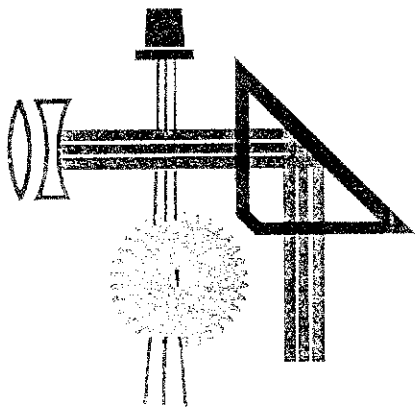
"SHOP"



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Laboratory and Laboratory Research

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MICROSCOPES

INSTRUCTIONS

for monocular, binocular, photomonocular
and photobinocular models:

Catalog No. 31-20-02
31-20-44 to 47
31-20-64
31-20-86 and 87
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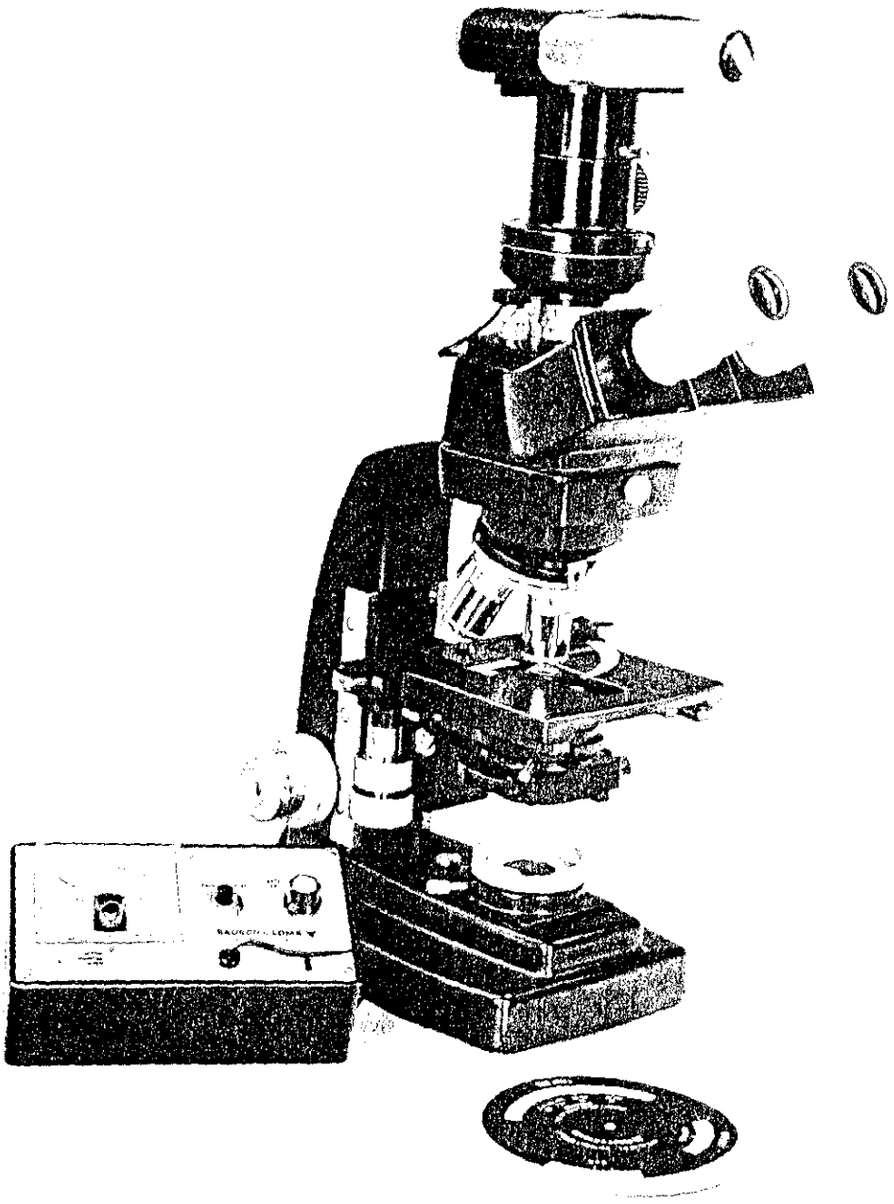


The Bausch & Lomb DynaZoom Research Laboratory Microscope with Accessories

SECTION - 0

TABLE OF CONTENTS

SERVICE

All optical and mechanical equipment requires periodic servicing to keep it performing properly and compensate for normal wear.

Anticipating this need by establishing a schedule of regular preventive maintenance will help to assure long life and sustained optimum performance for your instrument. It will also help to avoid unexpected trouble and the necessity of having the instrument serviced at inconvenient times.

Such a program of planned preventive maintenance involving a thorough cleaning, checking, and adjustment of mechanisms is recommended for all instruments.

This work should only be performed by qualified personnel with the proper training and equipment. Your dealer, or Bausch & Lomb, can arrange this service.

The chart on the following page provides a handy means of recording the service history of your instrument.

IF - unexpected trouble is experienced with your instrument, FIRST - contact your Bausch & Lomb dealer. He may be able to suggest simple remedies to correct the apparent difficulty without having to send the instrument out for servicing.

SHOULD - it become necessary to send your instrument out for service:

PLEASE - pack the instrument carefully in a crush resistant carton with at least three inches of shock absorbing material surrounding it to prevent transit damage. Saving the original carton in which your instrument is received will prove helpful for this purpose. If a suitable carton is not available, one may be ordered from the factory at nominal cost.

INCLUDE - A detailed letter in the shipping carton, preferably fastened to the instrument, describing the trouble experienced. This information will enable the service technician to effect required repairs promptly and at least expense.

NOTE: Please mark on shipping container FIRST CLASS LETTER ENCLOSED. First class postage will only have to be paid on the letter. The carton will be accepted at standard package rates.

SERVICE RECORD

Type of instrument _____
Model _____
Catalog number _____
Serial number _____
Date purchased _____ 19 _____
Purchased from _____
_____
_____ Phone _____

Date serviced	Service Center or technician servicing instrument	Preventive maintenance check up (check)	Other service performed or parts replaced (describe)

INTRODUCTION

The new, improved DynaZoom and Dynoptic series microscopes represent the achievement of a unique group of highly skilled research, design and manufacturing engineers whose goal has been to bring you the finest and most advanced instruments of this type possible. Superior performance, unmatched flexibility and convenience of use result from the many new optical and mechanical design concepts incorporated into these microscopes and the wide range of accessories available for them.

Some of the features of the DynaZoom and Dynoptic Microscopes are:

- A variety of standard and specialized body types which include Monocular, Binocular, Photomonocular and Photobinocular; Double, Triple or Quadruple Nosepieces.

- Achromatic, Apochromatic or Semiapochromatic Objectives as well as the Bausch & Lomb exclusive Flat Field Achromats.

- Wide Field, Compensating or Huygenian Eyepieces.

- Inclined Eyepiece Tubes for comfortable viewing; Dynoptic fixed magnification optical systems or DynaZoom variable magnification optical systems, the latter providing a continuously variable 1X to 2X magnification factor.

The binocular bodies have a self-correcting tubelength feature which maintains constant magnification and parfocality of the instrument regardless of the interpupillary setting. The photographic bodies have an aperture to accept the new 35mm Camera, 3-1/4 X 4-1/4 Polaroid Land Camera Back and 4 X 5 Cameras, as well as a tube for separately supported bellows-type cameras. A prism control knob on the Photobinocular body directs all of the illumination to either the eyepieces or the camera. A photomonocular body is equipped with a beam divider which enables a specimen to be viewed and photographed simultaneously.

The microscope body is rotatable a full 360^{o} in a stand of permanently fixed height. Focusing is achieved with a clutch-protected movable stage on ball bearing slides controlled with low position coaxial coarse and fine adjustment knobs. These are placed on both sides of the instrument. One of the fine adjustment knobs is graduated in microns. The stage is an integral type and is available in several styles: Plain, Glide, Ungraduated Mechanical, Graduated Mechanical and Revolving Circular Stage with built-in mechanical movements. Every stage except the circular stage is available with either a conventional or a centerable substage. The mechanical stages are provided with ball bearing slides and low position concentric controls below the stage.

The circular revolving stage is centerable and rotatable, has a vernier for reading rotation to 6 minutes of arc, and incorporates an integral mechanical stage graduated in single millimeters with verniers reading to 0.1mm. All stages are equipped with slide holders.

Illumination is achieved by a base-mounted interchangeable Mirror, Optilume, or High Intensity Variable Output Illuminators coupled with new improved Abbe condenser systems to supply superior illumination for viewing and for photomicrography.

All optics in the microscope are specially coated to reduce glare and to improve light transmission.

SECTION - 1

UNPACKING AND PREPARING FOR USE

This microscope has been packed to ensure that it reaches you in the best possible condition. Notice that a transparent plastic dust cover for the microscope has been packed with the instructions.

It is recommended that you read this section carefully before removing any of the items or attempting to assemble your microscope. When you have read this section and have finished assembling the instrument, carefully check all packaging material for any small items that may have been overlooked before discarding the cartons.

Remove the microscope stand and stage from its packaging. Remove the taped styrofoam block from above and below the stage slide and remove the tape securing the slide holder assembly (if unit is equipped with the mechanical stage) or the spring clips (if unit is equipped with standard stage). A hexagonal wrench for adjusting the stage and substage stops is included. It is sealed in an envelope which is packed in the accessory carton.

To attach the spring clips onto a standard stage, simply press them into the holes in the stage surface.

NOTE: Daylight filters for certain condensers are packed in an envelope which is packed in the accessory carton.

The illumination system should now be installed in the base of the microscope.

