ME-POL
BIO-POL
POLARIZING MICROSCOPE

INSTRUCTION MANUAL

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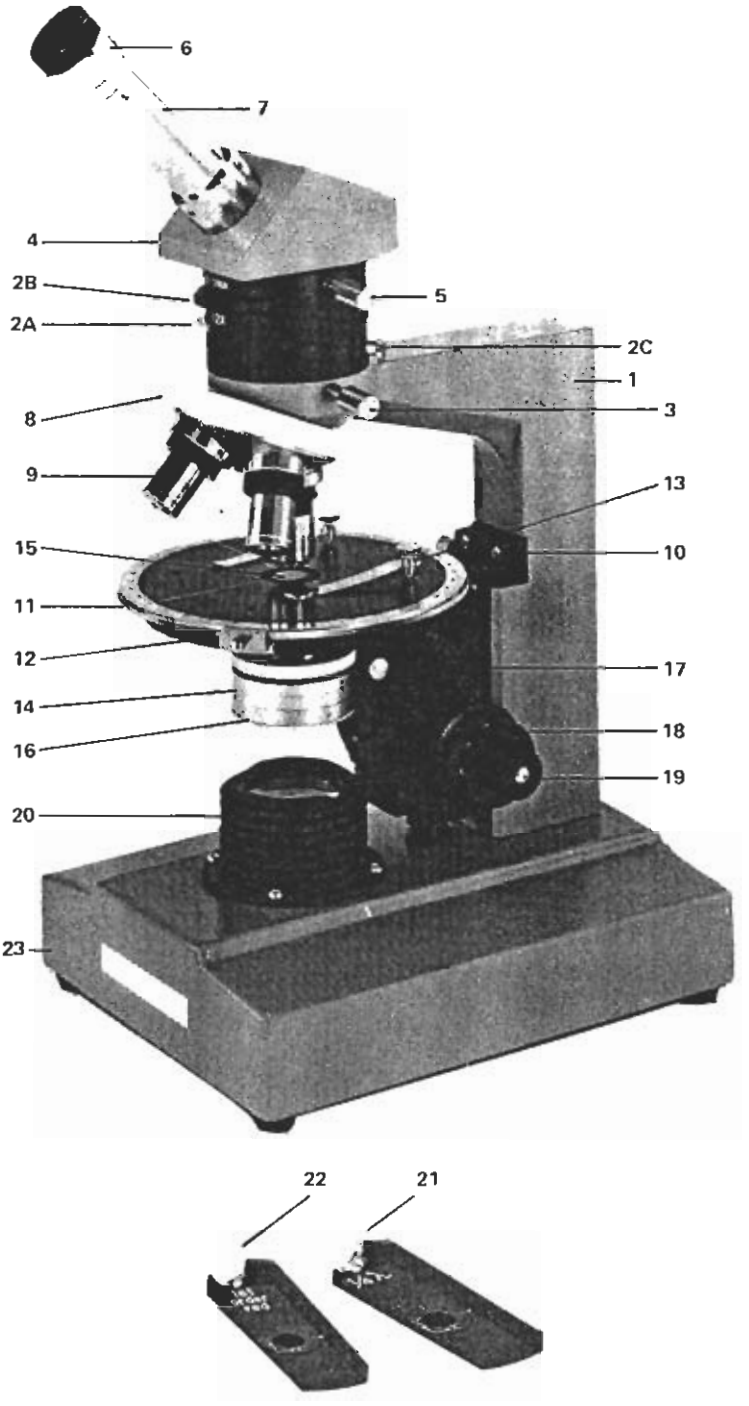

