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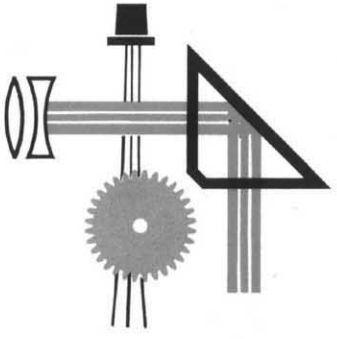

INSTRUCTIONS

DYNOPTIC POLARIZING MICROSCOPES

BAUSCH & LOMB

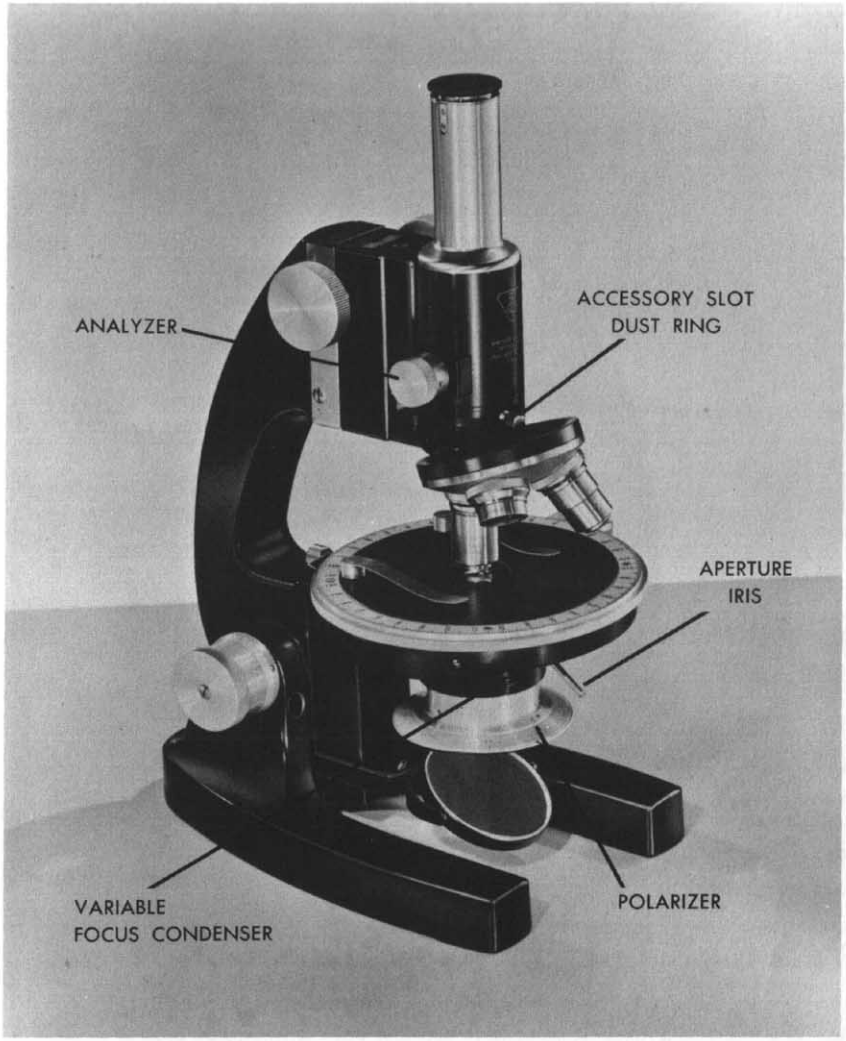

Figure 2

Model LM Dynoptic Polarizing Microscope

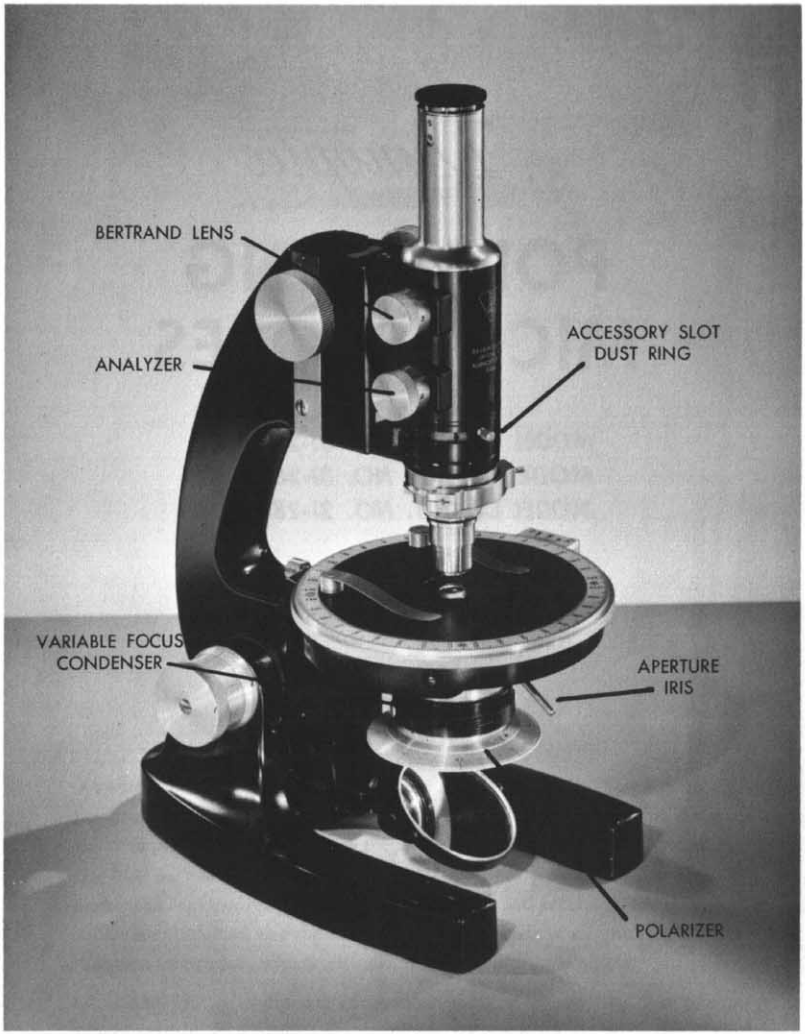

Figure 1

Model LI Dynoptic Polarizing Microscope

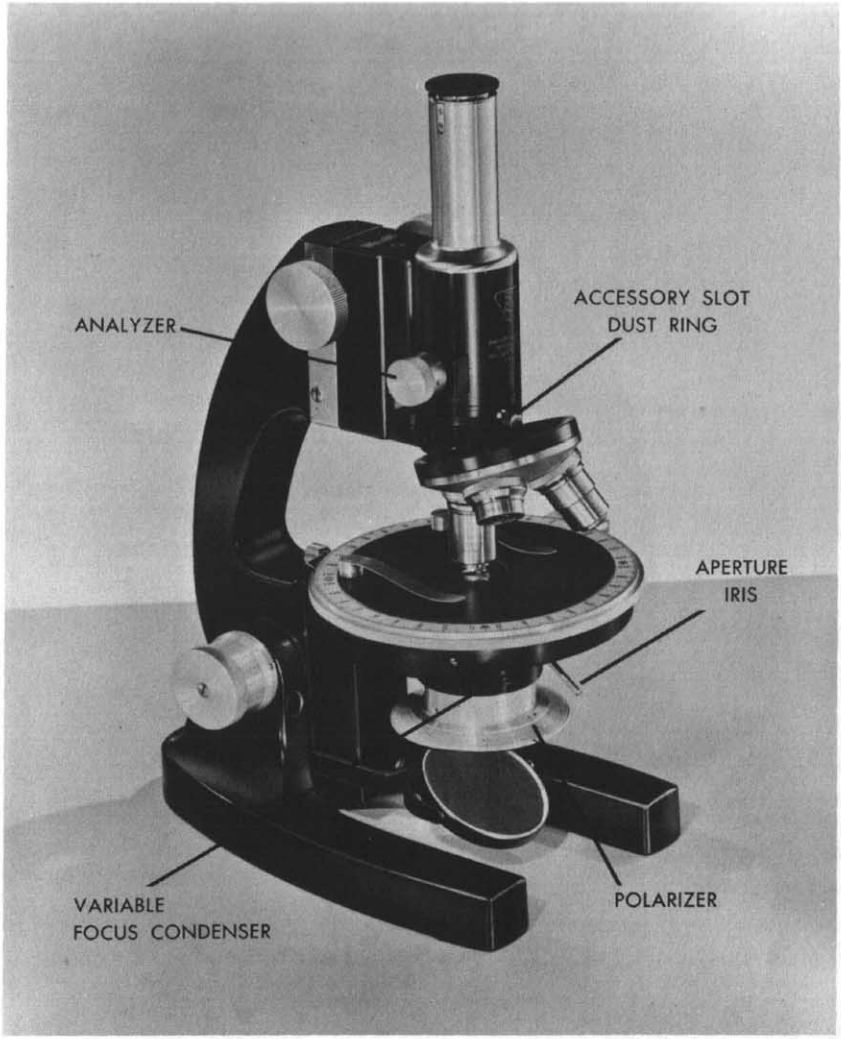

Figure 2

Model LM Dynoptic Polarizing Microscope

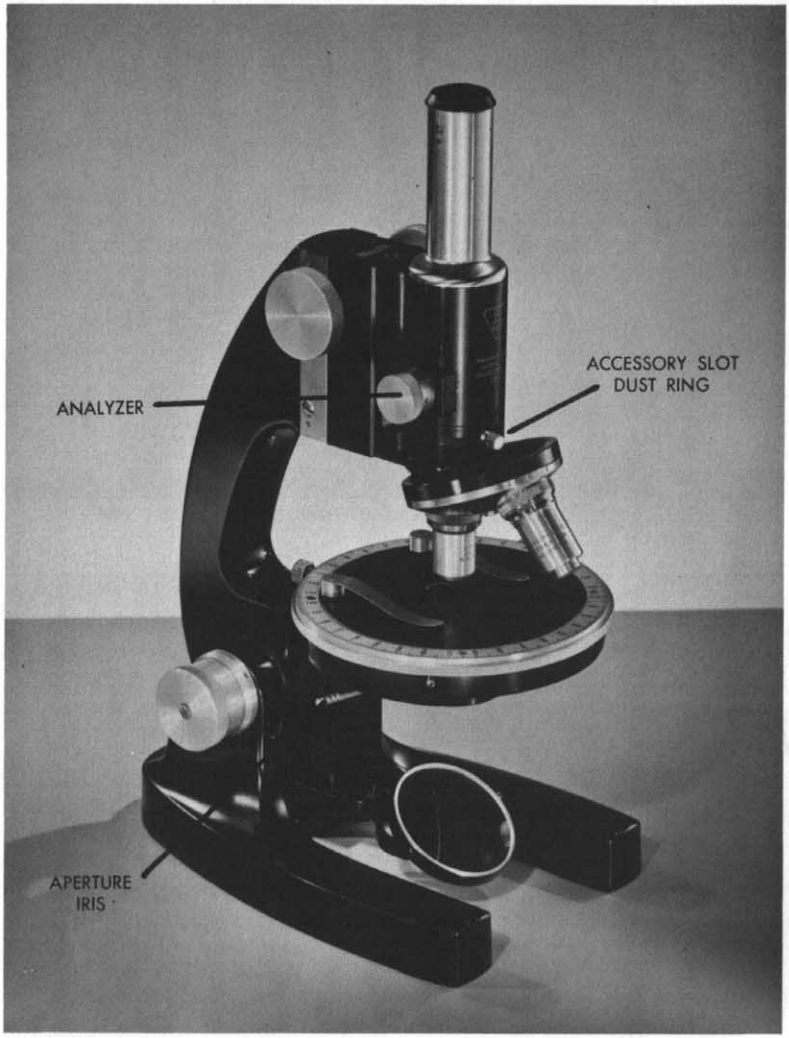

Figure 3

Model LS Dynoptic Polarizing Microscope

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BAUSCH & LOMB

POLARIZING MICROSCOPES

CAT. NO. 31-28-59-02
CAT. NO. 31-28-60-02
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Introduction

Bausch & Lomb Dynoptic Polarizing Microscopes embody all of the refinements of the laboratory type microscopes and, in addition, feature the