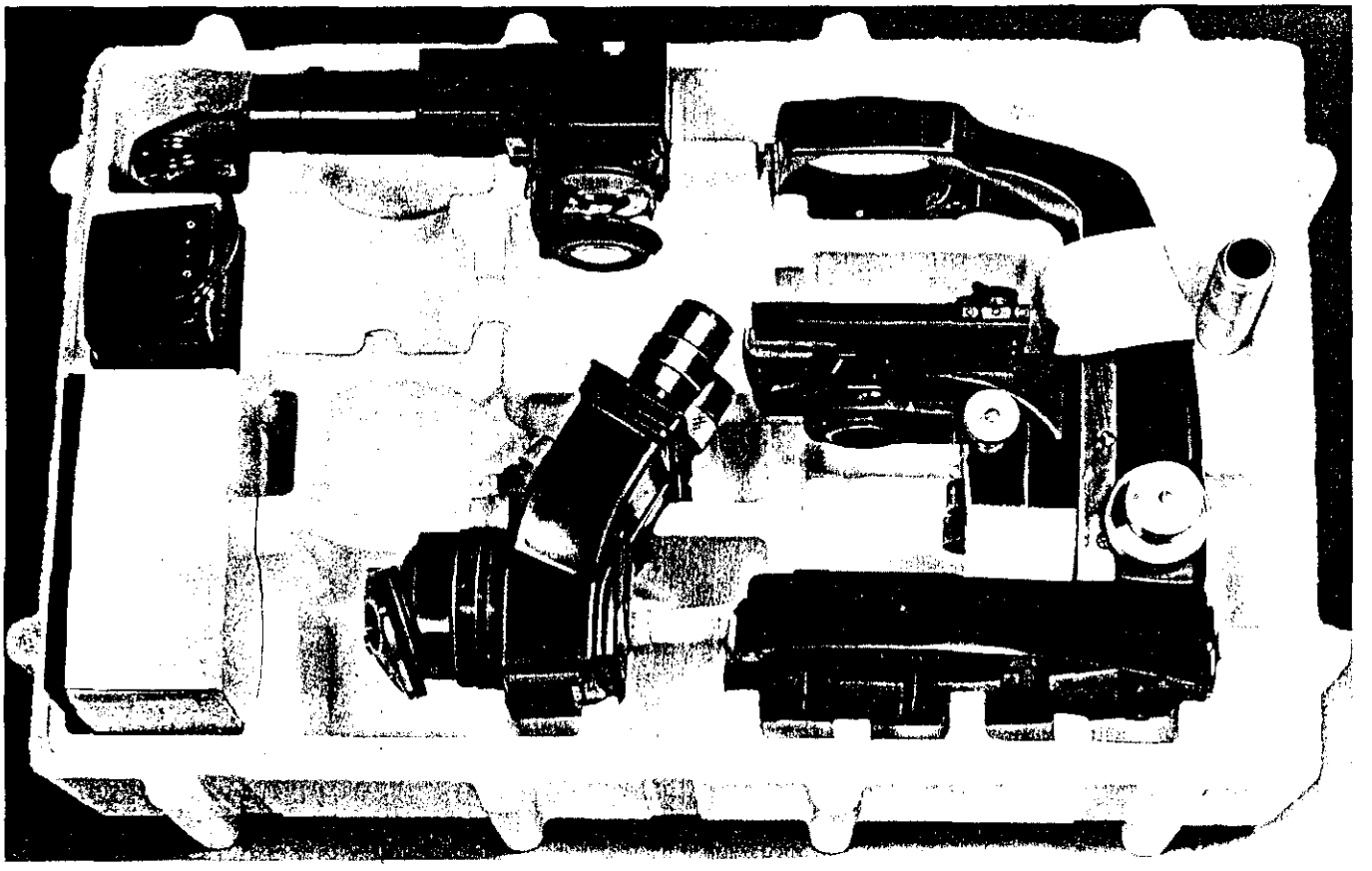


FIG. 1-1 - THE SHIPPING CONTAINER FOR THE MICROSCOPE

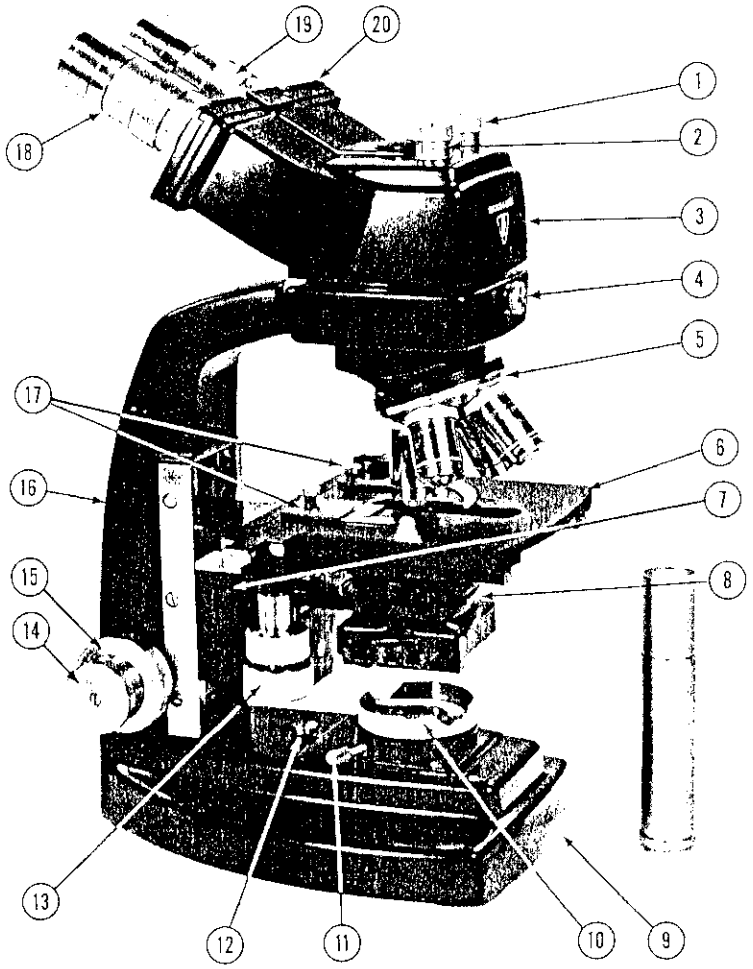


FIG. 1-2 - ASSEMBLED DYNAZOOM MICROSCOPE AND STANDARD NOMENCLATURE

1. Power Change Knob
2. Prism Control Knob
3. Body
4. Clamp Screw
5. Nosepiece
6. Stage
7. Stage Support
8. Aperture Iris Diaphragm
9. Base
10. Field Iris Diaphragm
11. Field Diaphragm Centering Screw
12. Spring Catch
13. Stage Control Knob
14. Fine Focus Adjustment
15. Coarse Focus Adjustment
16. Arm
17. Slide Holder Assembly (Right and Left)
18. Eyepiece
19. Knurled Collar (For Acuity Adjustment)
20. Knurled Ridges (For Interpupiliary Adjustment)

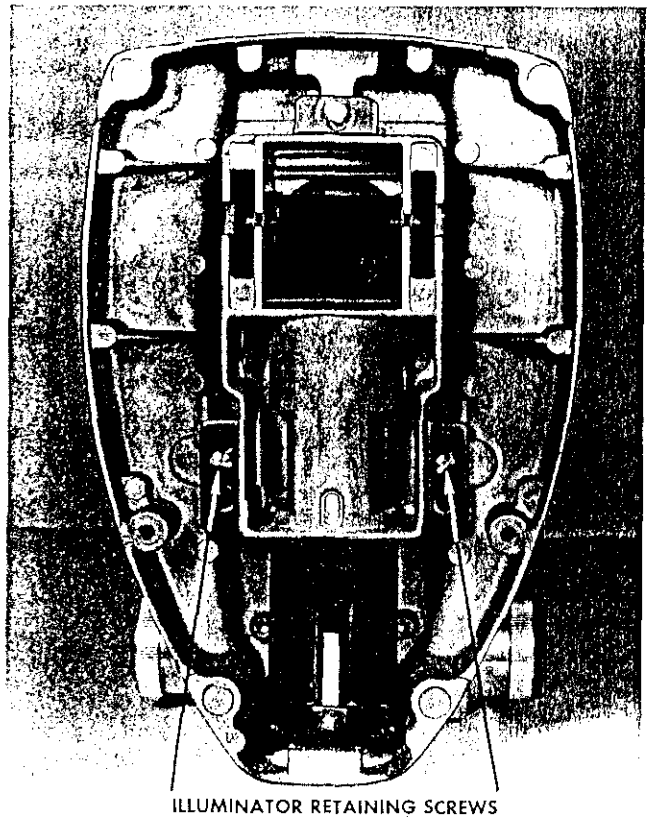


FIG. 1-3 - INSTALLING THE BASE ILLUMINATOR

Ordinarily, one of the following is shipped with the microscope: A Hi-Intensity base illuminator, an Optilume Illuminator, or a mirror with its mount. Remove the illuminator unit from container and check the packaging for additional small parts.

Before installation, remove the lamp and cord assembly from the illuminator housing by pulling outward. Remove the two knurled diaphragm centering screws, Fig. 1-2.

The base illuminator is installed in the following manner: Remove the plastic snap plug from the rear of the base. Tip the microscope on its back so that the underside of the base is exposed. Insert the rectangular raised section of the illuminator into the opening in the base, sliding back the spring catch, Fig. 1-2, to allow the housing to seat. Install the three screws found in the envelope packed with the lamp to secure the illuminator to the base, Fig. 1-3. Now stand the base upright. Replace the knurled centering screws, and reinsert the lamp housing into the illuminator through the rear of the base. (The plastic snap plug is not utilized with the base illuminator.) For proper adjustment of the lamp, see Section 8 on Illuminators.

The Optilume is an inexpensive illuminator with sufficient intensity for visual work which may be attached to the base, Fig. 1-4, or placed on the work table for use with the mirror. To attach the Optilume to the base, first remove the plastic snap plug at the rear of the base. Then thread the cord through the rear hole in the base. Reinsert the plastic snap plug so the cord runs through the notch in the plug. Insert the Optilume into the rectangular opening by tilting the switch end upward. Engage the front tab in the edge of the base opening and hold back the spring catch, Fig. 1-2. When the unit is properly seated, release the spring catch to secure the illuminator. Pull a convenient length of cord through the rear notch.

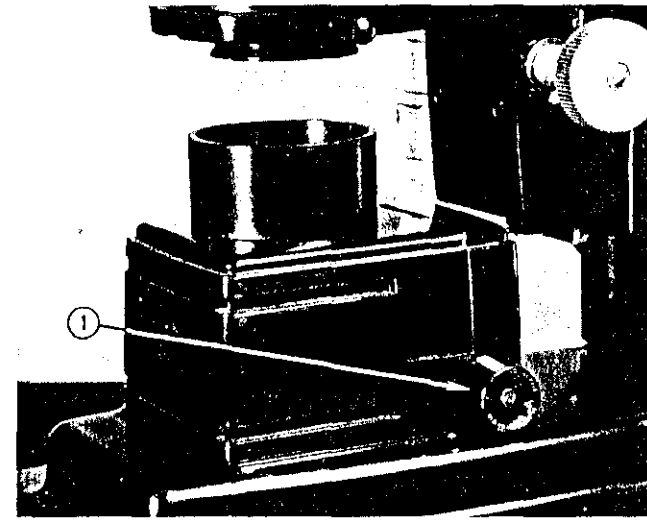


FIG. 1-4 - INSTALLING THE OPTILUME

The mirror and mount are attached to the base by engaging the small lip on the mount with the front of the rectangular hole in the base, sliding back the spring catch, Fig. 1-2, and seating the mount onto the base. Spread the arms of the mount slightly and insert the mirror so the pins on the U-shaped mount drop into the holes in the mirror mount.

If the revolving circular graduated mechanical stage, Cat. No. 31-59-08 was ordered

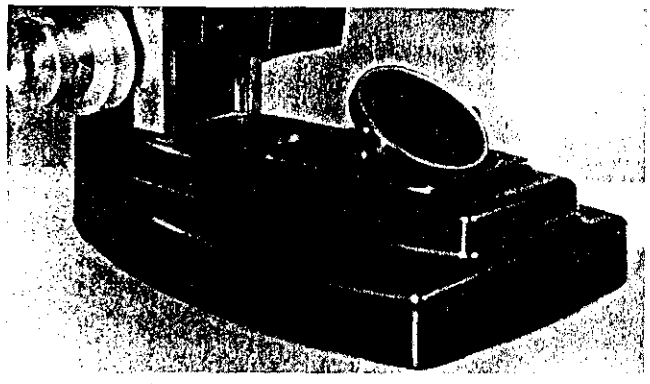


FIG. 1-5 - INSTALLING THE MIRROR

for your microscope, it will be packed separately and should be installed at this time.

To install it:

1. First, familiarize yourself with the nomenclature of the revolving circular stage, Fig. 1-6.

2. Align the 0 mark on the 360° circular scale with the 0 mark on the circular vernier. Secure the 360° circular scale and the circular vernier in this orientation by tightening the clamp screw on the vernier.

3. Back out the two stage centering screws until their ends no longer protrude within the inner circumference of the circular stage support. (The stage centering screws are a part of the stage support which has already been attached to the microscope stand at the factory.)

4. Check that the knurled head of the stage lock cap (also attached to the stage support) is turned out clockwise as far as it will go.

   NOTE: At the end of the lock cap assembly is a spring loaded pin which will remain in place as the cap advances and retracts.

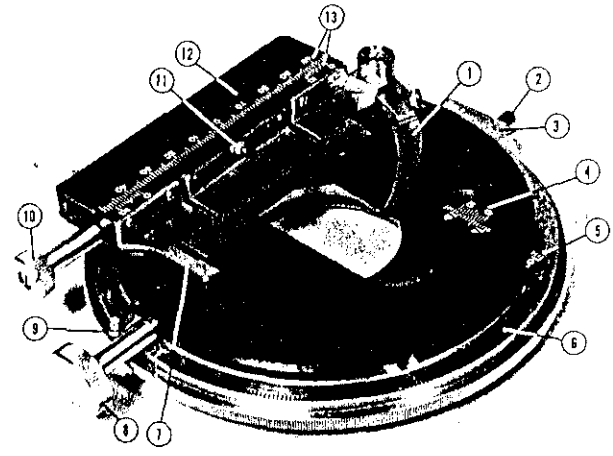
5. Turn the stage upside down, and note the small bullet-shaped slot on the outer circumference of the raised center ring. When the stage is installed on the microscope this detent must engage the spring loaded pin of the lock cap.

This is accomplished as follows:

(a) Orient the microscope stand so that the upright arm is facing away from you.

(b) Hold the stage in an upright position over the stage support and position it so that the circular vernier is at right angles to the microscope base and facing to the right. This will align the bullet-shaped detent with the spring loaded pin of the lock cap.

(c) Holding the stage in this position, fit it into the stage support so that the back portion of the raised center ring (which faces the microscope arm) rests in the bottom of the depressed circular area of the stage support while the front of the raised center ring (facing you) is resting on top of the stage support, outside of the depressed circular area.



1. Metal Finger
2. Rotation Clamp Screw
3. Circular Stage Vernier
4. North-South Vernier
5. North-South Scale
6. 360° Revolving Circular Scale
7. Slide Retainer
8. North-South Knob
9. North-South Clamp
10. East-West Knob
11. Plate Screw
12. East-West Motion Assembly
13. East-West Scale & Vernier

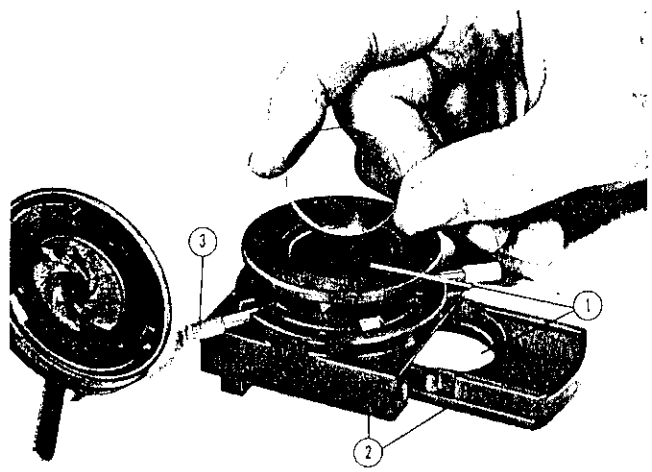
FIG. 1-6 - THE REVOLVING CIRCULAR STAGE

(d) Now, push the stage inward toward the microscope arm with slight pressure. It should drop into the proper location in the stage support.

(e) To check that the stage is properly seated, turn the two centering screws and lock cap inward until a slight resistance is felt. Grasp the circular vernier and gently attempt to rotate the stage in either direction. If it is seated properly, it should not rotate, although it may shift slightly as the spring loaded pin gives under the pressure applied. If the pin and detent have not been correctly aligned, this slight shifting action will cause them to engage with a "click" sound.

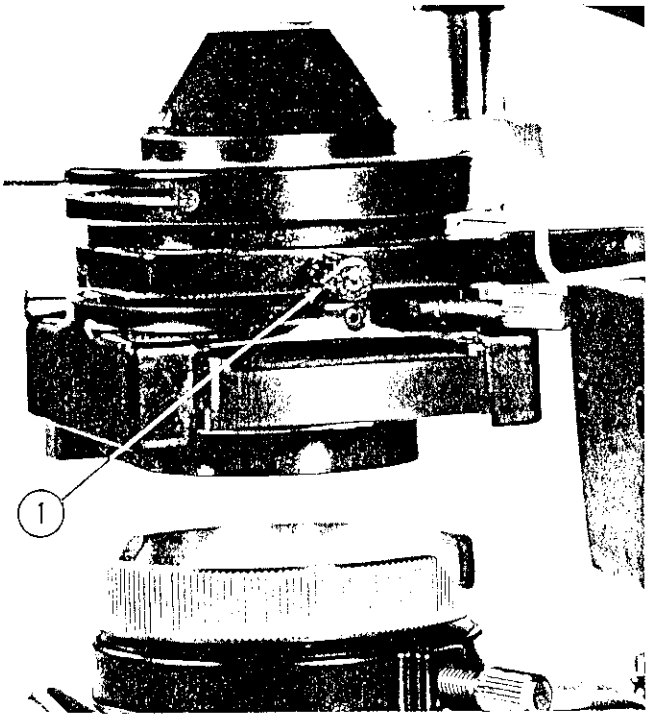
6. After the stage is seated properly, tighten the two centering screws and lock cap to secure the stage in position until ready for centering. See Page 5-2 for centering procedure. When these three have been tightened, carefully try to lift the stage to be sure it is locked in place.

