

UNITRON

MODEL MPS

POLARIZING MICROSCOPE

for

- Chemical Microscopy
- Crystallography
- Mineralogy
- Petrography
- Geology



UNITRON

INSTRUMENT COMPANY — MICROSCOPE SALES DIV.
66 NEEDHAM STREET, NEWTON HIGHLANDS 61, MASS.

Completely equipped . . . yet attractively priced for schools and laboratories

Certain transparent specimens possess structural detail which is revealed only when viewed with the aid of polarized light. For such specimens, the polarizing microscope is able to do more than provide a magnified image: it can also aid in the identification of the structure and characteristics of unknown materials.

These special properties of the polarizing microscope make it useful in many branches of science and industry. It has been found particularly valuable in studies of textile, ceramics, petroleum, chemicals, paper, paint, plastics and food products. It is essential for work in chemical microscopy, geology, toxicology etc., and is finding an increasing number of applications in biology and medicine.

The UNITRON Model MPS Polarizing Microscope, although priced below many routine student instruments, actually offers the features, performance, and versatility of expensive research

models. A Bertrand lens is provided which permits rapid and accurate examination of interference figures; it is not necessary to squint through a pinhole eyepiece or insert a cumbersome telescopic eyepiece. The objectives feature research-type mountings, individually centerable on the nosepiece for maximum precision, rather than merely being fitted to an ordinary revolving nosepiece. The focusable condenser system, with swing-out top elements, insures optimum illumination and resolution.

Model MPS comes completely equipped without the need to purchase costly extras. Standard equipment includes three coated, stain-free objectives; both a crossline and a micrometer eyepiece; and two compensating plates. Like all UNITRON equipment, it is sold with our standard guarantee for quality, workmanship, and performance. Accept a free 10 day trial without cost and obligation. See for yourself why UNITRON means MORE MICROSCOPE FOR THE MONEY.

FEATURES OF MODEL MPS

10X CROSSLINE EYEPIECE
FOCUSABLE FOR INDIVIDUAL VISION

DUAL COARSE FOCUS CONTROLS

MICROMETER FINE FOCUS

TWO COMPENSATORS
INCLUDED — QUARTER
WAVE AND FIRST
ORDER RED PLATE.

SLOT FOR COMPENSATORS

STAGE VERNIER
READS TO 6'

LOCK FOR ROTATABLE
STAGE

ARM INCLINES
TO 90°

WOODEN CABINET INCLUDED

KEYED
EYEPIECE TUBE

BERTRAND LENS,
ON SLIDEWAY, FOR
OBSERVING INTERFERENCE
FIGURES

ANALYZER ON
SLIDEWAY

QUICK-CHANGE
NOSEPIECE

STAGE CLIPS

GRADUATED ROTATABLE
STAGE DRILLED FOR
MECHANICAL STAGE.

3-LENS, FOCUSABLE CONDENSER

ROTATABLE POLARIZER

IRIS DIAPHRAGM

PLANO-CONCAVE MIRROR



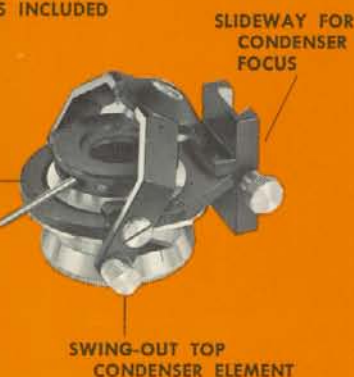
MICROMETER
EYEPIECE, 5X



ACCESSORY MECHANICAL
STAGE, MODEL STC



THREE STRAIN-FREE
COATED, OBJECTIVES
WITH CENTERING
MOUNTS INCLUDED



SLIDEWAY FOR
CONDENSER
FOCUS

SPECIFICATIONS OF POLARIZING MODEL MPS

STAND — Laboratory stand with arm inclinable to horizontal position. Coarse focusing by diagonal-cut rack and pinion slideway; fine focusing by micrometer screw adjustment. Quick-change nose-piece and individual objective centering mounts. Polaroid analyzer mounted in slideway. Bertrand lens with centering screws in slideway mounting. Slot for compensators. Quarter-wave plate and first-order red plate included. Fitted wooden cabinet and dustcover.