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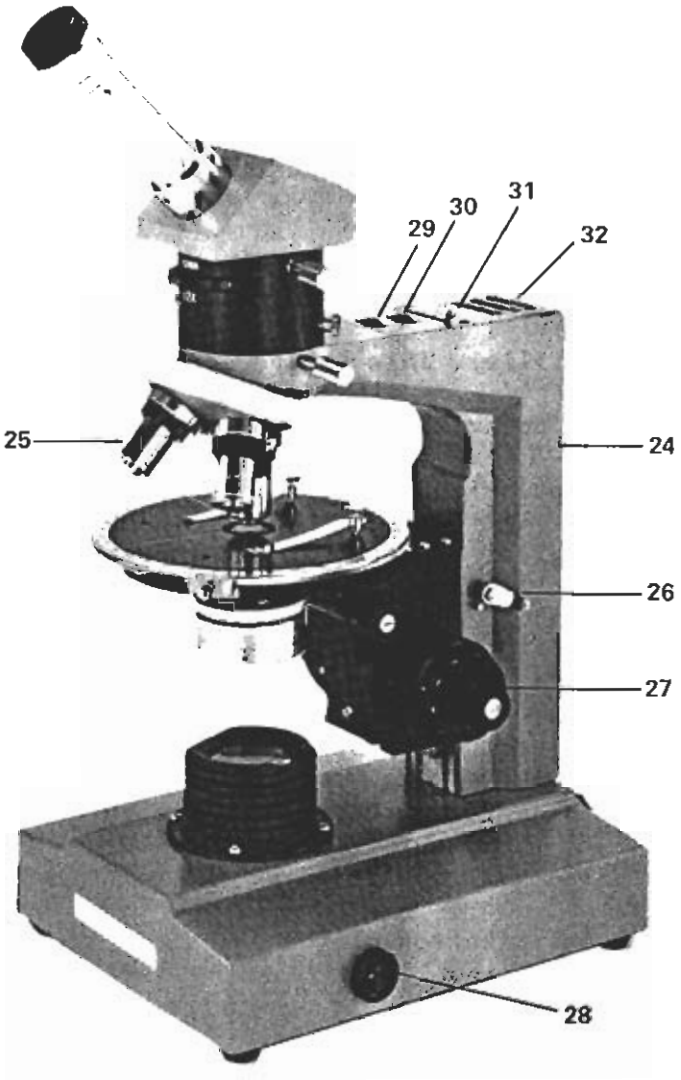

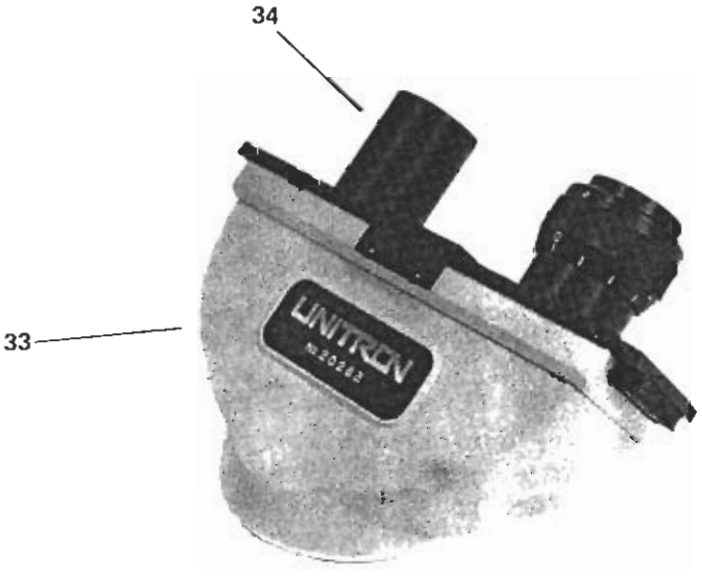

PART I: BASIC PRINCIPLES OF POLARIZATION MICROSCOPY

Light waves emanating from a source are generally unpolarized. By that, we mean that the light has an infinite number of orientations of planes of vibration. When we speak of polarized light, we refer to light where all planes of vibration are parallel. This can be accomplished by passing the light through a polarizer. Thus in polarization microscopes, a polarizer is located just below the condenser. The unpolarized light from the source is then linearly polarized prior to entering the optical elements of the microscope responsible for image formation.

A second polarizer, called an analyzer, is mounted in the ray path after the objective. The plane of polarization of these elements are usually crossed,i.e., at 90 degree with respect to each other. The light emanating from the source is linearly polarized by the polarizer; it has no component in the plane of polarization of the analyzer, thus, the field of view observed through the eyepieces should be entirely dark.

When we look through a polarizing microscope, we are trying to see if the specimen effects the polarization and is, therefore, birefringent or if the polarization is unaffected by the specimen and the specimen is isotropic in nature.