additional optics and accessories peculiar to and necessary for polarized light work. Thus we have in addition to the mirror, substage equipment, objective, and eyepiece, the polarizer, which is mounted in the substage, the analyzer, mounted above the objective, and, on the LI Model, the Bertrand lens, necessary for convenient viewing of the interference figure. Another point of difference between the polarizing microscope and the laboratory microscope is the accessory slot, located between the objective and analyzer, which allows for the introduction of compensation accessories such as the quartz wedge, quarter-wave plate, or the sensitive tint (first order red) plate. Also, it will be noticed that the end of the eyepiece adapter tube is slotted and that the eyepieces are correspondingly keyed. This is to ensure proper orientation of the reference crosshairs in the eyepiece.

All of these parts must be arranged so as not to interfere with the general manipulation of the instrument, to be conveniently operated, and to remain in adjustment over an indefinite period. In addition to these requirements, it is highly essential in an instrument of this kind that the objectives be free from strain.

This booklet is divided into five sections as follows: (1) Unpacking Instructions—applicable to both LI, LM, and LS models, (2) The LI Model—general operating instructions, (3) The LM Model—general operating instructions, (4) The LS Model—general operating instructions, and (5) The Use of Accessories — a brief description of some techniques of polarized light microscopy. For more detailed and extensive information concerning this subject we refer you to the standard texts on the subject, a partial bibliography being given on page 14.