STAGE — Diameter 115mm., revolves 360°, with locking clamp. Graduated in degrees and reads to 6' with vernier. The top is calibrated in mm. in two directions and is drilled and tapped to accept an accessory mechanical stage. Stage clips included.

SUBSTAGE — A three-lens condenser (N.A. 0.65), with upper elements centerable and on a swing-out mounting, provides either parallel or convergent light. Dovetail slide focusing mount. Polaroid polarizer, rotatable through 360°, graduated every 45°. Iris diaphragm. Plano-concave mirror.

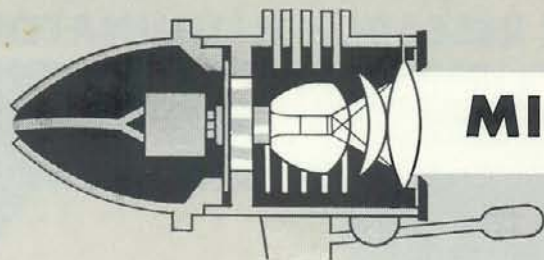
OPTICS — Three, coated, parfocal, achromatic, strain-free objectives: 4X (N.A. 0.1), 10X (N.A. 0.25), 40X (N.A. 0.65). Two coated eyepieces, each with focusing collars to provide sharp reticle images: Micrometer 5X (measures to 0.005mm. with 40X objective) and Crossline 10X.

PRICE LIST OF MODEL MPS AND ACCESSORIES

Model MPS, complete as described above **\$269**

- GRADUATED MECHANICAL STAGE, MODEL STC: allows 360° stage rotation 40.00
- UNGRADUATED MECHANICAL STAGE, MODEL STA: for applications not requiring full stage rotation 14.75
- 60X OBJECTIVE: N.A. 0.85, coated, achromatic 32.50
- 100X OIL IMMERSION OBJECTIVE: N.A. 1.25, coated, achromatic 43.50
- INDIVIDUAL OBJECTIVE HOLDER: centerable, for accessory objectives 4.50
- P15X EYEPIECE: periplan, without crossline 7.00
- KOEHLER ILLUMINATOR, MODEL LKR: with variable transformer. Provides the high intensity needed for polarized-light microscopy. (Described in a separate catalog sheet) 99.00

NOTE: An accessory quartz wedge will be made available.
Prices f.o.b. Newton Highlands, Mass.



UNITRON

MICROSCOPE ILLUMINATORS

for STUDENT • LABORATORY • RESEARCH
PHASE • STEREOSCOPIC • POLARIZING Models

ATTACHABLE SUBSTAGE ILLUMINATORS

for School, Laboratory, and Student-Phase Models

UNITRON offers two types of substage illuminators — a 110 volt model for routine student and laboratory work and a low-voltage model with transformer to provide the higher intensity needed for visual observation with high-powered eyepieces, photomicrography, and student phase microscopes. Both types offer the advantages of integral illumination and eliminate the need for troublesome mirror adjustments. The illuminator is designed to snap into the mirror support in place of the substage mirror and can be installed in a fraction of a minute. Perfect optical alignment and uniform illumination is maintained even if the microscope is moved or its inclination changed. The well-ventilated housing may be rotated through 180° to give the choice of two lamp apertures: either a special condenser lens or a diffuse plane surface. In this way, optimum illumination at all powers may be selected for microscopes which either have or lack a substage condenser. Both apertures are fitted with daylight-type blue filters to eliminate eyestrain during prolonged observations.

Model LHC, 110 Volt Illuminator

Priced within the range of even limited school budgets. This compact efficient illuminator gives ample light intensity for essentially all brightfield observations with student and laboratory microscopes. Also adequate for routine work with binocular models. Especially recommended for UNITRON Models MUS, MLEB, MLK, BMLK, Series MSH, MSF-H, and similar microscopes.

SPECIFICATIONS: UNITRON Model LHC Substage Illuminator with 15 watt bulb. Sturdy, well-ventilated housing with apertures for both concentrated and diffuse light, daylight-blue filters. Cord and plug for 110-115 volts, on-off line switch, spare bulb.