Specimens that are optically isotropic are characterized by having only one index of refraction. They are representative of a homogeneous distribution of atoms with no preferred orientation. Specimens that are optically birefringent are anisotropic in nature having two preferential directions. They are characterized by two refractive indices, one ordinary refractive index and other extraordinary

refractive index.

As the linearized polarized light passes the birefringent specimen it is broken up into two components, each vibrating in the direction of the corresponding refractive index with two different velocities. A change in the velocity introduces a path difference between the two components. The difference in the optical paths is a function of specimen thickness and index of refraction and results in a phase shift. A phase shift of 90 degree results in a circularly polarized light. Phase shift of 180 or 360 degrees result in linear polarized light, whereas all other phase shifts result in elliptical polarization. Thus, except for phase shifts of 360 degree, where the resultant polarization of the two components is crossed to the analyzer, some light will be transmitted. Since white light is composed from an infinite continuum of wavelengths between 400-700 nm, if there is one wavelength where the path difference is a multiple of that wavelength, that wavelength will be eliminated from the spectrum. The remaining colors can no longer produce white light and a specific color appears. For example, if the path difference is X nm, the light that corresponds to this path difference will be missing. The color observed in the specimen will then be the complementary color to that eliminated. Thus the color observed is a measure of specimens birefrigence.

PART II: SPECIAL PROPERTIES OF POLARIZATION MICROSCOPE

Most of the mineralogical specimens consist of tiny transparent crystals or thin sections cut and grounded perfectly flat. These specimens are too transparent or thin to modify the amplitude of light and thus lack structural information when observed under ordinary microscopes. However, most of these crystalline materials

have the important property that they are doubly-refractive birefringent and thus polarization microscope is capable of revealing the structural details of the specimen. Some other materials which can be examined in this way include certain textile, paper fibers, and biological cells and tissues.

When actual specimen are observed through the polarization microscope, the method is called "orthoscopic" observation. Indirect observation of the specimen by examining the interfernce figure located in the back focal plane of the objective is called "conoscopic" observation. The interference figure represents the effect of the specimen on the light distribution. By observing the conscopic image, the orientation and inclination of the birefringent specimen can be determined. Conoscopic observation of the back focal plane of the objective shows the angluar aperture of the illumination and each point in the back focal plane represents a particular direction of the illuminating light through the specimen. This means each point in the conscopic image has a different path difference and a different interference color. By simply rotating the specimen, one can determine the direction of the principles refractive indices and optical sign.

The polarization microscope has an additional application. When suitably equipped, it may be used to indentify crystalline materials using tests which are not based on magnification alone, but instead, on studying "interfernce figures". In practice, an additional optical element, the Bertrand Lens, is placed in the optical path and in conjunction with the eyepiece. This 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. Used in this way, the "microscope" is more properly described as a "polariscope".

For polariscope applications, some knowledge of optical crystallography is necessary if the technique and accessory equipment are to be used intelligently. It is not within the scope of present instructions to cover these techniques; the bibliography included in part VIII lists several references where such information can be found.

BIO-POL is equipped with transmitted illumination only and thus exclusively used for transparent specimens. ME-POL is equipped with both transmitted and incident light illumination and is suitable for inspection of transparent as well as opaque specimens. Both the series can be used for orthoscope and conoscope investigations of polarizing specimens.

PART III: DESCRIPTION OF COMPONENTS OF THE BIO-POL POLARIZING MICROSCOPE

Numbers appearing in the parentheses () refer to the illustration of the model shown in Figure I.

OBJECTIVES: Three coated, achromatic, strain-free objectives (9) are included normally as standard equipment: PO-A4X/N.A. 0.10, PO-A10X/N.A. 0.25, and PO-A40X/N.A. 0.65, with a spring loaded retractable front lens mount. Except for the 10X objective, the other objectives are equipped with centering mount with two centering keys. PO-A20X/N.A. 0.40, and PO-A100X/N.A. 1.25, spring loaded objectives are available as options.

Each objective is screwed onto a quadruple revolving nosepiece (8). The

nosepiece along with the objectives are pre-centered before shipment. In case, the objectives are misaligned, please follow the instruction of "Objective Centering" given in PART VII.