It is beyond the scope of this manual to serve as a text for manipulation of the microscope in general, or for polarized light microscopy in particular. For more detailed information concerning general microscopy we refer you to our Reference Manual for the Bausch & Lomb Dynoptic Laboratory Microscopes and to "The Theory of the Microscope," by J. R. Benford, copies of which accompany this instrument.

UNPACKING INSTRUCTIONS

Bausch & Lomb Dynoptic Polarizing Microscopes Models LM and LI are forwarded in an especially designed instrument case. Upon unlocking the case, it will be seen that the instrument is held in position in the case by a heavy screw extending through the bottom of the case. This screw must be removed to permit removal of the instrument from the case. Remove the protective cover which encloses the instrument, and remove the tissue packing surrounding instrument and accessories. The eyepieces will be packed in one drawer and the objectives in another. The substage equipment will be in place below the stage.

THE BAUSCH & LOMB MODEL LI DYNOPTIC POLARIZING MICROSCOPE

The LI Model Dynoptic Polarizing Microscope features, as standard equipment, a Bertrand lens, a nosepiece for use with individually centerable quick-change objective carriers, and a variable focus condenser-polarizer assembly. These are dealt with in detail below.

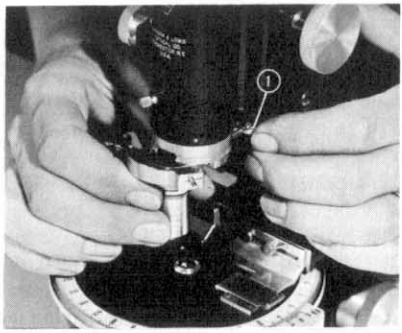
Attaching and Centering Objectives

The centerable nosepiece is composed of two components, the tube part which is fastened on the microscope, and the objective part which holds the objective. Fig. 4 shows the proper method of inserting an objective. The nosepiece lever (1) must be pulled back to permit the objective part to slide fully into place. When the lever is released the objective part is held securely in position with its centering screws bearing on the tube part. To remove an objective, pull back the lever and slide the objective part forward.

Each objective will have to be centered to the axis of rotation of the stage. The stage has been accurately centered at the factory and its adjustment should not be disturbed. Use any eyepiece equipped with a cross hair, and place the objective on the microscope as described in the preceding paragraph. Two small keys are provided for turning the centering screws. Place these on the centering screws Fig. 5 (2) and focus on some object, such as a rock section. Rotate the stage and notice what point in the specimen stands still. There is always some point in the specimen which coincides with the axis of the stage,

Figure 4

Attaching an Objective



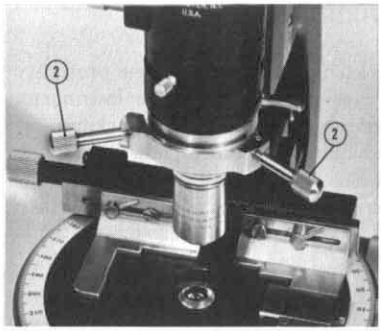


Figure 5

Objective with
Centering Keys Attached

and this point will remain fixed while all other points in the field will revolve around it. By means of the two keys adjust the centering screws until this stationary point is brought to the intersection of the crosshairs. It will be possible to make a very precise adjustment. When all of the objectives have been centered in this manner, they can be replaced during regular work without attention to further centering. It may be necessary to occasionally recenter the higher power objectives.

Condenser-Polarizer

The Condenser-Polarizer is composed of an iris diaphragm, heat-absorbing filter, polarizer, and two condensing lenses, the lower lens sliding up and down to change the numerical aperture of the illumination (See Fig. 1). The numerical aperture is variable from 0.05 N.A. to 1.25 N.A., depending upon the positioning of the slide and the opening of the iris diaphragm. The setting of this sliding lens will be determined by the field and aperture requirements of the objective and eyepiece combination in use. Refer to the Dynoptic Laboratory Microscope Reference Manual for more detailed information concerning the proper use of the variable focus type condenser.

The Polarizer, a Sextant Grade Polaroid Disc, is rotatable through 360° by the knurled ring at the bottom of the condenser-polarizer. When set at 0° the plane of vibration of the polarizer is north-south and it is crossed with the analyzer.

To approximate the use of parallel light illumination, place the condenser slide in its lowest position and close the iris down to its smallest aperture.

Warning: The polarizer is protected by a heat absorbing disc, but excessive heat is to be avoided. The polarizing elements should not be heated beyond 150°F. Diffuse light sources should not be located too near the polarizer. Incandescent sources greater than 100 watts should be used only with a heat-absorbing water cell in the beam. If a carbon arc is used, a 2% solution of copper sulphate must be used in the water cell.