Price, Model LHC **\$10.00**
Replacement bulbs, type EL-CHL, per dozen 3.00

Model LLV High-Intensity Illuminator

Designed for applications which require a high intensity of illumination. Provides ample light for binocular models even when special colored filters or high-powered eyepieces are used. Ideal for use with UNITRON Student Phase Models MPA and MPB. The variable transformer provides the correct intensity needed for both visual observation and photomicrography.

SPECIFICATIONS: UNITRON Model LLV Substage Illuminator with low-voltage bulb. Sturdy housing, with apertures for both concentrated and diffuse light, daylight-blue filters. Five-intensity transformer (0-14 volts) with pilot light, line cord, on-off switch, spare bulb.

Price, Model LLV **\$29.50**
Replacement bulbs, type EL-VLL, per dozen 6.00



Above: Illuminator snaps into support in place of substage mirror

Below: Transformer of Model LLV offers choice of 5 intensities



SPOTLIGHT ILLUMINATOR, Model LS

for Stereoscopic and Low Power Microscopes

- A budget-priced, spotlight illuminator especially recommended for industrial and school use
- Designed for incident illumination of opaque objects
- Focusable condenser varies lighting from concentrated spot to large-area illumination for wide-field observation at low powers
- Lamp house adjusts in height and direction to provide an incident beam of the desired angle for specimens of varying height
- Base transformer offers choice of three intensities
- Uses inexpensive tungsten bulb. Ventilated lamp house insures long bulb life

SPECIFICATIONS: UNITRON MODEL LS SPOTLIGHT ILLUMINATOR. Complete with ventilated lamp house adjustable in height and direction, focusable condenser, integral base transformer with three-intensity switch, line cord for 110-115 volt operation. Wooden cabinet and spare bulb.

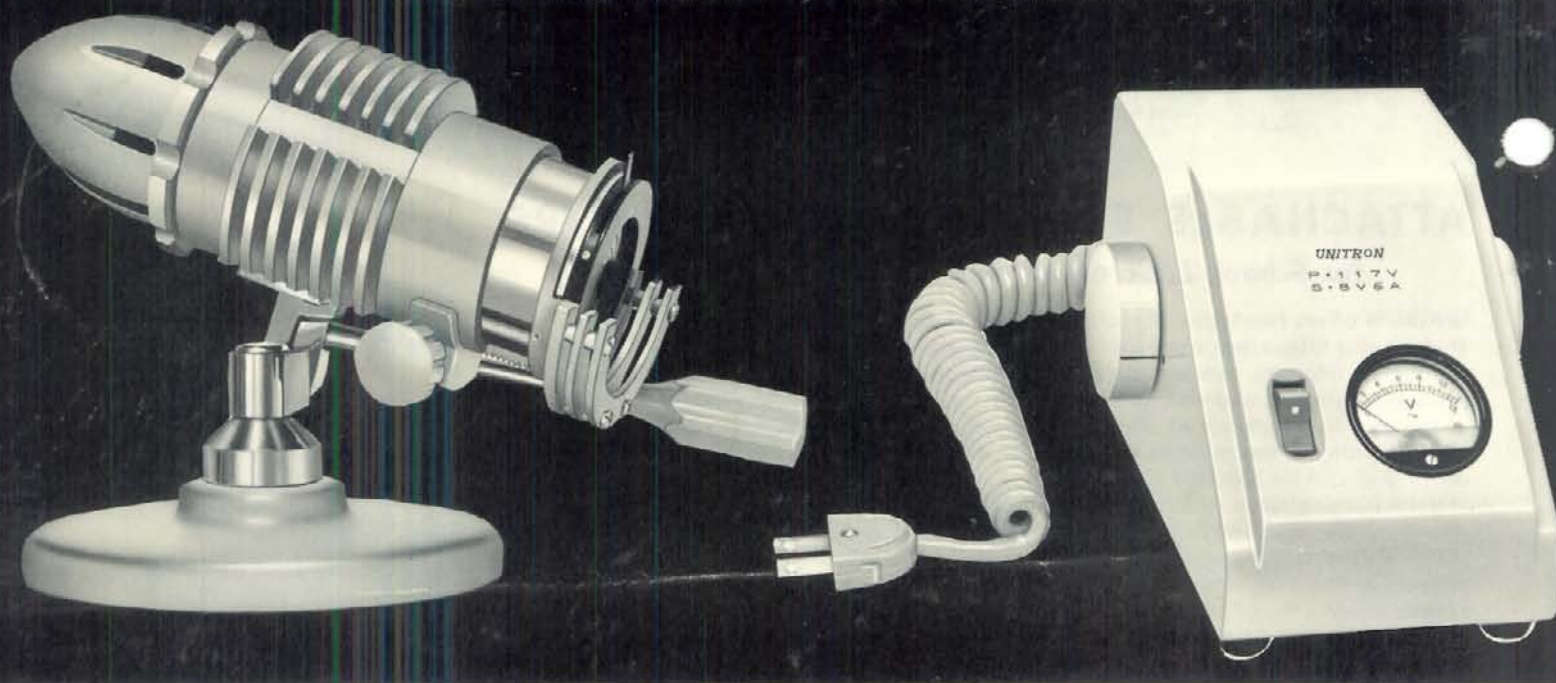
Price, complete **\$14.75**
Spare bulbs, type EL-SL, per dozen 3.00