The substage Abbe condenser, Cat. No. 31-58-07 is a factory-installed item. The condenser and slide-in-lens, Cat. No. 31-58-82, and the auxiliary lens, Cat. No. 31-58-27 will be found packed in the accessory carton and should now be attached to the Abbe condenser. The auxiliary lens is



1. Filter Recess
2. Slide-In Lens Assembly
3. Knurled Screw

FIG. 1-7 - INSERTING FILTER



1. Clamp Screw

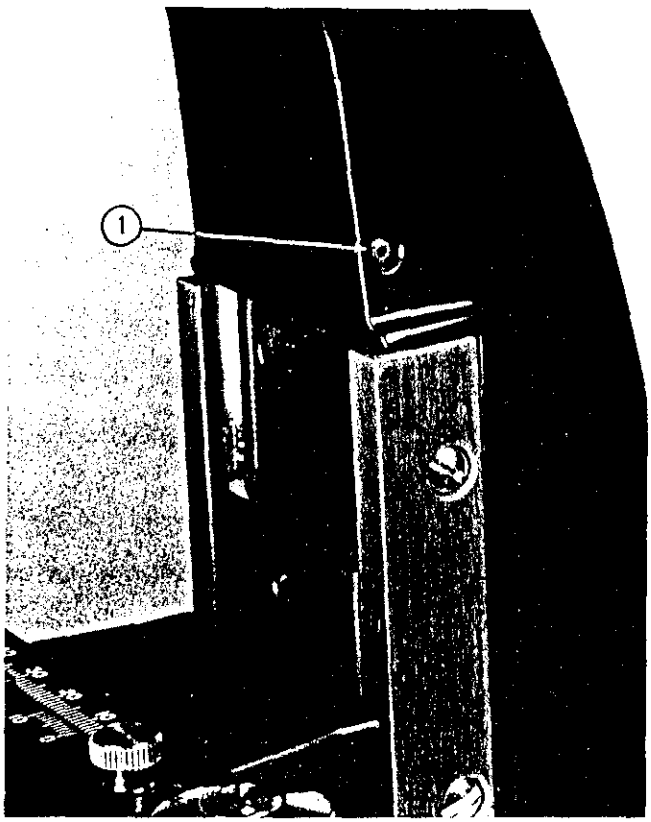
FIG. 1-8 - ABBE CONDENSER INSTALLED

installed by placing the locating pin on the lens into the small slot provided in the slide assembly and tightening the mounting screw.

Raise the substage with Abbe condenser to its maximum height and attach the lens to the Abbe with the two knurled screws on the upper part of the assembly, Fig. 1-7. See Fig. 1-8 for the complete installation. The slide portion of the slide and condenser assembly should be oriented so that the slide motion is either parallel or perpendicular to the plane of symmetry of the arm. (The Cat. No. 31-58-80 auxiliary lens attaches to the 31-58-07 in the same manner, using the two clamping screws on the lens mount).

The eyepieces for the Dynoptic microscope are also packed in the accessory carton.

NOTE: The Flat Field bodies are shipped with the objectives packaged separately in plastic containers in the accessory carton. Rubber protector plugs have been inserted in the objective receptacles of the nosepiece. Remove these plugs and insert the 4X, 10X and 40X objectives in



1. Stage Stop Lock Screw

FIG. 1-9 - STAGE STOP ADJUSTMENT

their proper locations by matching the color bands of the objective to the similarly colored dots on the rim of the nosepiece. Do not insert the 100X objective until the microscope body is placed in position on the stand.

The final step in this assembly is to attach the body of the microscope to the arm. Lower the stage to the lowest position making sure the substage is racked all the way up, and loosen the clamp screw, Fig. 1-2, on the arm enough to permit the body to be placed in position. Tighten this screw firmly, but do not force it. Insert the 100X objective.

POSITIONING THE STAGE

Place a glass slide with a cover slip on top in position on the stage below the objective. Cover the top surface with a thin piece of paper such as lens tissue. Rotate the nosepiece until the highest power objective is in viewing position. Next, raise the stage to a position that allows the paper-covered slide to contact the objective. Loosen the stage stop lock screw, Fig. 1-9, with the hexagonal wrench supplied to release the stage stop. Tap the rear of the arm to insure that the stage stop is in contact with the slide and retighten the lock screw.

Remove the eyepiece(s) from their plastic containers and insert them into the eyepiece tubes. Plug the line cord from the light source into a 120V, 60 Hz AC outlet (or to an outlet appropriate for export models). Your microscope is now ready to operate.

SECTION - 2

OPERATING PROCEDURE

The following description will assist you in achieving maximum performance from your microscope. If you have acquired more than one set of eyepieces, or if other compatible eyepieces are available, select the eyepiece which has the lowest magnification and insert it into the eyepiece tube. Rotate the nosepiece until the lowest power objective is in viewing position. Place a specimen slide on the stage, manipulating the specimen to the approximate center of the stage aperture. Turn on the light source.

FOCUSING

Look into the eyepiece(s) and focus the stage up or down with the coarse focusing adjustment, Fig. 1-2, until an image of the specimen is seen. The fine focusing adjustment knob, Fig. 1-2, should now be used to obtain the sharpest focus possible. Clean the optical surfaces regularly. (See CLEANING THE OPTICS, Section 14),

Having located an area of interest on the specimen and focusing on it sharply, you may now swing a higher power objective (on the nosepiece) into place, since all the objectives are parfocal. (Exceptions to this rule are the 40mm and the 32mm low power objectives supplied as optional accessories. When using these two, it is necessary to refocus when shifting to higher powers.)

If you desire still higher power, you may insert higher power eyepieces, or if your microscope has the zoom feature, power may be increased by turning the zoom control. Refer to BODY TYPES, Section 3.

The microscope has a safety clutch action at the limit of the focusing motion. Should it be inadvertently focused too close so that the objective contacts the cover glass, this feature will prevent serious damage to the objective and slide preparation. Refer to Section 14, SAFETY CLUTCH ADJUSTMENT, for instructions on the proper adjustment of this mechanism.

FIELD ILLUMINATION CONTROL

Some base illuminators have an integral field iris diaphragm, Fig. 1-2, which requires centration for optimum performance. To center this diaphragm, rotate the nosepiece until the 10X objective is in viewing position, and focus on the specimen. Make sure that the slide-in lens is removed from the optical path. Close the field iris diaphragm to the half-open position by rotating the knurled mount. Vary the condenser height until the sharpest possible image of the field iris diaphragm is formed on the specimen. It will be unnecessary to vary the condenser height for the other objectives so long as you continue to observe specimen slides of the same thickness.

Now proceed to open the field iris diaphragm until its image is barely visible in the field of view. Center the image by manipulating the two knurled diaphragm centering screws, Fig. 1-2. For best results, the field iris diaphragm should be recentered each time a different objective is used. The opening of the field iris diaphragm should be adjusted to the point where its image is just out of the field of view, regardless of which objective is in use. Under these conditions, your microscope will be functioning in accordance with the Kohler illumination principles.

If your microscope is equipped with a 1.30 N.A. Abbe condenser, Cat. No. 31-58-07, the auxiliary lens and slide-in lens assembly, Cat. No. 31-58-82 is recommended for filling the field of the 3.5X or 4X objective. The field iris diaphragm should be opened fully, and the sliding lens should be placed in the operating position by pulling the slide. It is not possible to focus the image of the field

iris diaphragm in this instance, nor is it strictly necessary, since only a slight departure from the Kohler conditions is effected, not enough to affect performance at such a low magnification. The low power condenser must be pushed out of the viewing position when observations are to be made with higher power objectives.

APERTURE ILLUMINATION CONTROL

The aperture iris diaphragm, Fig. 1-2, is the principal control at your disposal for modifying the image quality in the microscope. Opening and closing this iris changes the angle of the cone of illumination entering the objective. This modifies contrast, resolving power and depth of focus. Accordingly, it is of fundamental importance that its proper use be clearly understood.

If the iris is closed all the way down, contrast and depth of focus are generally at a maximum, but resolving power and brightness are at a minimum. As the iris is opened, contrast and depth of focus decrease, but resolving power and brightness increase. Since clarity of seeing is dependent on all of these factors, it is apparent that one should set the aperture iris for the best compromise possible.

The use of the iris to control brightness, however, is not the best solution to the problem. Other means, such as voltage control or filters, should be used instead. Using the iris to control brightness will impair its effectiveness in controlling contrast, resolving power and depth of focus since the aperture selected for desired brightness may not be the setting necessary to optimize the other factors.

This aperture diaphragm should not be opened wider than is sufficient to fill the objective with light (tested by looking at the back lens after removing eyepiece), and generally it is advisable to start with only about two-thirds of the back lens of the objective filled with light. From this starting point, open and close the diaphragm until the best compromise is obtained between resolution and contrast.

In the examination of most microscopic preparations, the problem is to differentiate low contrast structure which is difficult to see, because its color or opacity differs so little from its surroundings, rather than to observe detail at the limit of resolution of the objective. The skillful use of the aperture diaphragm will be extremely helpful in examining such specimens by bringing out the optimum definition in the image. Often different diaphragm settings are required for different types of detail within the same preparation. Experience and study are required to learn the most effective use of the diaphragm.

SUBSTAGES

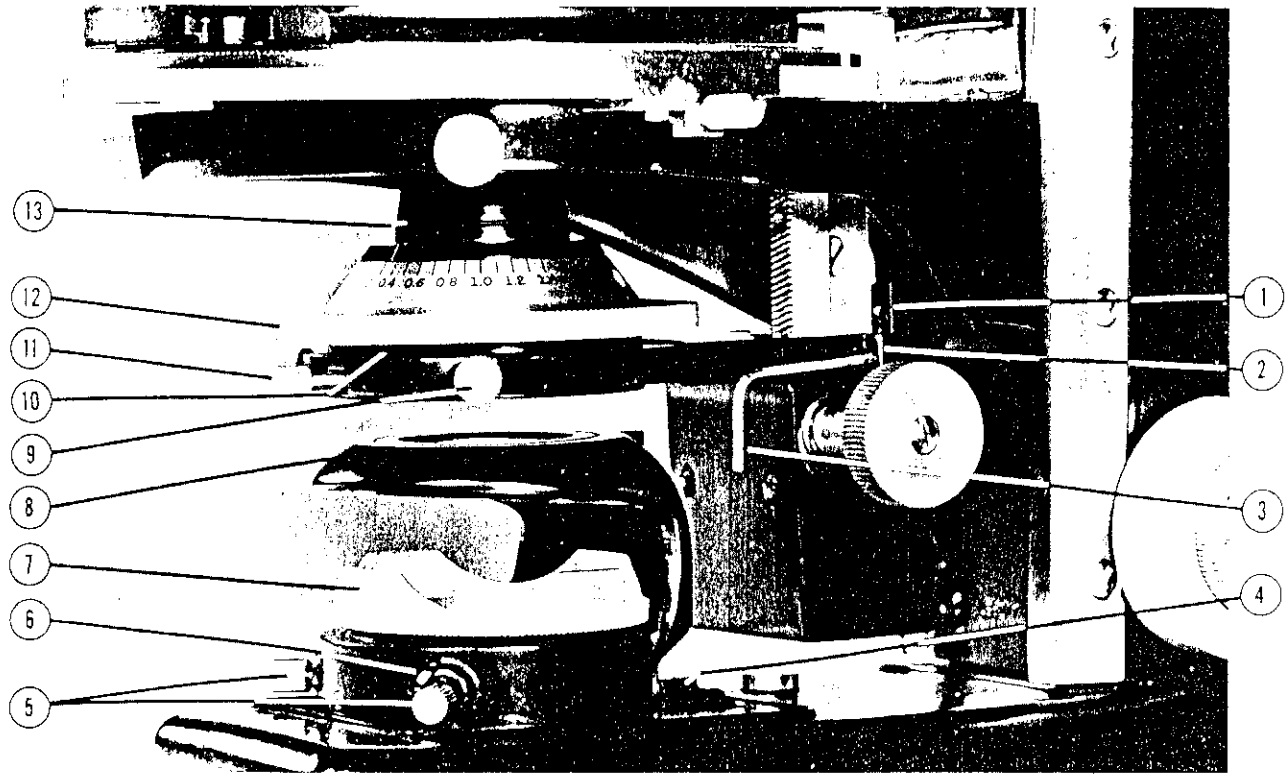
On the stages without rack and pinion focusing, the iris diaphragm, or the focusable condenser with iris diaphragm, are attached to the underside of the stage.

On the stages with rack and pinion substage, two types are available. Both use a dovetail slide for positive, accurate, easy travel. The condensers are securely held in a full 360° mount which can be either fixed or centerable. Both are precentered at the factory.

The centering substage, Fig. 2-1, is available for those who wish to do critical photomicrography or other work requiring precise centering of the substage condenser. To make critical adjustments with this substage, remove the eyepiece and replace it with a pinhole eyecap. If a pinhole eyecap is not available, remove the eyepiece and hold your eye centered to the eyepiece tube. Look at the rear aperture of the objective, and close down the substage iris until it just cuts into the objective aperture. Center the iris by means of the two knurled-head screws. In most cases when the substage is centered for the lowest power objective to be used, this initial centering will be quite acceptable for all other objectives.

