

See Chapter V: "Elementary Crystallography" and Chapter VI: "Identification of Crystals with the Polarizing Microscape".

4) N. H. Hartshorne and A. Stuart, "Crystals and the Polarizing Microscope", Edward Arnold Ltd., London 1960.

More advanced than any of the references listed above.

5) W. C. McCrone, Jr., "Fusion Methods in Chemical Microscopy", Interscience, New York, 1957.

Differs from the above references in that it is a specialized treatise devoted to fusion methods. Includes information on the use of heating and cooling stages for this technique.

MPS