Analyzer

The analyzer is a non-rotatable Sextant Grade Polaroid Disc held in a convenient swing-in mount. It is permanently set so that its plane of vibration is east-west.

Manipulation

All eyepieces furnished with this instrument are of the cross-hair type with focusable eye lenses. The focusable eye lens should be set so that the cross-hair is sharply focused to the eye.

The Bertrand lens assembly is held in a swing-in mount and is brought into working position by a quarter turn

of the upper knurled knob on the side of the body tube (See Fig. 1). When in operating position, the interference figure which is formed in the rear focal plane of the objective is imaged at the eyepiece focal plane, thus making the interference figure readily visible. A small fixed diaphragm is also attached to the mount about an inch from the Bertrand lens. This arrangement permits the isolation of interference figures of small crystals in the center of the field.

The analyzer is inserted or removed from the optical path by a quarter turn of the lower knurled knob on the side of the body tube (See Fig. 1).

The stage is a circular rotating stage graduated in one degree intervals throughout 360° and provided with a locking clamp and vernier, which enables a rotation setting to be read to six minutes of arc. The stage is drilled and tapped for the convenient use of stage accessories, such as the conventional clips or a mechanical stage. Do not disturb the centration of the stage —always center the objectives to the axis of rotation of the stage.

Accessories

For the more commonly used accessories such as the quarter wave plate, the quartz wedge, and the sensitive tint plate, a slot is provided immediately above the objective. This slot is concealed by a dust-proof sliding ring actuated by the finger pin which, when rotated in a clockwise direction, reveals the accessory slot. The accessories may be inserted from either side of the instrument.

In all compensation plates the direction of the slow ray is indicated by an arrow, or when not marked is understood to be across the mount, i.e., parallel to the shortest dimension of the mount. In using the accessories requiring a positive eyepiece, such as the graduated quartz wedge, insert the positive eyepiece, turn the polarizer to 45° and set the eyecap analyzer to 315°.

Accessories which are not included with the basic microscope stand, but which can be purchased separately, include:

Quartz wedge
Sensitive tint plate (1st order red)
Quarter wave plate
Accessory Slot Compensator
Vertical illuminator
Microscope lamps
Cameras, slides
Micrometer eyepieces
Mechanical stage
Objectives, eyepieces

THE BAUSCH & LOMB MODEL LM DYNOPTIC POLARIZING MICROSCOPE

The Bausch & Lomb Model LM Dynoptic Polarizing Microscope has been designed to meet the needs of the chemical microscopist. It features a triple nosepiece and a variable focus condenser-polarizer assembly.

Condenser-Polarizer

The Condenser-Polarizer is composed of an iris diaphragm, heat absorbing filter, polarizer, and two condensing lenses, the lower lens sliding up and

down to change the numerical aperture of the illumination (See Fig. 2). The numerical aperture is variable from 0.05 N.A. to 1.25 N.A., depending upon the positioning of the slide and the opening of the iris diaphragm. The setting of this sliding lens will be determined by the field and aperture requirements of the objective and eyepiece combination in use. Refer to the Dynoptic Laboratory Microscope Reference Manual for more detailed information concerning the proper use of the variable focus type condenser.

The Polarizer, a Sextant Grade Polaroid Disc, is rotatable through 360° by the knurled ring at the bottom of the condenser-polarizer. When set at 0° the plane of vibration of the polarizer is north-south and it is crossed with the analyzer.

To approximate the use of parallel light illumination, place the condenser slide in its lowest position and close the iris diaphragm down to its smallest aperture.

Warning: The polarizer is protected by a heat absorbing disc, but excessive heat is to be avoided. The polarizing elements should not be heated beyond 150°F. Diffuse light sources should not be located too near the polarizer. Incandescent sources greater than 100 watts should be used only with a heat-absorbing water cell in the beam. If a carbon arc is used, a 2% solution of copper sulphate must be used in the water cell.

Analyzer

The analyzer is a non-rotatable Sextant Grade Polaroid Disc held in a convenient swing-in mount. It is permanently set so that its plane of vibration is east-west.

Manipulation

All eyepieces furnished with this instrument are of the cross-hair type with focusable eye lenses. The focusable eye lens should be set so that the cross-hair is sharply focused to the eye.

The analyzer is inserted or removed from the optical path by a quarter turn of the knurled knob on the side of the body tube (See Fig. 2).

The stage is a circular rotating stage graduated in one degree intervals throughout 360° and provided with a locking clamp and vernier, which enables a rotation setting to be read to six minutes of arc. The stage is drilled and tapped for the convenient use of stage accessories, such as the conventional clips or a mechanical stage. Do not disturb the centration of the stage —always center the objectives to the axis of rotation of the stage.