SUBSTAGE FOCUSING STOP

Each rack and pinion substage has an easily adjustable focusing stop, Fig. 2-1. This feature is most advantageous when various



1. Substage Stop
2. Substage Lock Screw
3. Hex Wrench
4. Condenser Focusing Control
5. Field Iris Centering Screws
6. Research Base Illuminator
7. Field Iris Diagram
8. Integral Auxiliary Lens
9. Condenser Centering Screws
10. Centering Substage
11. Clamp Screw
12. Aperture Iris Diagram
13. 1.40 N.A. Achromatic Condenser

FIG. 2-1 - RESEARCH MICROSCOPE SUBSTAGE

types of condensers are to be used on the microscope. The focusing stop should be set so that the condenser in use never rises above the stage surface or contacts the specimen slide. To adjust the stop, loosen the focusing stop lock screw, Fig. 2-1, slightly with the hexagonal wrench provided. Position the condenser at the desired height and retighten the lock screw.

CONDENSER WITH OIL IMMERSION OBJECTIVES

It has often been stated that little is gained in using an oil immersion objective unless the condenser is also oil immersed. This is not so. Experience has shown that the most satisfactory image is the result of a compromise between resolution and contrast, and that this is obtained when the objective is used at approximately 2/3 of its maximum aperture. This condition is almost automatically established when an oil immersion objective is used with a dry condenser. It is therefore common practice to use oil immersion objectives without immersing the condenser. The objective, of course, must always be immersed.

It is true, however, that the objective will be unable to deliver its maximum resolving power unless its back aperture is filled with light, and this condition cannot be satisfied for an oil immersion objective unless the condenser is also oil-contacted to the slide. To accomplish this, place a drop of oil on the top lens of the condenser, place the slide on the stage and then bring up the condenser with the focusing adjustment until contact of

oil and slide is established. The illuminator adjustments described earlier should now be repeated.

THE COVER GLASS

The cover glass, which is normally placed over the specimen, might appear to be a rather insignificant item and little consideration given to it in the preparation of the specimen slide. This, however, is far from true, as the cover glass becomes an integral part of the optical system, especially when dealing with high power dry objectives. All Bausch & Lomb Laboratory Microscope Objectives have been designed to be used with 0.18mm thick, plane-parallel cover glass having a refractive index of N_D 1.522. Variations of only a very few hundredths of a millimeter in thickness from the nominal 0.18mm are sufficient to cause a marked deterioration of image contrast when using the 43X, 0.65 N.A. objective.

The change in aberration correction (spherical aberration, primarily) with respect to cover glass thickness increases exponentially with numerical aperture for dry objectives. At 0.95 N.A. the sensitivity is so great that variations of the order of 0.001mm in cover glass and mounting medium thickness are sufficient to cause an image degradation under the most severe conditions. For this reason, the 0.95 N.A. apochromatic objective is fitted with a correction collar. Rotation of this collar varies the optics of the objective, introducing a compensating amount of aberration, thus providing a corrected image for the combination of mounting medium, cover glass and objective. In practice, one observes the image, rotating the collar and refocusing until the image of highest contrast is obtained. This may best be judged by noting that there will be symmetrical light distribution in the out-of-focus image as the focus is changed slightly both above and below the optimum focus position.

Since the objective will be parfocal with other objectives on the nosepiece when the correction collar is set for use with a 0.18mm thick cover glass, always use cover glasses in this thickness range.

Low power objectives having N.A.'s of 0.25 or less are much less sensitive to cover glass thickness. Oil immersion objectives are also insensitive, because the oil and glass are almost homogeneous in refractive index.

However, oil immersion objectives have a very short working distance (distance from front of the objective to the specimen) and with too thick a cover glass, it will be impossible to focus on the specimen.

Cover glasses are available from any laboratory supply house and are usually sold according to thickness. The usual commercial classifications are Nos. 1, 1-1/2, and 3, the thickness range of each group being:

No. 1	0.13 to 0.17mm thick
No. 1-1/2	0.16 to 0.19mm thick
No. 2	0.17 to 0.25mm thick
No. 3	0.25 to 0.50mm thick

Cover glasses No. 1, 1-1/2, and No. 2 are the ones used most commonly.

Number 1 cover glasses, because of their thickness, are preferable for use with all oil immersion objectives. Number 1-1/2 cover glasses may also be used with these objectives.

The number 2 cover glass is a general purpose glass used for examining specimens under low power dry objectives, the thicker slips in this group being used for the lower powered objectives. The latter are not recommended for any work with high powered objectives.

NOTE: Thickness or depth measurements may be made with the microscope, using the graduations on the fine adjustment knob as a measuring reference. Modern Bausch & Lomb microscopes have graduations for each micron (0.001mm) of vertical travel.

The technique is as follows: Note the amount of vertical motion between focus positions for the two points of interest. An important consideration must be kept in mind if the points whose separation is being determined are separated by a

medium other than air. Due to refraction effects, the points will appear to be closer together than they actually are. The vertical motion will be t/n, where t is the thickness or separation of the points and n is the index of refraction of the medium in which they lie. To obtain the true thickness or separation, the measurement must be multiplied by the index or refraction. As an example, to measure the thickness of a cover glass, mark with ink, two perpendicular lines on opposite faces of the cover glass as focusing references. If the vertical movement between focus positions on the top and bottom surfaces of the cover glass is 115 graduations of the fine adjustment knob, or 0.115mm and, assuming that the index of the cover glass is 1.52 (determined on a refractometer), the true thickness is 0.115 X 1.52 or 0.175mm.

Greatest accuracy will be obtained if the following practices are observed:

1. Use the objective of greatest possible numerical aperture whose working distance is commensurate with the thickness or separation to be measured.

2. When making the measurement move the fine adjustment knob with continuous motion in the same direction to avoid errors due to the small amount of residual backlash which may be present in the focusing mechanism.

SECTION - 3

BODY TYPES

Body types are directly interchangeable on the microscope stand. The bodies are designed for use with flat field achromats or conventional achromats, fluorites and apochromats.

DYNAZOOM BODIES

The DynaZoom bodies may be used with either flat field or conventional microscope objectives, depending on the model of microscope being used. All DynaZoom bodies contain a continuously variable magnification system. A power changer knob mounted on the top is engraved in 0.1X intervals from 1.0 to 2.0 magnification. This lens system permits changing continuously from 1X to 2X without changing eyepieces.

If, for example, you are using a 10X objective and a 10X eyepiece, this zoom lens system enables you to go continuously from 100X to 200X. If the knob reads 1.5X, total magnification with the 10X eyepiece is 150X.

DYNOPTIC BODIES

The Dynoptic (non-zoom) body is a microscope body designed for use with either flat field or conventional microscope objectives, depending on the model.

STRAIGHT AND INCLINED BODY FEATURES

Bausch & Lomb microscopes are made to accommodate both straight and inclined bodies which are designed to be used with either flat field or conventional microscope objectives, depending on the model.

BODIES DESIGNED FOR PHOTOMICROGRAPHIC USE

Bausch & Lomb microscope bodies are available with a provision for performing photomicrographic work in both the inclined monocular and inclined binocular models.

BODY CAPABILITIES AND USE

The microscope bodies are rotatable through a full 360°. Nosepieces rotate with the body, leaving an unobstructed view of the stage and specimen for any body orientation. A clamp screw, Fig. 1-2, permits locking the body at any point in its 360° rotation.

To set the binocular body for the proper interpupilliary distance, grasp the straight knurled ridges, Fig. 1-2, on the eyepiece slider at the base of the eyepiece tubes and slide the eyepieces apart to the desired distance as indicated on the interpupillary scale. In the event that you do not know your own interpupillary distance setting, move the eyepieces together or apart until you are seeing the full field of view with both eyes. Check this by closing one eye and then the other without moving the head. After you have found the proper setting, record and remember it for future use.

As you adjust the interpupillary distance, the eyepieces automatically focus in and out to compensate. This keeps the tube length constant for optimum image quality. Furthermore, it holds magnification constant so that measuring eyepieces that have been calibrated remain in calibration for all interpupillary distances. Also, it maintains strict parfocality among the objectives on a multiply nosepiece.

The left eyepiece tube is individually focusable by means of the knurled collar, Fig. 1-2, so that equally sharp images on both the left and right side may be attained. To set them for your eyes, it is recommended that you use the lowest power objective since the setting is most sensitive in this case. Focus the microscope using the

fine adjustment until the right image appears sharp to your right eye. Then, without changing the fine adjustment, focus the left eyepiece until the image appears sharp to your left eye. The microscope is now adjusted properly for your eyes.

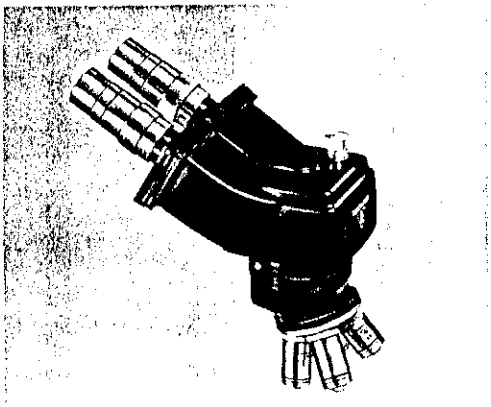
Those models intended for photomicrographic use (except for the Cat. No. 31-19-41) have a movable prism which directs all of the illumination to either the vertical tube for photomicrography or the inclined eyepieces for visual observation. It may be used optionally with external or attachable cameras, as described under PHOTOMICROGRAPHY, Section 13. To switch from visual to camera use, give the prism control knob a partial turn until it comes to a positive stop. This transfers all of the illumination from the visual inclined eyepieces to the vertical photographic tube.

The 31-19-41 body contains a special beam-dividing prism which directs about 10% of the light to the 60° inclined eyepiece and transmits the other 90% directly upward to the vertical camera tube.

The constant tube length of the binocular eyepiece system assures parfocality between visual and photographic images when either of the four attachable cameras, properly adjusted, are used. For further information on the photomicrographic use of any body, refer to Section 13, on PHOTOMICROGRAPHY.

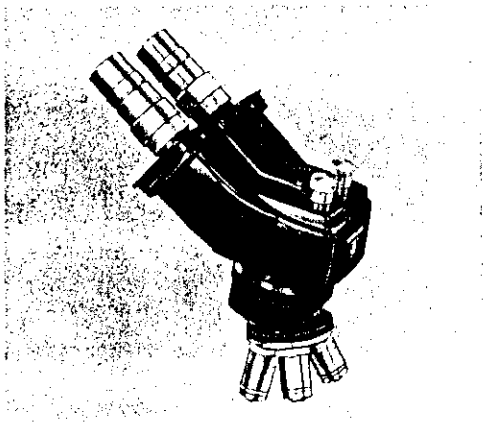
THE MICROSCOPE BODY TYPES

The DynaZoom Flat Field Binocular, Cat. No. 31-18-02



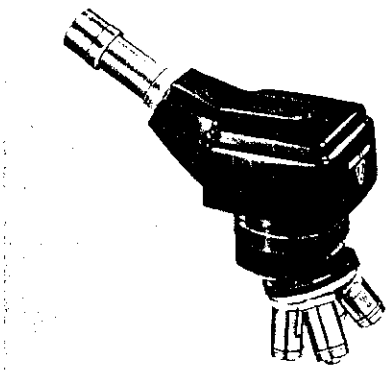
** FIG. 3-2

The DynaZoom Flat Field Photo Binocular, Cat. No. 31-18-03



** FIG. 3-3

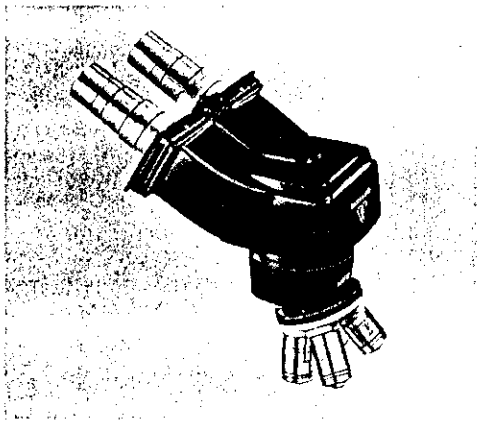
Dynoptic Flat Field Inclined Monocular, Cat. No. 31-18-11



** FIG. 3-4

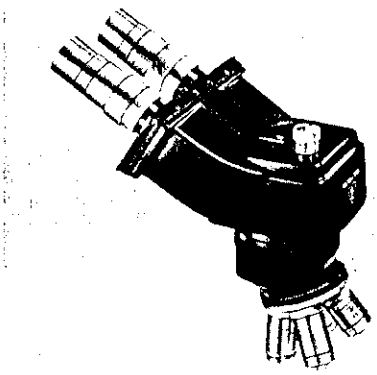
* Eyepieces inclined at 45° from vertical.
** Eyepieces inclined at 60° from vertical.