EYEPIECES: One eyepiece EWF10X(6) with an accurately centered crossline reticle is included with the BIO-POL-1. This eyepiece has a location pin which fits into the slotted eyepiece tube (7). The eyepiece is equipped with a helical focusing collar (6A) which allows the crossline reticle to be sharply focussed and establishes the location of the center of field for references. This is the eyepiece which is used in most applications.

When the binocular head (33) is used with BIO-POL-2, another eyepiece EWF10X (34) without the crossline is provided. This fits into the other eyepiece tube without a slot. This eyepiece is also equipped with a focussable collar mount.

STAGE: The circular stage (11) of 150 mm diameter can be rotated through 360 degree. This stage is graduated in degree, and reads 6 minutes of arc using the vernier (12). A knurled thumbscrew is provided to lock the stage against rotation. A set of stage clips (13) is also furnished. In addition, the top of the stage contains tapped holes to accept accessory mechnical stages. Attachable mechnaical stages are available as options.

FOCUSING CONTROL: Coarse and fine focusing is done using coarse adjustment knob (18) and fine adjustment knob (19) respectively. A 17 mm coarse adjustment and 1.4 mm fine adjustment is possible. The position of the fine focusing can be read by the index provided on the right hand knob. To vary the tension of focusing knob,

there is a tension adjustment knob adjacent to the focusing knob.

POLARIZER: The polarizer (16) is located below the condenser (14) and is rotatable using the knurled ring. Each of the calibration lines corresponds to a rotation of 15 degree. In practice, extinction is achieved when the polarizer is crossed i.e.,90 degree to the analyzer (2A). Optically, the field of view will appear dark (without a specimen) when extinction is achieved.

ANALYZER: The analyzer (2A) is a part of intermediate attachment (2). This is swing-in-out type of analyzer. When pushed all the way in, the analyzer is in the optical path for polarizing measurments. For some applications which do not require polarized light, the analyzer can be swung out.

BERTRAND LENS: The Bertrand Lens (2B) is also a part of intermediate attachment (2). This lens is not used for "orthoscopic" observation but only for "conoscopic" applications. A knurled rotatable turret can place the lens in or out of the optical path. The turret can be rotated to two positions marked "O" and "C". When it reds "O" the lens is out of optical path and when it reads "C" the lens is in the path.

COMPENSATORS: Two compensating plates are included as standard equipment: a quarter wave plate (21) and a first order red sensitive plate (22). These fit into the slot (C) of the intermediate attachment (2). The red sensitive plate is especially recommended for a weak birefringent specimen.

CONDENSER AND IRIS DIAPHRAGM: Two-lens strain free Abbe type with N.A. 1.25,

condenser with iris diaphragm (14) is attached on the polarizer. The condenser system is focused by means of the rack and pinion focusing knob. Orthoscopic observation needs only 4X and 10X objectives, thus the top lens of the condenser is usually removed. However, in practice, N.A. 1.25, with the top lens does not change the quality of the image, so the condenser with the top lens as a complete set can be used for most applications.

The iris diaphragm is usually closed to reduce the aperture in order to gain contrast and field depth, especially when observing specimens with a high degree of transparency. However, if the diaphragm is closed too far, the image resolution is decreased. The iris should never be opened beyond the point needed to illuminate the full objective aperture. Otherwise, unnecessary glare will be introduced.

ILLUMINATION: For polarizing microscope, a high intensity illumination is required, especially if weak birefrigence is to be detected. The illuminator must be carefully aligned in order to obtain the highest degree of resolution. The BIO-POL has a built-in base illuminator (23) which contains 6V,20W Halogen lamp. The strain-free condenser provides proper illumination of the specimen. The intensity of illumination can be controlled by a knob located in the base of the microscope.

PART IV: DESCRIPTION OF COMPONENTS OF THE ME-POL POLARIZING MICROSCOPE

Most of the components of ME-POL microscope; eyepiece, stage, focusing control knobs, polarizer, Bertrand Lens, compensators, condenser and iris diaphragm and transmitted illumination are just the same as in BIO-POL. Please refer to PART III, for the description of these components. In this section only those components are

described which are exclusively used with the ME-POL.