Accessories

For the more commonly used accessories such as the quarter wave plate, the quartz wedge, and the sensitive tint plate, a slot is provided immediately above the objective. This slot is concealed by a dust-proof sliding ring actuated by the finger pin which, when rotated in a clockwise direction, reveals the necessary slot. The accessories may be inserted from either side of the instrument.

In all compensation plates the direction of the slow ray is indicated by an arrow, or when not marked is understood to be across the mount, i.e., parallel to the shortest dimension of the mount. In using the accessories requiring a positive eyepiece, such as the graduated quartz wedge, insert the positive eyepiece, turn the polarizer to 45° and set the eyecap analyzer to 315°.

Accessories which are not included with the basic microscope stand, but which can be purchased separately, include:

Quartz wedge
Sensitive tint plate (1st order red)
Quarter wave plate
Accessory Slot Compensator
Vertical illuminator
Microscope lamps
Cameras, slides
Micrometer eyepieces
Mechanical stage
Objectives, eyepieces

THE BAUSCH & LOMB MODEL LS DYNOPTIC POLARIZING MICROSCOPE

The Bausch & Lomb Model LS Dynoptic Polarizing Microscope has been designed to meet the requirements of a polarizing microscope for use by students of petrographic and chemical microscopy and for routine laboratory use. It features a multiple revolving nosepiece, an accurately centered rotating stage and a fixed diffusing polarizer with variable iris diaphragm.

Polarizer Assembly

The polarizer assembly consists of an iris diaphragm and a Sextant Grade Polaroid Disc with a diffusing surface. The polarizer is fixed in position so that its plane of vibration is north-south. The opening of the iris diaphragm may be regulated by a simple rotation of the iris actuating handle. (See Fig. 3).

Warning: The polarizing elements should not be heated beyond 150°F. Diffused light sources should not be located too near the polarizer. Incandescent sources greater than 100 watts should be used only with a heat absorbing water cell in the beam. If a carbon arc is used, a 2% solution of copper sulphate must be used in water cell.

Analyzer

The analyzer is a non-rotatable Sextant grade Polaroid disc held in a convenient swing-in mount. It is permanently set so that its plane of vibration is east-west.

Manipulation

The analyzer disc may be removed from the optical path by a quarter turn of the knurled knob on the side of the body tube. (See Fig. 3). When the analyzer is brought into operating position it is always crossed with the polarizer.

The stage is accurately centered at the factory to the axis of the high power objective. This adjustment should not be disturbed. The stage is rotatable through 360° and is graduated in one degree intervals. An index line provides a point of reference for measurement of angular rotation.

Accessories

The body tube, directly above the circular nosepiece, is provided with a slot for such accessories as the quarter wave, or red of the first order plates, and the quartz wedge. These accessories are generally used between

crossed polarizer and analyzer, and are oriented with their slow axes diagonal to the planes of vibration of the polaroids. Hence, generally speaking, when using these accessories, make sure that the analyzer is in the optical path.

Note: Accessories are not included with the microscope.

Suggestions

Keep instrument in case when not in use. Keep all optical parts free from dust and finger prints, or the microscope will not give the best extinction when the polarizer and analyzer are crossed.

Keep the accessory slot dust ring closed when not in use.

Extras for your Microscope

Vertical Illuminator for metallographic work.

Microscope lamps, cameras, slides, micrometer eyepieces, mechanical stage, objectives, auxiliary telescope for viewing interference figures.

USE OF ACCESSORIES

The optical properties of minerals and mineral sections can be conveniently grouped into two classes: (1) Those which are more or less qualitative in nature and for whose expression data of actual measurement are not required such as color, pleochroism, absorption, optical ellipsoidity, optical character. (2) Those which are essentially quantitative in nature, such as refractive index, birefringence, optic axial angle, and extinction angle. The first three properties in group one are not necessarily qualitative. They have been included in that group, however, because of the difficulty involved in making quantitative measurements. To make such measurements auxiliary apparatus would be required whose cost and complexity in application have not appeared to be justified by the value of the results. Color, pleochroism, and absorption are, therefore, estimated rather than measured, and are expressed descriptively rather than in terms of units of measurement.

Optical ellipsoidity of a mineral, that is, whether the mineral is isotropic, uniaxial, or biaxial, is best determined in polarized light. Focus on the grain with a 4mm objective and look for an interference figure by swinging the Bertrand lens into position. The interference figure will be formed in the upper focal plane of the microscope objective. Interference figures are not always similar to the beautiful circles and crosses shown in text books. An interference figure may only be part of an isogyre passing through the aperture of the objective and this may cover half or more of the aperture of the objective. To be sure that the mineral or crystal is anisotropic when such a condition is seen, rotate the stage of the microscope while observing the interference figure. If it sweeps across the field, the crystal is anisotropic.