The Dynoptic Flat Field Binocular, Cat. No. 31-18-12



** FIG. 3-5

The Dynoptic Flat Field Photo Binocular, Cat. No. 31-18-13



** FIG. 3-6

Dynoptic Vertical Monocular, Cat. No. 31-19-43

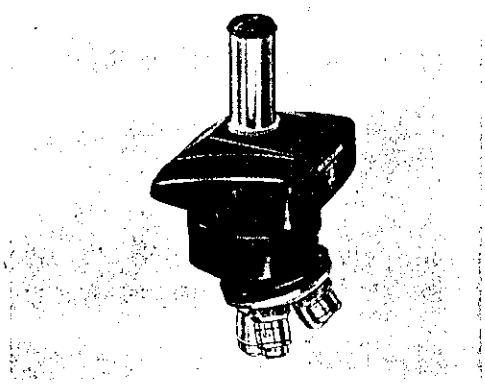
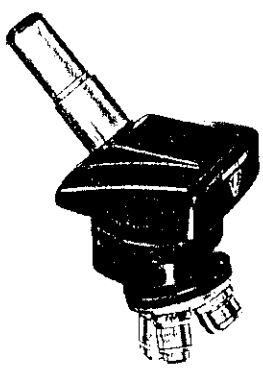


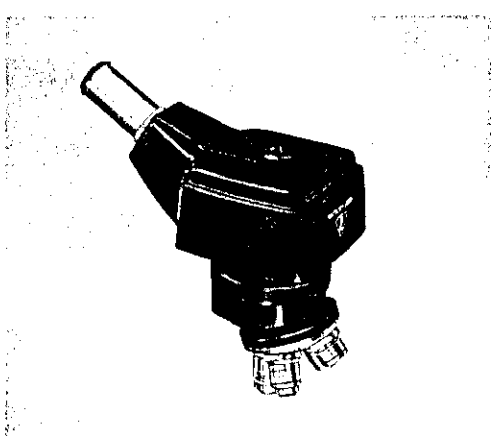
FIG. 3-7

Dynoptic Inclined Monocular, Cat. No. 31-19-42



* FIG. 3-8

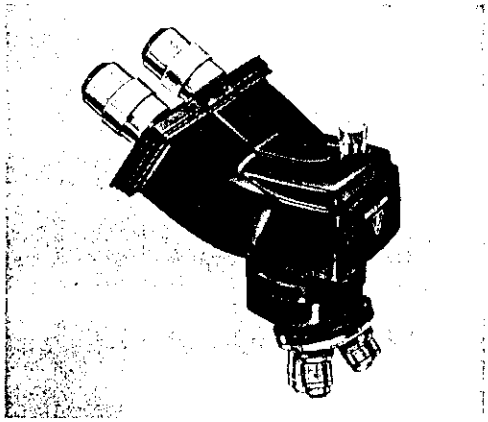
Dynoptic Inclined Photo Monocular Cat. No. 31-19-41



** FIG. 3-10

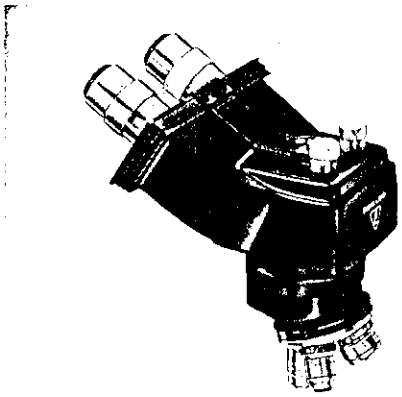
* Eyepieces inclined at 45^{0} from vertical.
** Eyepieces inclined at 60^{0} from vertical.

DynaZoom Binocular,
Cat. No. 31-19-39



** FIG. 3-11

DynaZoom Photo Binocular,
Cat. No. 31-19-59



** FIG. 3-12

** Eyepieces inclined at 60° from vertical.

SECTION - 4

OBJECTIVES AND EYEPIECES

This section describes the types of objectives and eyepieces available for DynaZoom and Dynoptic Laboratory and Lab Research microscopes and lists various optimum equipment combinations.*

OBJECTIVES

There are four basic types of objectives available for use with Bausch & Lomb Dyna-Zoom and Dynoptic Laboratory and Lab Research Microscopes. They are:

- Standard Achromats
- Fluorite (Semi-apochromats)
- Apochromats
- Flat Field Achromats

The first three types reflect a progressive improvement in their degree of color correction and the ratio of their numerical aperture to magnification. The fourth type, the flat field achromats are similar to the standard achromats in color correction and numerical aperture characteristics, but differ in their improved correction for curvature of field, which makes it possible for the entire field of view to be seen in sharp focus at one time.

A comprehensive discussion of objectives as well as other components of the microscope will be found in the booklet, "The Theory of the Microscope", which accompanies this manual.

*With today's modern microscope, which achieves superior performance by means of complex integrated optical systems, the selection of such optimum objective and eyepiece combinations have become critical. Certain types of objectives are designed for use only with certain types of eyepieces. And, in turn, these compatible combinations must be used only with certain types of microscope bodies. These bodies contain complementary optical elements necessary for the proper functioning of the complete optical system of which they are a part.

Accordingly, when selecting an objective and eyepiece for use in a particular application, it is important to select them according to the complete optical system to which they belong. The right objective and eyepiece must be mounted on the right body.

MEASURING WITH THE MICROSCOPE

Eyepieces fitted with micrometer discs are known as micrometer eyepieces, and are used for measuring the linear dimensions of microscopic objects. Micrometer discs are glass plates of a diameter which permits introducing them into standard eyepieces. They can be purchased separately or come already installed in the Bausch & Lomb eyepiece. The first type should be placed on the eyepiece diaphragm with the scale downwards. The second type is available in two forms, in one the plate is fixed in position and in the other it is movable laterally by means of a screw.

Before measurements can be made with any eyepiece micrometer disc it must be calibrated for the particular objective, eyepiece, and tube length employed.

This consists of determining the magnification factor, or the value of a division on the eyepiece scale of a known dimension, shown magnified in the field of view. For this purpose, a stage micrometer is required. This is usually a glass slide carrying a scale of known intervals.

The first step is to focus the stage micrometer scale. They set the stage micrometer so that one line on it coincides with a line to left center of the eyepiece scale. Count across the eyepiece scale to the right from this point to another point where a line of the eyepiece scale coincides with a line on the stage micrometer scale. If no lines coincide within the range of the eyepiece scale, estimate the fraction of a division marked by a line on one scale by the other.

OBJECTIVE TYPES	BODY	EYEPIECE		
Flat Field Achromats	Dyna Zoom (Variable Power) Flat Field	5X	10X	10X Widefield
		——	——	31-05-22 Comp. W.F.
	Dynoptic (Fixed Power) Flat Field	——	31-05-24 Huygenian	31-05-23 W.F.
Apochromats Fluorites	Dyna Zoom (Variable Power) Conventional	31-05-70 Compensating	31-05-75 Compensating	31-05-22 Comp. W.F.
Low Power Achromats (10X and below)	Dynoptic (Fixed Power) Conventional	31-05-03 Huygenian	31-15-09 Huygenian	31-05-60 W.F.
	Dyna Zoom (Variable Power) Conventional	31-15-08 Huygenian	31-15-09 Huygenian	31-05-60 W.F.
Med. Power Achromats (21X – 60X)	Dyna Zoom (Variable Power) Conventional	31-05-40 Hyperplane	31-05-44 Hyperplane	31-05-22 Comp. W.F.
High Power Achromats (97X)		31-05-70 Compensating	31-05-75 Compensating	31-05-22 Comp. W.F.

TABLE OF RECOMMENDED OBJECTIVE–BODY–EYEPIECE COMBINATIONS FOR OPTIMUM RESULTS

FIG. 4-1

Magnification Factor Method

When both stage micrometer and eyepiece micrometer are graduated in the same system, it is very easy to determine the number of times an object is magnified by the objective and field lens of the eyepiece when focused in the plane of the eyepiece micrometer disc. Therefore, the size of any object as shown on the eyepiece scale will be that dimension divided by the magnification factor. To determine the magnification factor, divide the dimension subtended in the eyepiece scale by the actual dimension on the stage micrometer scale included. Thus, if 0.1mm on the stage covers 1.86mm on the eyepiece scale, the magnification factor is 18.6 (1.86 ÷ 0.1 = 18.6). If an object subtends 0.25mm in the eyepiece, its actual size is 0.25mm ÷ 18.6 = 0.0134mm.

Eyepiece Scale Value Method

If the value of the eyepiece micrometer scale is not known, this method is more convenient. In this case one simply determines the number of divisions in the eyepiece scale subtended by a known value on the stage micrometer when in focus.

To determine the value of one eyepiece scale interval, simply divide the value of the stage micrometer interval by the number of eyepiece scale intervals which it subtends in the image.

For example, 0.1mm on the stage micrometer scale covers 18.6 divisions in the eyepiece scale. Therefore, one division of the eyepiece scale equals 0.1mm ÷ 18.6 div. or 0.00537mm/div. The size of an object subtending 2.5 divisions in the eyepiece will be 2.5 div. ÷ 0.00537mm/div. = 0.0134mm.

In calibrating the instrument and in making measurements, it is important that the object and the eyepiece micrometer scale appear to lie exactly in the same plane. This can be brought about by giving careful attention to focusing.

Magnifications and Real Fields

ACHROMATIC AND FLUORITE OBJECTIVES—HUYGENIAN EYEPIECES

Microscope Tube Length 160mm ***Image Distance 250mm*** ***Real Fields in mm***

OBJECTIVES		EYEPIECES						
Cat. No. Working Distance	Magnification Numerical Aper.	5×	6.4×	7.5×	10×	Micrometer Value* with 10× Eyepiece	12.5×	15×
31-10-05 Achro. 59.0mm	2X 0.08	10× 10.2	12.8× 9.6	15× 9.2	20× 7.8	0.076mm	25× 6.9	30× 5.65
31-10-07 Achro. 43.5mm •	2.6X 0.08	13× 8.0	16.6× 7.25	19.5× 7.1	26× 5.9	0.058mm	32.5× 5.25	39× 4.25
31-10-06 Achro. 17.8mm	3.5X 0.09	17.5× 5.9	22× 5.4	26× 5.2	35× 4.3	0.044mm	44× 3.9	52× 3.4
31-10-09 Achro. 38.0mm	4X 0.10	20× 5.25	25.6× 4.80	30× 4.63	40× 3.87	0.038mm	50× 3.43	60× 2.82
31-10-18 Achro. 15.5mm	6X 0.17	30× 3.48	38.4× 3.20	45× 3.08	60× 2.56	0.024mm	75× 2.26	90× 1.87
31-10-17 Achro. 7.7mm	10X 0.25	50× 2.05	64× 1.90	75× 1.80	100× 1.50	0.0149mm	125× 1.33	150× 1.10
31-10-27 Achro. 1.6mm	21X 0.50	105× 1.01	134× 0.93	157× 0.89	210× 0.74	0.0072mm	262× 0.65	315× 0.55
31-10-59-02 Flour. 0.27**	40X 1.00	200× 0.51	256× 0.47	300× 0.45	400× 0.37	0.0037mm	500× 0.33	600× 0.27
31-10-26 Achro. 0.6mm	43X 0.65	215× 0.48	275× 0.44	322× 0.42	430× 0.35	0.0034mm	537× 0.31	645× 0.26
31-10-31 Achro. 0.3mm	45X 0.85	225× 0.47	288× 0.43	337× 0.41	450× 0.35	0.0034mm	562× 0.31	675× 0.26
31-10-35 Achro. 0.2mm	60X 0.85	300× 0.35	384× 0.32	450× 0.30	600× 0.25	0.0025mm	750× 0.225	900× 0.185
31-10-69 Achro. 0.13	97X 1.25	485× 0.205	620× 0.19	727× 0.18	970× 0.15	0.0015mm	1212× 0.135	1455× 0.11
31-10-73-02 Flour. 0.13mm	98X 1.30	490× 0.21	627× 0.19	735× 0.18	980× 0.15	0.0015mm	1225× 0.14	1470× 0.11

* Value in plane of specimen corresponding to 0.1mm in plane of eyepiece diaphragm using 31-15-09 Eyepiece

** Up to 1.5mm on special order

FIG. 4-2

Magnifications and Real Fields (Cont.)

ACHROMATIC AND FLUORITE OBJECTIVES—HYPERPLANE EYEPIECES

Microscope Tube Length 160mm ***Image Distance 250mm*** ***Real Fields in mm***

OBJECTIVES		EYEPIECES						
Cat. No. Working Distance	Magnification Numerical Aper.	5×	7.5×	10×	Micrometer Value* with 10× Eyepiece	12.5×	15×	20×
31-10-17 Achro.. 7.7mm	10X 0.25	50× 2.05	75× 1.90	100× 1.60	0.0127mm	125× 1.33	150× 1.20	200× 0.85
31-10-27 Achro. 1.6mm	21X 0.50	105× 1.00	157× 0.93	210× 0.79	0.0063mm	262× 0.65	315× 0.60	420× 0.43
31-10-59-02 Flour. 0.27mm**	40X 1.00	200× 0.50	300× 0.47	400× 0.40	0.0032mm	500× 0.33	600× 0.29	800× 0.21
31-10-26 Achro. 0.6mm	43X 0.65	215× 0.47	322× 0.44	430× 0.38	0.0030mm	537× 0.31	645× 0.28	860× 0.20
31-10-31 Achro. 0.3mm	45X 0.85	225× 0.47	337× 0.44	450× 0.38	0.0030mm	562× 0.31	675× 0.28	900× 0.20
31-10-35 Achro. 0.2mm	60X 0.85	300× 0.35	450× 0.32	600× 0.27	0.0022mm	750× 0.23	900× 0.20	1200× 0.145
31-10-69 Achro. 0.13mm	97X 1.25	485× 0.205	727× 0.19	970× 0.16	0.0013mm	1212× 0.13	1455× 0.12	1940× 0.09
31-10-73-02 Flour. 0.13mm	98X 1.30	490× 0.21	735× 0.195	980× 0.165	0.0013mm	1225× 0.135	1470× 0.12	1960× 0.09

APOCHROMATIC OBJECTIVES—COMPENSATING EYEPIECES

OBJECTIVES		EYEPIECES						
Cat. No. Working Distance	Magnification Numerical Aper.	5×	7.5×	10×	Micrometer Value* with 10× Eyepiece	12.5×	15×	25×
31-11-71 4.85mm	10X 0.30	50× 2.13	75× 1.80	100× 1.50	0.0132mm	125× 1.33	150× 1.15	250× 0.65
31-11-78 0.50mm	20X 0.65	100× 1.08	150× 0.91	200× 0.76	0.0067mm	250× 0.68	300× 0.59	500× 0.33
31-11-81 0.18mm	47.5X 0.95	237× 0.44	356× 0.37	475× 0.31	0.00275mm	594× 0.275	712× 0.235	1187× 0.135
31-11-89-02 0.12mm	61X 1.40	305× 0.355	457× 0.295	610× 0.25	0.0022mm	762× 0.22	915× 0.19	1525× 0.108
31-11-91-02 0.12mm	90X 1.30	450× 0.23	675× 0.195	900× 0.16	0.00142mm	1125× 0.145	1350× 0.125	2250× 0.070
31-11-93-02 0.07mm	90X 1.40	450× 0.23	675× 0.195	900× 0.16	0.00142mm	1125× 0.145	1350× 0.125	2250× 0.070

* Value in plane of specimen corresponding to 0.1mm in plane of eyepiece diaphragm using 31-15-09 Eyepiece

** Up to 1.5mm on special order

FIG. 4-3

FLAT FIELD ACHROMATIC OBJECTIVES

OBJECTIVES				EYEPIECES		
Cat. No.	Magnification	Working Distance	Numerical Aperture	10X Wide Field Cat. No. 31-05-22 [2]	10X Wide Field Cat. No. 31-05-23 [3]	10X Huygenian Cat. No. 31-05-24 [3]
31-10-62	4X	8.6mm	0.09	a. 40X b. 4.60mm c. 23.2mm	40X 4.60mm 23.3mm	40X 3.75mm 6.7mm
31-10-66	10X	2.4	0.25	a. 100X b. 1.84X c. 23.1	100X 1.84 23.3	100X 1.50 6.8
31-10-63	10X	5.4	0.25	a. 100X b. 1.84 c. 23.1	100X 1.84 23.3	100X 1.50 6.8
31-10-61	20X	0.60	0.50	a. 200X b. 0.92 c. 23.0	200X 0.92 23.1	200X 0.75 6.7
31-10-64	40X	0.40	0.65	a. 400X b. 0.46 c. 22.8	400X 0.46 23.0	400X 0.375 6.6
31-10-65	100X	0.12	1.25	a. 1000X b. 0.18 c. 22.8	1000X 0.18 23.0	1000X 0.15 6.5

a. Total magnification (multiply by zoom magnification if other than 1.0X)
b. Diameter of field of view in specimen plane, in mm.
c. Eye relief, in mm.
1. Distance from front of objective to the top of a 0.18mm thick cover glass.
2. Use with Dyna Zoom Flat Field bodies.
3. Use with Dynoptic Flat Field bodies.