Note: The Model LS Spotlight Illuminator is not recommended for transmitted-light microscopy with high-magnification, high-numerical aperture laboratory or student models.

UNITRON

Model LKR KOEHLER RESEARCH ILLUMINATOR

HIGHEST IMAGE CONTRAST • EVEN ILLUMINATION • MAXIMUM RESOLUTION



THEORY OF KOEHLER ILLUMINATION

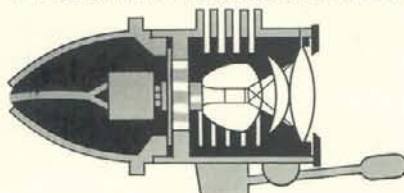
The benefits of Koehler Illumination can be achieved only by using a microscope lamp which has been designed especially for the purpose. To set up the illuminating system, an enlarged image of the bulb filament is reflected from the substage mirror and brought to a sharp focus in the plane of the iris diaphragm of the microscope condenser. Focusing this condenser will cause a sharp image of the lamp iris diaphragm to appear in the field of view. By regulating this lamp "field" diaphragm, only the portion of the specimen actually in the observed field will be illuminated. A corresponding adjustment of the "aperture" diaphragm of the microscope condenser limits the cone of entering light rays to a size which can actually be transmitted and utilized by the objective lens. Correct adjustment of these two iris diaphragms assures highest image contrast and eliminates the stray light which causes glare. In the Koehler system, these adjustments are completely independent of each other, giving the microscopist the advantage of the greatest degree of control. For example, the aperture diaphragm may be closed down to increase depth of field and contrast without changing the size or evenness of illumination in the observed field of view. Similarly, adjustments of the field diaphragm increase contrast by eliminating glare and not by decreasing the effective aperture of the objective.

ADVANTAGES OF UNITRON KOEHLER ILLUMINATOR

All adjustments such as alignment of the lamp house, focusing of the condenser, regulation of the iris field diaphragm, changing light intensity, and insertion of filters are made with the greatest of convenience while the user remains seated in the customary position for observing. A unique feature of the UNITRON lamp is the single control lever and locking device for varying orientation in the up-down and left-right directions. The focusable aspheric condenser is carefully corrected for spherical aberration to insure highest image contrast. Correct intensity for all application is obtained from the variable transformer. A voltmeter is provided so that intensity settings can be recorded for future reference, a particular advantage in photomicrography.