The optical character of an uniaxial or biaxial mineral is best determined in polarized light by means of a sensitive tint plate. Observe the interference figure and note if it is a uniaxial figure. A uniaxial figure will be a symmetrical Maltese cross with a series of concentric rings or circles of color. Introduce the quarter-wave plate or red of the first

order in the slot directly above the objective and note in which two opposite quadrants two black dots appear. Note the direction of an imaginary line joining these dots. If the direction of the line is perpendicular to the plane of vibration of the slow ray of the sensitive tint plate, the crystal is positive. If the line is parallel to the slow ray, the crystal is negative. The plane of vibration of the slow ray is indicated on the sensitive tint plate by an arrow. If the interference figure comes from a biaxial crystal, it will be composed of two dark hyperbolae. Rotate the stage of the microscope until the axes of the two hyperbolae are parallel to the direction of the slow ray of the quartz wedge. Introduce the quartz wedge, moving it across the field slowly and noting whether the hyperbolae expand or contract. If they expand, the crystal is positive, and if they contract, the crystal is negative.

Refractive Index

Transparent crystal grains immersed in a colorless liquid are only visible if their index of refraction is unlike that of the liquid. Complete disappearance of the crystal grains gives evidence that they have the same index of refraction as the liquid. Consequently, the exact index of refraction of small crystal grains may be determined. The two most popular procedures are known as the Becke line method and the oblique illumination method. Both methods require a series of immersion liquids of known index of refraction. They are usually prepared so that the difference from one liquid to the next is 0.01. The crystal grains are immersed in any one of the liquids and a test made to see if the crystal is higher or lower in index than the liquid. After the first test is made, the grains are transferred to another liquid of higher or lower index than the first in an attempt to get disappearance of the crystals.

The Becke line determination of whether the grain is higher or lower index than the crystal is carried out in the following manner. Focus on the crystal grains which have been mounted on a clean slide and immersed in the liquid selected. Reduce the aperture of the substage condenser by closing the iris diaphragm. A contact between the crystal and the liquid will appear as a sharp line. Focus up with the objective. A distinct band of light will be recognized parallel to the edges of the grains, and this band of light moves toward the substance with the higher index as the objective is raised.

Oblique illumination of the crystal grains can also be used to determine whether their index of refraction is higher or lower than the immersion liquid. Focus on the mounted grains and insert just below the condenser a card or opaque screen until it extends just beyond the middle of the condenser. A dark shadow will appear in the image of the grain on the side opposite the screen, if the index of the grain is greater than that of the immersion fluid. If the shadow appears on the same side as the screen, the index of the grain is less than that of the mineral.

Birefringence

To detect weak birefringence, focus on the specimen with the polarizer set at 0, introduce in the slot above the objective a sensitive tint plate and rotate the stage above the microscope. If any part of the crystal exhibits a change of color on rotation, it is birefringent.

Order of Interference Color

Rotate the stage after focusing on a crystal until a prominent axis of the crystal is parallel to the slow ray of the quartz wedge. See that the polarizer is set at 0. Push in the quartz wedge slowly, noticing if the original color of the crystal becomes dark gray. When this occurs, the original color of the crystal is compensated by the retardation in the quartz wedge, and the order of interference color may be determined by counting the number of times the red band has passed across the field. Thus, if the specimen appears blue between crossed Polaroids and the red band moves across the field twice before compensation is secured, the interference color of the crystal is described as third order blue. If compensation does not occur in the position selected for the crystal, rotate the stage 90° and repeat the above procedure. At a point compensation in a birefringent crystal the slow ray of the crystal must be perpendicular to the slow ray of the quartz wedge. Therefore, when the order of interference color is known, the direction of the fast and slow ray in the crystal is also known. If the direction of the slow ray is parallel to the major crystal axis, the sign of elongation is positive. On the contrary, if the direction of the slow ray is perpendicular, to the length of the crystal, it is negative elongation.

Recommendation

It is recommended that if the instrument is to be left out of the case for any protracted period, that an eyepiece be left inserted in the body tube, in order to prevent dust from accumulating within the microscope. Also, close the accessory slot dust ring.

References

For further details of theory and practice concerning petrography, crystallography, and the use of the polarizing microscope, the following selection of references is suggested, although many equally valuable books have been omitted for want of space.

1. "Crystallography and Practical Crystal Measurement"—two volumes.
A. E. H. Tutton
MacMillan and Company

Note: Volume 2 is an especially fine reference for the theory of the optical phenomena connected with the polarizing microscope.