FIG. 4-4

SECTION - 5

STAGE TYPES

The Plain Stages, Cat. Nos. 31-59-13, 31-59-36, 31-59-37

The Glide Stages, Cat. Nos. 31-59-28, 31-59-29

The Mechanical Stages, Cat. Nos. 31-59-11, 31-59-38, 31-59-39, 31-59-42, 31-59-43, 31-59-89, 31-59-97

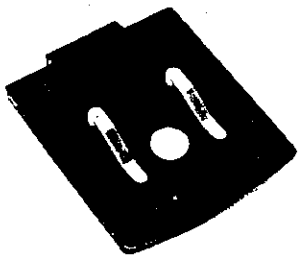


FIG. 5-1

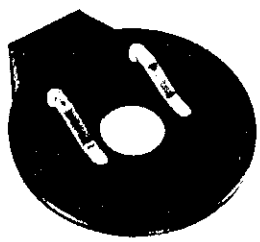


FIG. 5-2

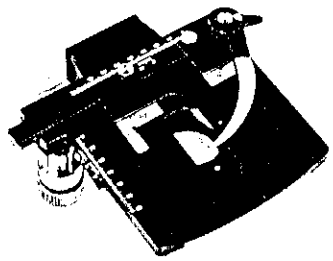


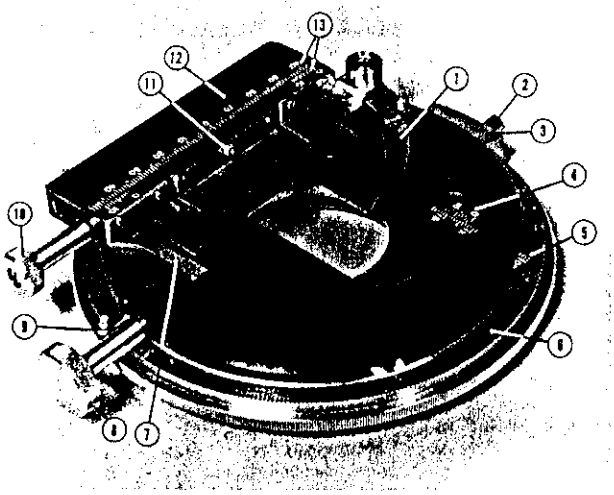
FIG. 5-3

GENERAL DESCRIPTION OF STAGES

Stage clips come mounted on the plain and glide stages to hold the specimen slide. The glide stage may be manipulated in any direction by pushing the entire stage surface. A special grease-layer bearing on the under surface of this stage gives a controlled drag motion to the stage, so that accuracy of control may be maintained. On the mechanical stages, the slide is held in place by a spring-loaded finger which secures the slide against a slide holder assembly. The slide motion is controlled by the concentric stage control knobs, Fig. 1-2, on the large vertical shaft. The north-south motion, controlled by the upper knob moves just the specimen slide and slide holder. The motion is adequate to cover a 2" by 3" specimen slide. The verniers on the graduated mechanical stages are graduated to 1mm, and permit readings to 0.1mm. This feature makes it possible to record the location of a particular area of a slide for later reference. Length and separation measurements may also be made with this device. An unobstructed stage surface for the hand scanning of slides with a low power objective is available by loosening the knurled screws holding the slide holders and removing the holders from the stage surface.

THE CIRCULAR MECHANICAL STAGE, Cat. No. 31-59-08

The circular stage for the DynaZoom laboratory microscope is rotatable and centerable. The centerable focusing substage with an adjustable stop is an integral part of the circular stage. A vernier permits reading the angular position of the stage to 6 minutes of arc. Verniers also permit the reading of the location of the mechanical stage in the north-south and in the east-west directions to 0.1mm. Travel of the mechanical stage in the north-south direction is controlled by



1. Metal Finger
2. Rotation Clamp Screw
3. Circular Stage Vernier
4. North-South Vernier
5. North-South Scale
6. 360° Revolving Circular Scale
7. Slide Retainer
8. North-South Knob
9. North-South Clamp
10. East-West Knob
11. Plate Screen
12. East-West Motion Assembly
13. East-West Scale & Vernier

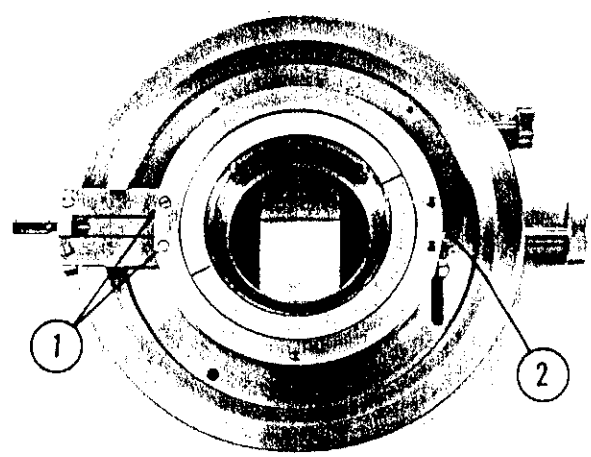
FIG. 5-4 - THE REVOLVING CIRCULAR STAGE

the larger of two stage knobs, and in the east-west direction by the smaller knob, Fig. 5-4. The rotational motion of the stage may be locked by means of the clamp screw which extends from the stationary stage vernier, Fig. 5-4. The friction of the north-south movement of the mechanical stage may be adjusted by means of the north-south clamp, Fig. 5-4.

Specimen slides in common usage are usually 1" by 3" in size. Should it be desired to use slides which are 2" in width, it will be necessary to remove the plate which is marked for removal. This is done by unscrewing its single mounting screw. You will notice because of differing scale values, that it is possible to record the position of a point of interest on a slide by two numbers only, without the necessity of specifying whether they are in the north-south or the east-west direction.

Some interference will be encountered between the stage knobs and the arm of the microscope when the stage is in certain positions. To keep this interference to a minimum, the shaft which operates the east-west travel is retractable. Pulling outward on the east-west knob in a direction parallel to the shaft will extend the shaft, thereby increasing the range of the east-west travel to 75mm. However, the interference-free range of the stage is thereby reduced. It is recommended that the east-west shaft be kept pushed in except when the additional stage motion is necessary.

The axis of rotation of the stage should always be centered to the optical axis of the microscope. Stage centration is best performed as follows: Focus on the specimen using a low power objective and eyepiece combination (10X objective and 10X eyepiece). Observe a point in the field near the edge of the eyepiece diaphragm as the stage is rotated. Loosen the stage lock cap, and by means of the stage centering screws, adjust the position of the stage so that as the stage is rotated, the point remains concentric with the eyepiece diaphragm. Final adjustment may be made using a higher power objective, if required. After completing the centering, tighten the stage lock cap. It should be kept tightened at all times except when centering. This lock cap will not prevent the stage from moving when the centering screws are unscrewed.



1. Vernier Screws
2. Slot for Locating Vernier on Opposite Side of Stage

FIG. 5-5 - REVOLVING STAGE (BOTTOM VIEW)

The circular stage vernier may be removed and reinstalled on the opposite side of the stage at the convenience of the customer. Remove the upper portion of the revolving stage. Loosen the two centering screws and release the lock cap screw. Remove the stage and place it upside down on the table. Remove the two screws shown in Fig. 5-5 and slide out the stage vernier. Slide it into the slot on the opposite side of the stage, and refasten it with the two screws. Then replace the stage in the stage support as described on Page 1-4 in this manual.

NOTE: Stages can be interchanged on all microscopes, but this should be done by an authorized repair station or at the factory to assure their perfect alignment.

TABLE OF STAGE TYPES AND CAPABILITIES

Stage	Plain Stage Clip (2)	Mechanical Stage	Condenser Mounted Underside of Stage	Focusable Substage & Noncenterable Condenser Mount	Focusable Substage & Centerable Condenser Mount
31-59-13	X		X		
31-59-36	X			X	
31-59-37	X				X
31-59-28	X			X	
31-59-29	X		X		
31-59-11		X	X		
31-59-38		X		X	
31-59-39		X			X
31-59-42		X Graduated		X	
31-59-43		X Graduated			X
31-59-89*		X		X	
31-59-97*		X Graduated		X	

*Stages with left hand control.

SECTION - 6

SUBSTAGE CONDENSERS

Abbe Condenser, Cat. No. 31-58-07

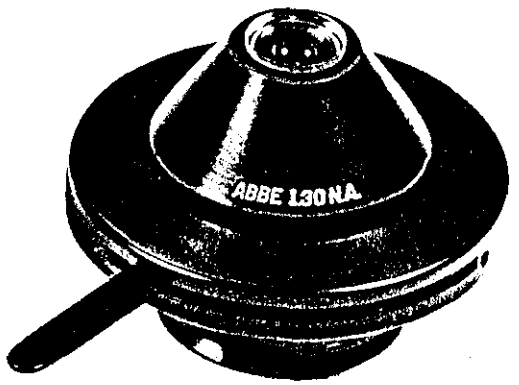


FIG. 6-1

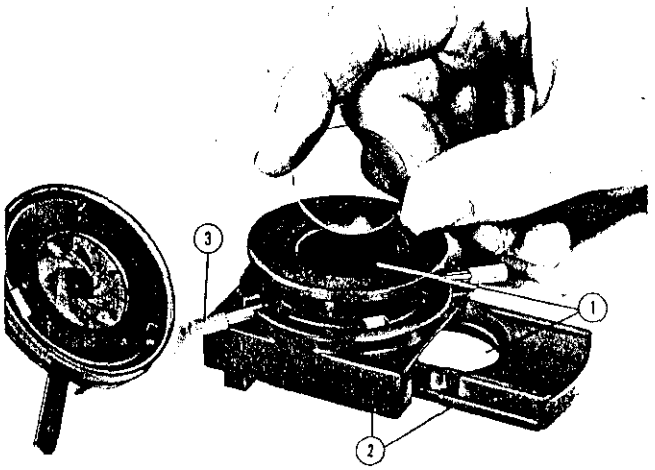
The Abbe condenser is a universally popular form of substage condenser. It consists of two elements, a double convex lower element, a hemispherical upper element, and an iris diaphragm.

In addition, a concentric mounting diameter is provided for the slide-in lens attachment. With an extended or diffused light source, the Abbe condenser gives good field and aperture coverage from the 10X, 0.25 N.A. objective to the 97X, 1.30 N. A. oil immersion objective.

ACCESSORIES FOR ABBE CONDENSER

For proper adjustment of the Abbe condenser when it is used with a base illuminator, see Field Control, Operating Procedure, Section 2. When this condenser is used with other forms of illumination (i.e. mirror and external light source), the adjustment is essentially the same. The field diaphragm or the illuminator condenser lens should be brought into focus in the plane of the specimen. It may be desirable to slightly defocus this image so that a diffusing surface may be thrown out of focus.

A blue glass filter is supplied with this condenser for those who prefer blue-white, daylight type illumination. A filter recess is provided in this condenser for the blue-glass filter, dark field stops, or the disc polarizer. To install these items, remove the Abbe condenser from the substage. Unscrew the upper and lower halves and place the filter in the recess provided. Reassemble the condenser and replace on the substage.



1. Filter Recess
2. Slide-In Lens Assembly
3. Knurled Screw

Fig. 6-2

Slide-In Lens Attachment, Cat. No. 31-58-82

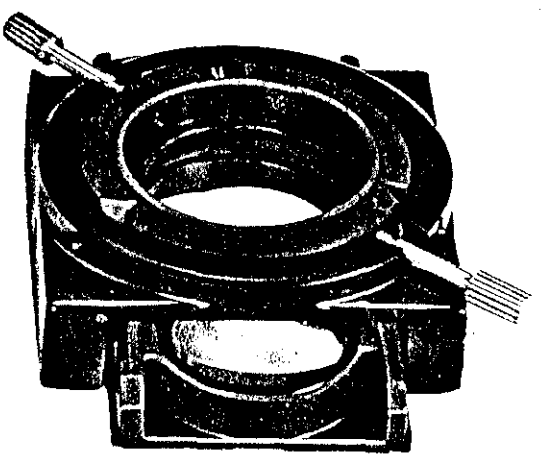


FIG. 6-3

The Slide-In Lens Attachment is a condenser that is attached to the lower part of the 31-58-07 condenser to fill the field of view of the 3.5X and 4X objective and at the same time match the N.A. of the objective and condenser. The condenser is mounted in a slide and may be removed from the field of view without moving the position of the Abbe condenser. The slide will also accept a dark field stop or filter.