NOTE THESE MANY OUTSTANDING FEATURES

- High-intensity for brightfield, darkfield, phase contrast and polarized light microscopy
- Provides true Koehler illumination for all objectives, from low power to oil-immersion
- All controls within easy reach of the operator
- Uses inexpensive tungsten-filament bulb in prefocused base to insure perfect alignment
- Rack and pinion control for precise focusing of condenser
- Aspheric two-lens condenser system. Completely free of surface blemishes to produce uniform illumination
- Calibrated iris field diaphragm and filter holder
- Ventilated lamp house with radiation fins assures long bulb life and prevents stray light
- Heavy base for maximum stability
- Single-lever locking control for convenient adjustment of lamp position
- Heavy-duty transformer with continuously variable intensity control; voltmeter; on-off switch. Kink-free, coiled line cord eliminates clutter
- Modern appearance and sturdy construction
- Priced within the reach of limited budgets



Cross section view of
UNITRON'S Research Lamp

SPECIFICATIONS: UNITRON Model LKR KOEHLER RESEARCH ILLUMINATOR, High-Intensity Illuminator: with finned, ventilated housing, heavy base, two-lens aspheric condenser with rack and pinion focus, single-lever positioning and locking control, calibrated field diaphragm, holder for 2" square or round filters. Transformer: with variable-intensity control (0-12 volts, 5 amps), voltmeter, on-off switch, kink-free coiled line cord. Two prefocused tungsten bulbs included.

Price, complete	\$99.00
Green contrast filter, X1 transmission, Type F-KG	6.00
Blue color balancing filter, for color photography with "outdoor film", Type F-KB	4.00
Replacement bulbs, Type EL-RKL, per 3	3.00