2. "The Methods of Petrographic-Microscope Research."
Fred Eugene Wright
Carnegie Institution of Washington

A careful study of the relative accuracy of various methods.

3. "Manual of Petrographic Methods"
Albert Johannsen
McGraw-Hill Book Company

An accepted, widely used text which covers every phase of petrographic procedure.

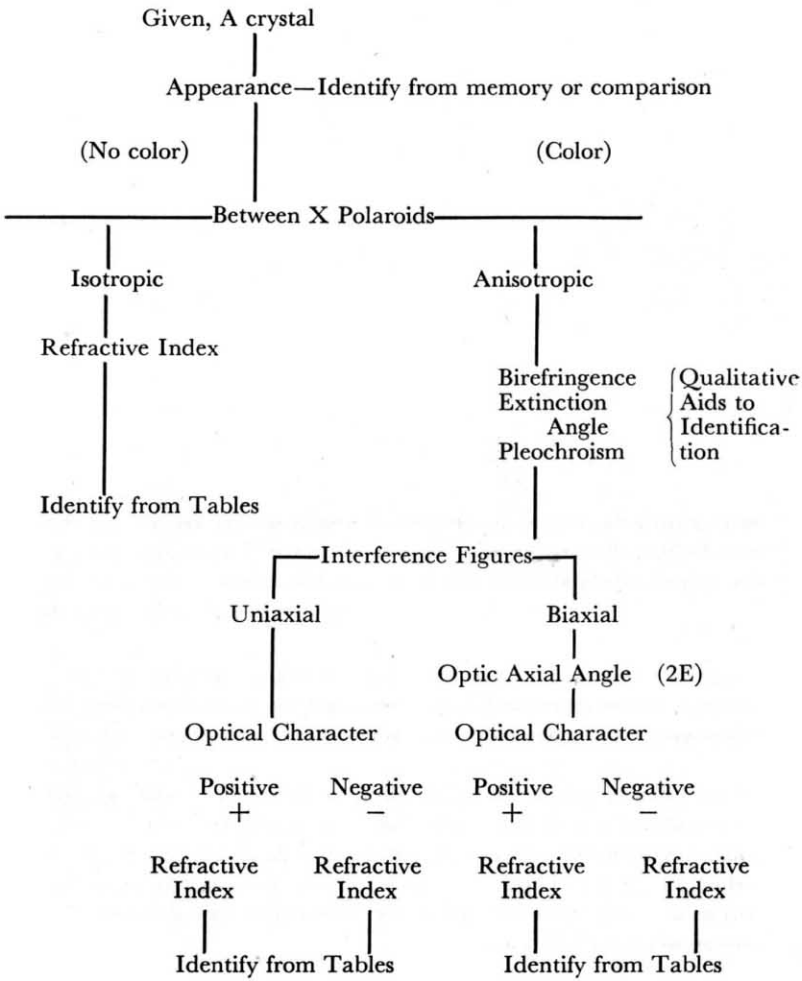
4. "Microscopic Characters of Artificial Minerals"
Alexander Newton Winchell
John Wiley and Sons

One of the more recent books covering a field which has had little attention hitherto. Invaluable to ceramists, workers with abrasives, slags, chemicals, etc. The book includes a valuable chapter by R. C. Emmons, describing the new methods available since the development of the Universal Stage and the Emmons Double Variation equipment.

5. "Handbook of Chemical Microscopy"
E. M. Chamot and C. W. Mason
John Wiley and Sons

A two-volume work. Volume I is of the most interest to users of the polarizing microscope. A very clear text for anyone taking up the study of crystallography from the chemist's viewpoint. Experiments are suggested in the text.

OUTLINE FOR EXAMINING CRYSTALS



Refractive Indices of crystals are Tabulated under these headings:

Isotropic Uniaxial + Uniaxial − Biaxial + Biaxial −

THESE DIRECTIONS or instructions do not presume to cover all details, variations, or changes in this equipment; nor to provide for all possible contingencies to be met in connection with installation or use. We would be glad to help on any problems not covered in this manual.

RESPONSIBILITY FOR DELIVERY: Every shipment of Bausch & Lomb products is in good condition when it leaves the factory. The transportation company, when it accepts the shipment, becomes the consignee's agent and is responsible for safe delivery.

If shipment shows evidence of rough handling, the receiver should have the agent note on the receipt "Received in bad order"; or if "concealed damage" is revealed after unpacking, he should call the representative of the transportation company within 48 hours and have him make out a "Bad order" report. Unless this procedure is followed, the customer loses all right to recovery from the carrier.

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