Auxiliary Condenser Lens, Cat. No. 31-58-27

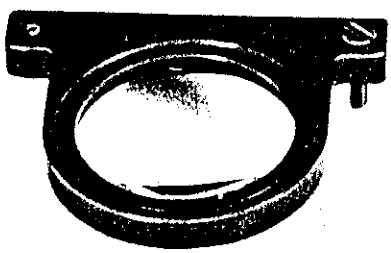


FIG. 6-4

The Auxiliary Condenser Lens is used with the 31-58-82 slide in condenser if the 31-33-69 illuminator is used. This condenser is necessary to image the field iris diaphragm of the 31-33-69 illuminator in an optically correct position.

Auxiliary Condenser, Cat. No. 31-58-80

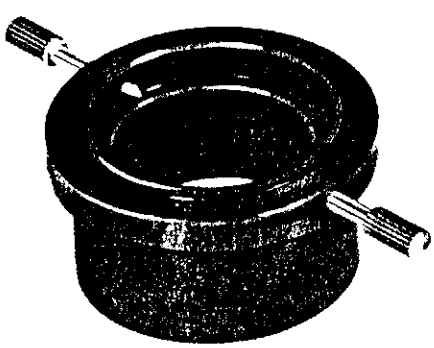


FIG. 6-5

The Auxiliary Condenser is designed to attach to the 31-58-07 Abbe condenser. It is necessary if the Abbe condenser is used with 31-33-69 illuminator, to image the field iris diaphragm of the illuminator in an optically correct position. This condenser is used in place of 31-58-82 and 31-58-27 when a 3.5X or 4X objective is not used.

1.30 N.A. Simplified Abbe Condenser, Cat. No. 31-58-34

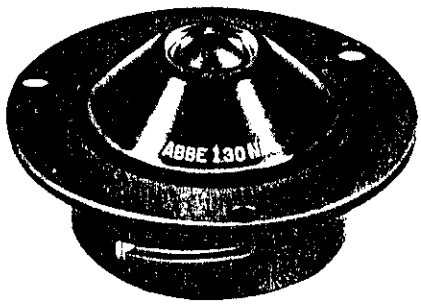


FIG. 6-6

A simplified 1.30 N. A. Abbe Condenser is available in a simple sleeve mount that attaches to the underside of the stage. This type of mount replaces the rack and pinion focusing mount found in the Abbe. A helical groove in the sleeve permits focusing by simply rotating the condenser.

1.25 N.A. Verti-Slide Condenser, Cat. No. 31-58-87

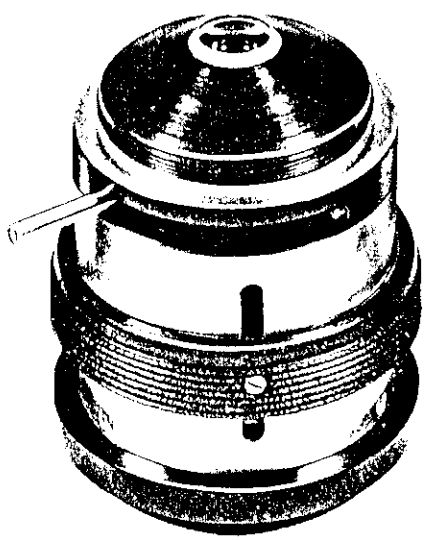


FIG. 6-7

The Verti-Slide Condenser is a simplified form of variable focus condenser. It mounts on the underside of the stage. This condenser has a simple, sliding lens mount rather than rack and pinion focusing. It is recommended for use on any microscope when objectives with a magnification of lower than 10X are employed. The condenser features a lower optical element that may be focused independently. This lower element is usually focused all the way up except when the microscope is employed in low power observations. When objectives lower than 10X magnification are used, the lower element is focused downward until the illuminated field of view completely fills (and slightly exceeds) the microscope field of view. The condenser is equipped with an iris diaphragm and a slotted recess to hold the daylight filter.

1.40 Variable Focus Achromatic Condenser, Cat. No. 31-58-56

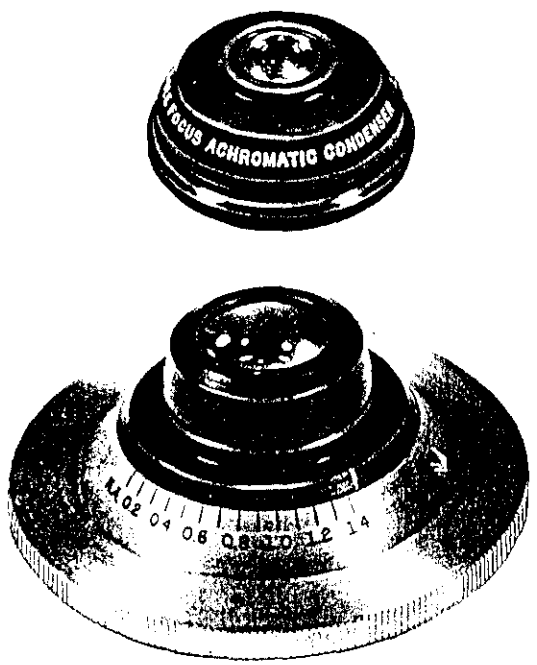


FIG. 6-8

When superior quality, color-free illumination is required, the use of the 1.40 N. A. Achromatic Condenser is highly recommended, particularly for photomicrography. The high N. A. of the condenser is also desirable when apochromatic objectives are used. The research base illuminator, or an external light source and mirror are the most suitable illumination sources when this condenser is used. This is a variable focus condenser calibrated in units of numerical aperture which provides a guide for setting the aperture iris diaphragm. Proper scale readings may be obtained when the condenser is focused so that the field diaphragm is imaged in the plane of the specimen assuming that the specimen slide is approximately 1.2mm thick. The field of low power objectives can be substantially filled by racking the lower condenser element downward. Both the field and the aperture diaphragms should be opened fully when making low power observations.

1.40 Achromatic Condenser, Cat. No. 31-58-85

FIG. 6-9

The simplified condenser is similar to the 31-58-56 but without an integral iris diaphragm. To fill the field of low power objectives when using the simplified condenser, it is necessary to remove the upper lens mount from the condenser. The use of a 31-58-28 iris diaphragm is recommended for use with this 1.40 N. A. achromatic condenser for aperture control.

OTHER CONDENSER TYPES

Other condenser types such as the Paraboloid and Cardioid Dark Field Condensers are discussed under Section 9, Dark Field Microscopy, and also in separate instruction manuals supplied with these condensers.

SECTION - 7

IRIS DIAPHRAGMS

Iris Diaphragm and Adapter, Cat. No. 31-58-45

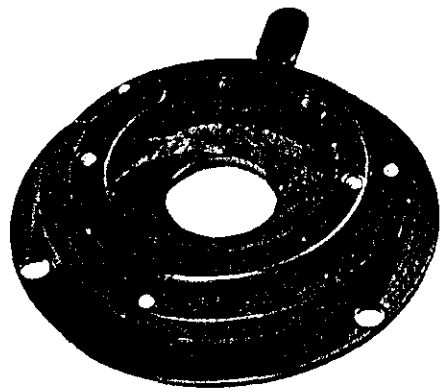


FIG. 7-1

The Iris Diaphragm is equipped with an Adapter to accept a blue filter and a second adapter to permit it to be fastened to a plain stage.

Iris Diaphragm, Cat. No. 31-58-28

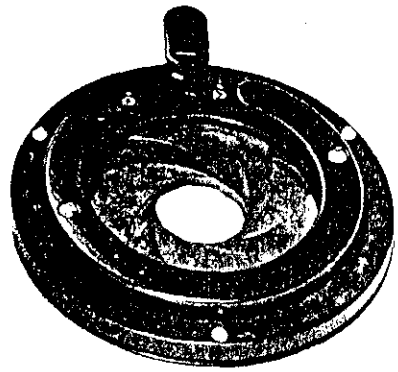


FIG. 7-2

This is a simple Iris Diaphragm with adapter to accept a blue filter and threaded for attaching the unit to various condensers.

Decenterable Iris Diaphragm, Cat. No. 31-58-31

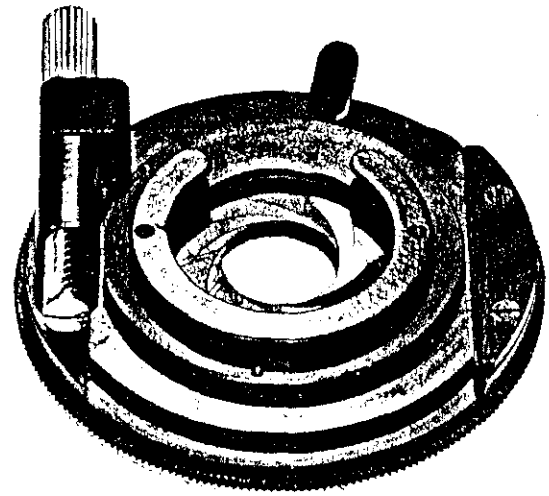


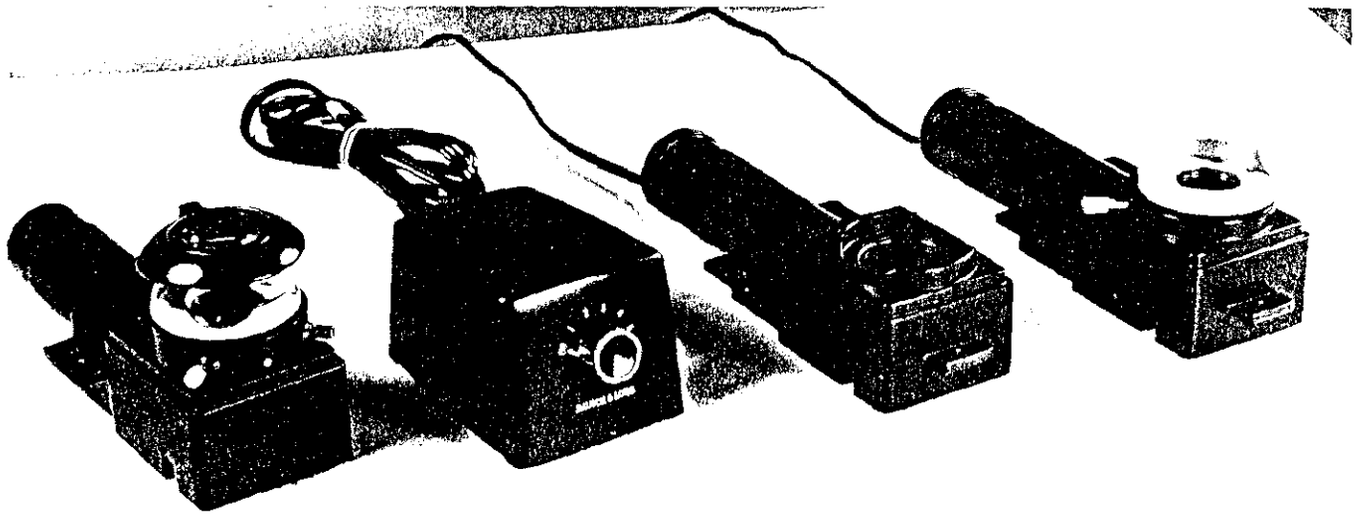
FIG. 7-3

The Decenterable Iris Diaphragm is designed to allow the use of oblique illumination, a technique which has great value in the study of certain specimens. This particular diaphragm is both decenterable and rotatable. When centered, it may be used as an aperture control for axial illumination unles this diaphragm is being used in combination with the variable focus condenser or Abbe condenser, both of which have integral aperture diaphragms.

The diaphragm opening is controlled by an actuating lever. Decentering is accomplished by turning the knurled knob. Azimuth orientation is made by rotating the diaphragm unit with finger pressure against the decentering mechanism. When the diaphragm is closed to its minimum aperture, the edge of this aperture may be moved to the circumference of the aperture of a 1.40 N. A. objective, and the diaphragm aperture may be rotated through a range of approximately 190^{o}.

SECTION - 8

ILLUMINATORS



31-33-20 | Transformer
31-35-48 120V 2-Wire
31-35-49 120V 3-Wire
31-35-50 240V 3-Wire | 31-33-07 | 31-33-69

FIG. 8-1 - ILLUMINATORS

The Hi-Intensity Illuminator with Field Iris, Cat. No. 31-33-69

The Base Illuminator provides high intensity Koehler illumination which is achieved through the use a low voltage compact coil filament lamp combined with a high speed triple lens condensing system, a centerable field iris diaphragm, and an opening for 2" round filters. Consult the Operating Procedure, Section 2, Field Illumination Control, for proper centration procedure for the diaphragm.

The base illuminator must be fastened to the underside of the base. Consult: Unpacking and Assembly, Section 1.

A final adjustment of lamp position must be made to ensure maximum performance. Use the 10X objective and the lowest power eyepieces available to make this adjustment. Turn on the illuminator and, looking down the tube(s), adjust the position of the lamp filament along the axis of motion (in and out) and rotate the socket assembly until the entire field of view is evenly illuminated. Satisfactory results will generally be obtained with all other objectives by leaving the filament in the initial position. However, to obtain maximum performance for critical observation, it is recommended that the lamp filament position be adjusted for each individual objective. This procedure will ensure optimum illumination of both field and aperture.

When high power objectives are employed, the most advantageous position for optimum illumination is best judged by observing the objective aperture with the eyepieces(s) removed.

For maximum bulb life, use the lowest voltage which permits comfortable viewing, reserving the higher voltages for photomicrography. The following data, based on an

average lamp, transformer and line voltage supply, give the variations of the listed characteristics to be expected for the various tap settings of the transformer. Refer to Fig. 8-2.