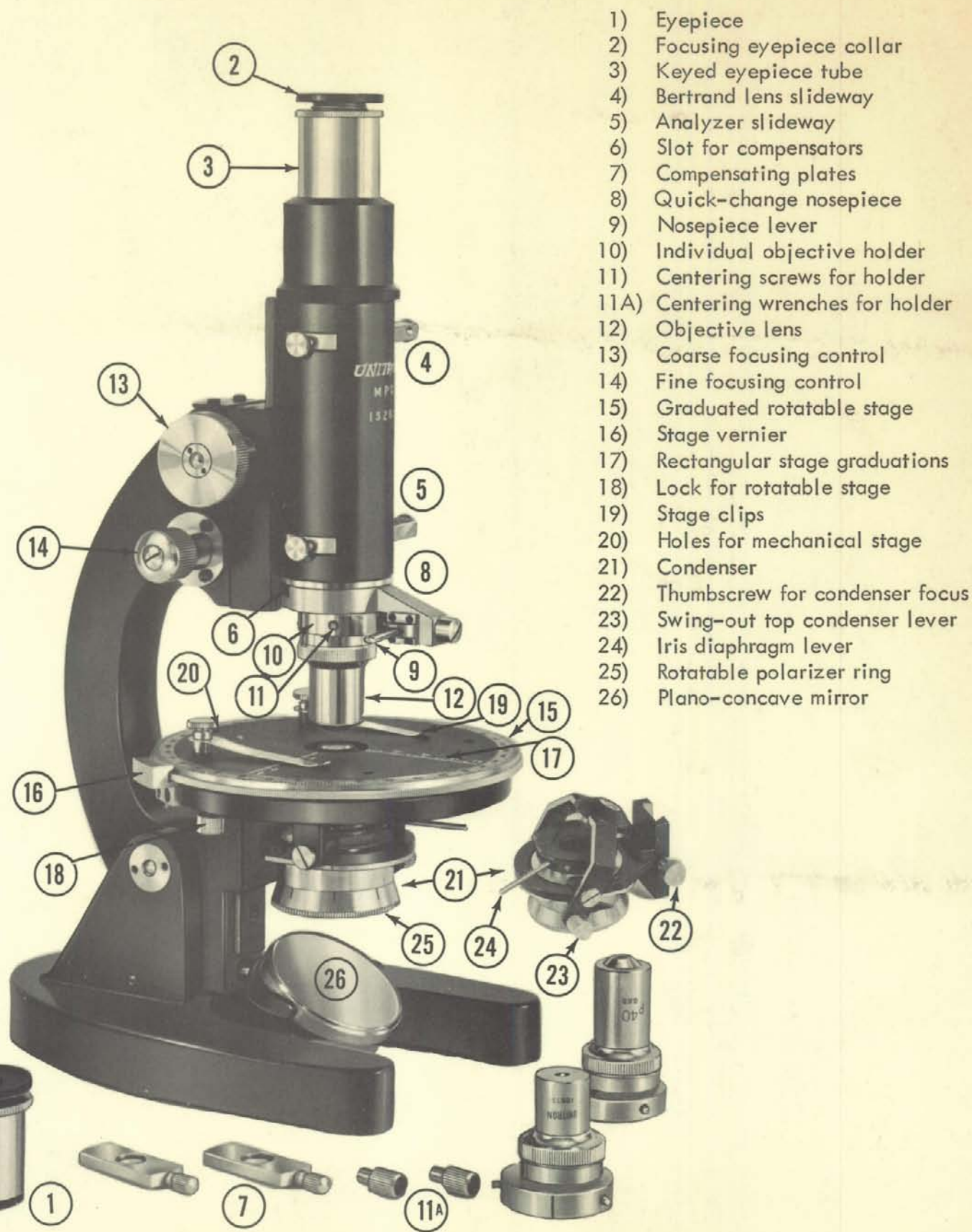
Prices F.O.B. Newton

Printed in U.S.A.

Instructions

UNITRON POLARIZING MICROSCOPE

MODEL MPS



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 a comparison with microscopes of other types. A "microscope" can be defined roughly as an instrument which produces a 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 of special techniques of examination.

One of 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 case 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. Alternatively, 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 polished to a high finish to remove scratches which would otherwise mar an image of the grain and other surface structures. However, a specimen so prepared is essentially a mirror. Since all parts of the object reflect light to an approximately equal degree, an untreated metal specimen is generally "invisible". By the use of a suitable 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 analogous 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 transparent specimens of this type lack visibility for the same reason noted above for biological specimens: they are too thin to modify the amplitude of the light wave. However, most crystalline materials have the important property that they are doubly-refractive and, therefore, change the state of polarization 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, all that is needed in practice is a microscope 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 only 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 based 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 additional optical element, the Bertrand Lens, is placed in the optical path and in conjunction with the eyepiece, acts as a magnifier to observe an 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 from a wide range of angular directions, rather than (as in the ordinary microscope) to form a "primary 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 magnification 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 identification of materials, some knowledge of optical crystallography is necessary if the techniques and accessory 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 can 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 performance of which this instrument is capable.

* * *

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, accessory 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 that the slot faces the spring-loaded contact pin, and release the lever. Make 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 location of the center of the field of view for reference purposes. This is the eyepiece which is used for most applications.

The Micro 5X eyepiece contains an accurately centered micrometer scale 5mm in length, graduated in 50 divisions. The scale is used to measure dimensions on the specimen and 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 location 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 collar (2) which allows the reticle pattern (crossline or micrometer) to be focused 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 through 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 stage. To lock the stage against rotation, tighten the thumbscrew (18) on the bottom lefthand of the stage.

A set of stage clips (19) is furnished as standard equipment. In addition, the top of the stage is drilled and tapped (10) to accept the accessory 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 knob).

POLARIZER: The polarizer is located 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 polarizer 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 applications which do not require polarized light, move the slideway all the way to 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 lower element and a top element which can be removed or inserted from the optical path using the swing-out lever (23). To focus the condenser, loosen the thumbscrew (22) and move the complete unit along the dovetail slide to the desired height. The lever (24) adjusts 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 into the slot (6) located above the objective holder and are inserted from the front with the engraved side facing upward.

* * *

PART III: USING THE MICROSCOPE

ADJUSTMENT OF ILLUMINATION: Proper illumination is essential with any microscope in order to achieve optimum results. For 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 to the microscope in order to obtain highest resolution of the specimen image for orthoscopic observations and full illumination of the objective rear focal plane for conoscopic 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 Part IV.

The general question of 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 large areas. Swing the top condenser lens out of the optical path. 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 advantage in preference to 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 position, swing the lens out of the optical path. In general, however, the plane surface of the mirror 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 condenser lens remain in the optical path and that the plane surface of the mirror be used.
- 4) Condenser focus: Whatever the objective, it is important 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 microscope. 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, optical resolution 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 distribution 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 objective. As the condenser is focused, note how the illuminated area changes in diameter. Adjust the condenser height and the mirror angle to 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 observed 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 objective 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 resolution is reduced. The iris should never be opened beyond the point needed to illuminate the full objective 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 observing 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 control or, alternately, place neutral-density filters in front of the lamphouse.