OBJECTIVES: The ME-POL comes equipped with PO-M5X/N.A. 0.10, PO-M10X/N.A. 0.25, and PO-M40X/N.A. 0.65, strain-free semi-plan achromatic objectives designed optically without the cover-slip for incident light microscopy. As an optional accessories: PO-A20X/N.A. 0.40, PO-A100X/N.A. 1.25, for transmitted light microscopy and PO-M20X/N.A. 0.40, for incident light microscopy, are available.

INCIDENT ILLUMINATION: This is equipped with 6V-20W Halogen lamp incident illuminator (32) also. A switch is provided in the base for selecting incident or transmitted light. By simply switching from incident to transmitted light, the system can be changed to a BIO-POL model. An aperture diaphragm (30) and a field diaphragm (29) for the purpose of Koehler illumination and a 90 degree rotatable polarizer (31) are included in the path of incident illumination.

Focusing Adjustment: Coaxial and fine adjustment knobs are the same as in BIO-POL, but the focusing ranges are 35 mm and 1.4 mm for coarse and fine adjustments respectively.

PART V: CONOSCOPIC OBSERVATION

In order to observe interference figures it is essential that certain conditions be fulfilled.

SPECIMEN: The specimen must be correctly prepared and the portion observed must include a well-formed crystal. An "arbitray" specimen will not produce an

interference figure. As an experiment, try observing the interference figures produced by flakes of mica of varying thickness: section about 0.5 to 1.0 mm thick. Alternately, the beginner 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., 51 Commerce Street, Cedar Grove, NJ (07009), Phone: (201) 239-6633

OBJECTIVES: The 40X, or 100X oil objectives must be used. Interference figures cannot be produced with the 4X or 10X objectives. However, 10X objective can be used for initial scanning of the specimen and centering purpose if needed.

OBJECTIVE FOCUS: The objective must be properly focused on the top surface of the specimen. If the objective is too high in power with relation to the interference figures, the outer portion of the interference figures will be cut off.

EYEPIECE: Always use the cross 10X eyepiece. This choice will produce the largest image of the interference figure.

EYEPIECE FOCUS: For normally-corrected vision, the interference figure will appear in sharpest focus when the collar of the eyepiece has been focused to produce the sharpest image of the crossline.

BERTRAND LENS: The Bertrand Lens must be in the optical path. This lens acts as a magnifying lens to see the actual image produced in the rear focal plane of the objective.

CONDENSER: The condenser must be focused properly so as to completely fill with light the rear focal plane of the objective. Otherwise, the outer portion of the interference figure will be cut off.

ILLUMINATION: Uniform illumination is especially required for conoscopic observation: to judge the interference colors correctly.

PART VI: OBJECTIVE CENTERING

Objective centering is very essential factor for the effective polarizing observation. The rotatable circular stage must be perfectly centered against objectives. The center of the stage and objectives are pre-centered before shipment. In case, the objectives are not centered, the following procedures will assure the centering.

1. Look through the microscope with crossline 10X eyepiece and with 10X objective.

2. Move the specimen slide so as to place a small but prominent specimen detail in the exact center of the eyepiece crossline. This detail will serve as a point of reference (P).

3. Now, rotate the microscope stage and observe the motion of the reference point. If the 10X objective is not perfectly centered, the point P will not remain superimposed in the crossline, but instead, will move in a circular path.

4. Rotate the stage to a position such that the reference point is at greatest distance from the center of the crossline.

5. Now turn the three centering screws on the side edge of the lower stage plate, until the reference point moves to a new position which is almost halfway along the line joining the orginal position P and the center of the crossline.

6. Next, move the specimen so as to recenter the reference point on the cross line 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, now the reference point will move in a circle of smaller diameter.

7. Repeat the centering process until they are perfectly centered. This procedure ensures the centering of the stage with respect to 10X objective.

8. Rotate the nosepiece and bring the 40X objective in the optical path by focusing on the specimen. Check the centering of this objective with the already centered stage.

9. In case, they are not centered, adjust the centering keys provided on the objective, until they are perfectly centered.

PART VII: CARE OF THE MICROSCOPE

Dust is the enemy of optical instruments. 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 lens tissue. Do not disassemble the eyepieces; the chances of 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 high power, it is advisable to raise the body tube to allow ample space for easy rotation. 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 VIII:SELECTED BIBLIOGRAPHY

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