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 observed must include a well-formed crystal. An "arbitrary" specimen will not produce an interference figure. As an experiment, try observing the interference figures produced by flakes of mica varying from sections 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.

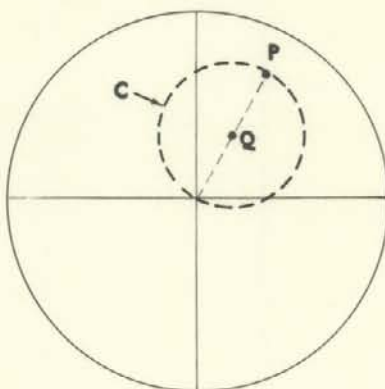
- 2) Objective: The 40X (or higher) powered objective must be used. (Interference figures cannot be produced with the 4X or 10X objectives).
- 3) Objective Focus: The objective must be focused on the top surface of the specimen.
- 4) Polarizer and Analyzer: The polarizer must be rotated to "cross" the analyzer: that is, polarized light is essential.
- 5) Bertrand Lens: The Bertrand Lens must be in the optical path.
- 6) Mirror and Illuminator: The plane mirror must be used in conjunction with a suitable illuminator.
- 7) Condenser: The condenser must be focused so as 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, part of the interference figure will be cut off.

Reference to the following hints will aid in achieving best results.

- 1) Eyepiece: Unless special micrometer measurements are being made, always use the Cross 10X eyepiece. This choice will produce the largest image of the interference figure.
- 2) Sharpness of image: For normally-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). Alternately, in some cases a sharper image can be obtained by raising 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 portion 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 detrimental to image quality for orthoscopic observations but the lines may prove distracting for conoscopic observation of interference figures. To remove these lines and 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 daylight-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 pattern can be seen than is possible with the standard 40X objective. Frequently, the additional pattern 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.

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 centration.

While looking through the microscope using the Cross 10X eyepiece, move the specimen slide so as to place a small but prominent specimen detail in the exact center of the eyepiece crosslines. This detail will serve as a point of reference. Now, rotate the microscope stage and observe the motion of the reference point. If the objective is not perfectly centered, the point will not remain superimposed on the crosslines but, instead, will move in a circular path like that shown by C in the accompanying figure. In such a case, rotate the stage to 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 to the objective holder. Turn the wrenches so as to move the reference point to a new position, Q, halfway along the imaginary line joining the original position P and the center of the crosslines.



Next, move the glass slide so as to recenter the reference point on 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 move along the circumference of a circle of smaller diameter. Repeat the centering process until the required accuracy of centration has been obtained.

In the case of objectives of higher power, an objective in a holder which has not previously been centered may be sufficiently out of centration so as to cause the reference point to move completely out of the observed field when the stage is rotated a full 360° . This makes the centering procedure for high powered objectives slightly more difficult. It is suggested that you practice centering the low power 4X objective as a means of becoming 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 not in use, cover the microscope with the plastic dustcover which is provided. The extra objectives and eyepieces should always be kept covered in the accessories box which forms part of the microscope cabinet.

Spots which are seen in the field of view and which rotate when the eyepiece is raised (from its keyed slot) and turned are caused by dust on the eyepiece lenses. Wipe the top and the bottom lenses with a high grade of lens tissue or a clean handkerchief. Do not disassemble the eyepieces; the chances for dust within the eyepieces are negligible.

When using the coarse focus control care should be taken to prevent focusing the objective downward to the point where it contacts the specimen. When changing to the 40X and objectives of higher power, it is advisable to raise the body tube to allow ample space for easy insertion.

Keep the front surfaces of the objective and condenser clean. Fingerprints and foreign matter may not prevent the formation of an image but they will often cause a noticeable reduction in image contrast.

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 illumination in this way, glare is kept to a minimum and image contrast is highest. For this reason, Koehler illumination is especially valuable for photomicrography.
- 2) Evenness of illumination: In a Koehler system the bulb filament is focused in such a 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 detail to insure correct results.

- 1) Adjustment of the Microscope: Incline the arm 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 and of the angle of the substage mirror is needed to provide enough light to focus a specimen image. Turn on the illuminator 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 are 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 image 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) Change of Lamphouse Inclination: achieved by using the extension-locking lever.
 - ii) Rotation of the Illuminator about its Base: leaving the relation between the base and the microscope unchanged.

Alignment of the optical axes of the microscope and the illuminator requires adjustment of the orientations of both the substage mirror and the illuminator. 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 that 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 sharp image of the lamphouse iris diaphragm in the field of view. This image will, in general, not be centered (Fig. 1). Adjust the mirror angle to move the iris image to the center of the field, as shown in Fig. 2.

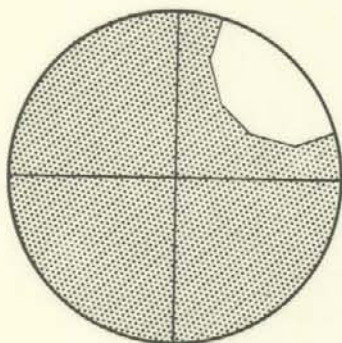


Fig. 1

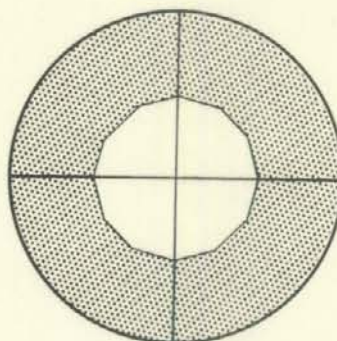


Fig. 2

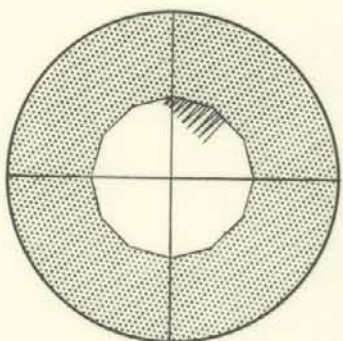


Fig. 3

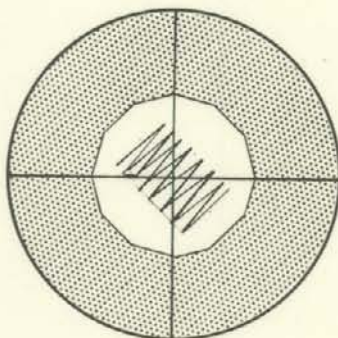


Fig. 4

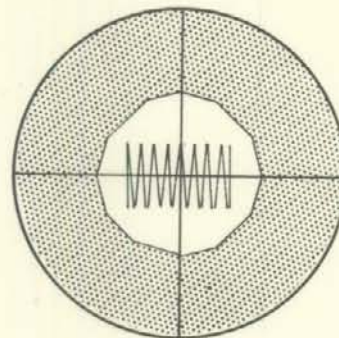


Fig. 5

- b) Turn the lamp condenser focus knob so as to move the condenser out all the way (the position closest to the microscope). Without changing the microscope focus, move the specimen slide to a place where no specimen details are present (for example, towards the edge of the cover glass), so as to obtain an "empty" field of view. You will see an 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 image 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, and then the other, mutual centration can be obtained by successive approximation. (Note: for purposes of judging centration, it may be easier to observe a 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 diaphragm all the way. As the lamp condenser knob is focused to move the condenser inward, the filament 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 method for illumination have now been completed. Close the lamp field aperture diaphragm and an image of the iris diaphragm will be seen in the center of the field. While looking 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 should be taken not to disturb the relative positions of illuminator, microscope and substage mirror.

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 photomicrography with a variety of cameras. (Refer to the catalog sheet on 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 objective holder, ready to use with Model MPS. \$37.00
- 8) 100X OBJECTIVE WITH CENTERABLE OBJECTIVE HOLDER: N.A. 1.25 oil 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 normal fashion for ordinary (orthoscopic) 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. MPS

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 bibliography 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 introduction 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 Microscope".

- 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