To replace a lamp in the base illuminator, withdraw the cord and socket assembly from the rear of the base by pulling on the flanged end. Tip the lamp slightly and turn it counter-clockwise to release it from the retaining pins. Insert a new lamp, Cat. No. 31-31-37. There is only one lamp position in which the three pins will engage. A partial clockwise turn will lock the lamp in place. Reinsert the unit into the microscope base.

The Hi-Intensity Illuminator for Phase Contrast, Cat. No. 31-33-07

The Phase Contrast Hi-Intensity Illuminator has a light output 2-1/2 times greater than that of the 31-33-69 Illuminator. It has been designed to compensate for the low light transmission characteristics of phase contrast microscopy and dark field systems.* Its installation into the microscope base is performed the same as for the 31-33-69 Illuminator described earlier. Replacement of the lamp (Cat. No. 31-31-37) is the same as for the 31-33-69 Illuminator.

*In Phase Contrast microscopy, a good portion of the light initially supplied by the lamp is absorbed by the dark green filter necessary using this method. In addition, this decreased light beam is further reduced by the restricted aperture of the condenser annular diaphragms. Still more reduction takes place at the light-absorbing film which is on the phase-shifting pattern of the objective.

In the case of dark field microscopy, the more sophisticated dark field condensers use only a portion of the light beam. None of this light enters the objective directly, and most of it is lost. Only those few rays that are deflected by the specimen itself into the objective actually form the image.

Clearly, these two methods require an illuminator having a very high initial light level due to their extremely low light-transmitting efficiency.

Research Base Illuminator, Cat. No. 31-33-20

The Research Base Illuminator is a more sophisticated unit which combines the advantages of both Hi-Intensity illuminators described above, and incorporates its own integral auxiliary lens. It has the advantage of greater intrinsic brightness and features a special focusable condensing system as well as an integral field diaphragm and an opening for 2" round filters. Consult the FIELD ILLUMINATION CONTROL Section of OPERATING PROCEDURE, Section 2 for the proper centration procedure for the field iris diaphragm.

The focusable condensing system is actuated by the condenser focusing control, Fig. 2-1, which permits optimum adjustment of both field and aperture illumination for the particular objective in use. Use this control whenever possible. The proper setting is easily determined by adjusting the control until a bright, evenly illuminated field is obtained. Refer to the chart in Fig. 8-2 for relative light output, transformer tap settings and other relevant information. (Note: The 31-31-37 lamp is

TRANSFORMER TAP SETTING	LAMP VOLTAGE	RELATIVE LIGHT OUTPUT	COLOR TEMPERATURE IN DEGREES KELVIN		LAMP LIFE IN HOURS*
			31-33-69 Base Illuminator	31-33-07 and 31-33-20 Research Base Illuminator	
1	12	0.7	2250	2390	60,000
2	14	1.0	2380	2520	20,000
3	16.5	2.0	2530	2660	2,500
4	20	4.0	2680	2830	200
5	25	8.0	2880	3050	10

FIG. 8-2

*manufacturer's estimate under optimum conditions (lamp life values are rough guides only, and not guaranteed values).

also used in this illuminator. Replacement of the lamp is the same as for the 31-33-69 illuminator.

TRANSFORMERS

Cat. No. 31-35-48, 120 Volt 2-Wire
Cat. No. 31-35-49, 120 Volt 3-Wire
Cat. No. 31-35-50, 240 Volt Export

FOR USE WITH 31-33-07, 31-33-20, AND 31-33-69 ILLUMINATORS.

The Transformer Switch is a six position switch - "OFF & 5 ON positions to control lamp voltage". (See Fig. 8-2)

Illuminator plugs into receptacle in rear of transformer housing.

The Optilume, Cat. Nos. 31-33-86, 31-33-87, 31-33-88 and 31-33-89, (120 Volt), 31-33-62 and 31-33-65, (240 Volt)

The Optilume is a simple, less expensive illuminator. The 31-33-86 and 31-33-62

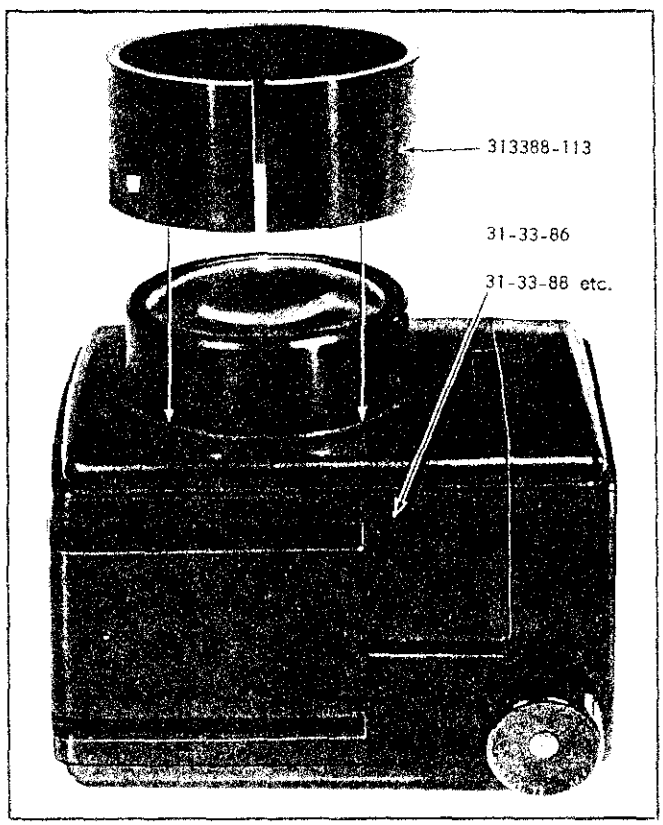


FIG. 8-3

optilume (with blue glass filter) and the 31-33-87 optilume (with frosted white glass) are available for use with monocular microscopes. The 31-33-88 and 31-33-65 optilum (with blue glass filter) and the 31-33-89 optilume (with frosted white glass) are available for binocular microscopes. The latter three have a built-in reflector.

The optilume may be attached to the microscope base as shown in Figure 1-4, or placed on the work table and used in conjunction with the substage mirror. Normally it is used fastened to the base, since this provides the advantages of a permanently aligned built-in system of illumination. Instructions for attaching the optilume to the microscope are given in Section 1, UNPACKING AND ASSEMBLY.

To replace a lamp in the optilume illuminator, disconnect it from the power source, and remove it from the microscope base by releasing the spring catch and tipping the rear portion up and out. Insert and twist a coin to separate the base from the upper part of the optilume. Pull off the base of the optilume, unscrew the lamp and replace it with a new one. Use Cat. No. 31-31-15, 120 volt, or 31-31-18, 240 volt. Reassemble the optilume and reinsert into the base.

The Mirror and Mount

Mirror, Cat. No. 31-50-21
Mirror, Cat. No. 31-50-22
Mount, Cat. No. 31-50-90
Mirror & Mount Assembly
Cat. No. 31-50-21-02

The mirror and mount are available for those who prefer to use an external light source, or for microscopes using daylight illumination. To obtain the mirror and mount as an accessory, order Cat. No. 31-50-21-02. To attach the mirror and mount, refer to the section on UNPACKING AND ASSEMBLY.

The side of the mirror which is used (plane or concave) depends on the type of illumination and the objective being employed. For general microscopy, the plane side is recommended. However, for low power work,

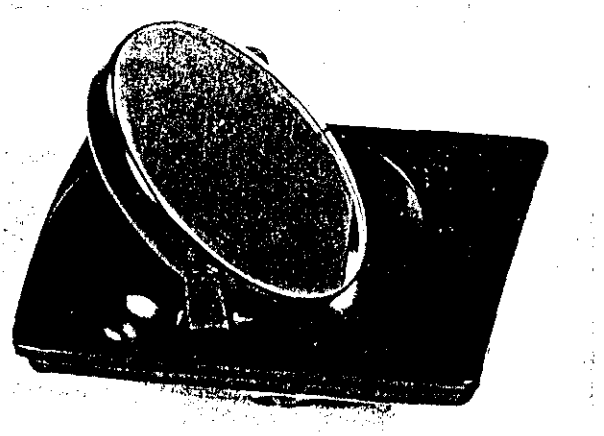


FIG. 8-4

or for work without a substage condenser, the concave side will cover a larger field.

For U. V. work and for other critical observations, an interchangeable first-surface mirror (Cat. No. 31-50-22) is available as an accessory.

EXTERNAL ILLUMINATORS

The use of Koehler illumination with an external illuminator requires the use of a plane mirror. The light source should be imaged in the substage condenser diaphragm plane, and the lamp condenser lens is then imaged in the field of view by focusing the substage condenser properly. For the best field coverage, set the illuminator for the best working distance as specified by the manufacturer. If one is not given, use a distance of about 8 inches (lamp condenser to mirror). Focus the substage condenser until the lamp condenser (or field diaphragm adjacent to this condenser) is in focus on the specimen. Some adjustment of the light source or lamp condenser may then be necessary to achieve the best uniformity of field illumination. Refer to the illuminator reference manual.

SECTION - 9

DARK FIELD MICROSCOPY

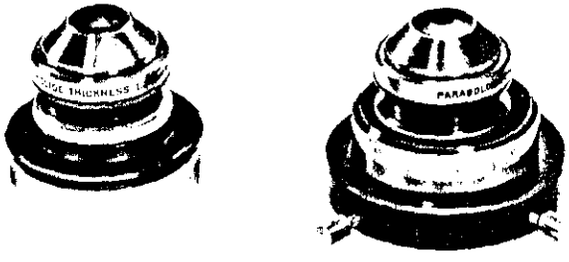
Various means have been developed for accomplishing dark field illumination. The device used generally consists of a special condenser for the substage of the microscope replacing the condenser employed for bright field illumination. It is usually used in conjunction with a conventional microscope illuminator and provides a hollow, annular cone of light. The apex of the cone is formed at the object plane. For a brief general description of dark field microscopy, refer to Pages 21 through 23 of the booklet, "The Theory of the Microscope".

In the Bausch & Lomb Laboratory Microscope, dark field illumination is achieved with either the 31-58-50 and 31-58-25 Paraboloid Condenser, or the 31-58-60 and 31-58-26 Cardioid Condenser. Separate reference manuals cover details of operation of these condensers when using external light sources. The standard base illuminator, Fig. 1-8, provides ample illumination for dark field use with either the paraboloid or cardioid Condenser, and has the advantage of being a built-in permanently aligned unit.

Through the use of Dark Field Stops, Cat. No. 31-50-71, in conjunction with the 1.30 N.A. Abbe condenser, suitable dark field illumination may be achieved for routine survey work with low or medium power objectives. The dark field stops may be placed in the filter recess of the condenser and slide or in the filter recess of the Abbe condenser itself, Fig. 1-7. The condenser should be focused to provide the maximum contrast in the image. Specimen slides approximately 1.25mm (or less) thick are recommended.

Successful dark field illumination requires a light source of high intensity. Sky light and the light provided by frosted lamps of the common variety are inadequate. An illuminator incorporating a concentrated source of high intensity such as carbon arc, low voltage coil, or ribbon filament lamp, with a condensing lens is most suitable.

DARK FIELD ILLUMINATION WITH THE PARABOLOID CONDENSER, CAT. NOS. 31-58-25 and 31-58-50



31-58-25 31-58-50

FIG. 9-1

Paraboloid Condensers are primarily designed to be used with a medium to high power objective. The 31-58-25 Paraboloid condenser is designed for use on a centerable substage. The 31-58-50 has a built-in centering adjustment for use on a non-centerable substage.

The principle of the paraboloid dark field condenser is illustrated in Fig. 9-2. Parallel light passes around the opaque central stop and is reflected at the parabolic surface and exits through the upper plano surface into the object slide. For optimum results, (achieving maximum contrast between object detail and background) the object plane must coincide with the point of focus of the paraboloid condenser. Light passes through this point under angles equal to numerical aperture limits of 1.24 to 1.33. Since the N. A. limits are greater than 1.00, it is always necessary to maintain oil contact between the condenser and object slide. Furthermore, to realize the dark field image, it becomes necessary to use an objective with an N. A. of less than 1.24. The best results are achieved when the objective N. A. is not more than 1.00.

stage. Then lock it in place by means of the lock ring.

Adjust the rack and pinion to bring the condenser level with the top of the microscope stage and lock the substage stop.

CENTERING THE CONDENSERS

Make sure that the dark field condenser is adjusted flush with the microscope stage when the substage is racked to its highest position. By means of the two centering screws, Fig. 2-1, adjust the condenser until its top is centered in the stage opening. Rough centering may be performed by focusing the stage assembly upward so that the tip of an objective is close to the condenser, and then centering the condenser to it.

Select a specimen slide having a maximum thickness of 1.35mm. Make sure that the slide is clean. Mount the material to be examined on it and cover it with a #1-1/2 cover glass.

Place a generous drop of oil on the condenser and lower it slightly below the level of the microscope stage by racking the substage down. Place the slide on the stage and rack the condenser up until oil contact with the slide is made. Use a 10X objective and focus on the slide. Focus the condenser up and down by means of the substage rack and pinion until the smallest spot of light is seen in the field. Make final centering adjustments of the condenser by means of the centering screws, Fig. 2-1. Place the spot of light in the center of the field. Refocus the condenser, making certain that the size of the illuminated field is smallest at the same position where it will also be the most intense.

Having completed the above adjustments, all that remains in order to proceed with dark field observations is to substitute the desired high power objective for the 10X objective used for centering purposes.

ALIGNMENT OF MICROSCOPE AND ILLUMINATOR

Successful dark field observation depends, among other things, upon correct alignment of microscope and illuminator as well as the employment of an illuminator of suitable intensity. Representative of illuminators suited to dark field microscopy are the Bausch & Lomb Cat. No. 31-33-20 Research Base Illuminators, 31-33-69 Base Illuminator and the No. 31-33-27 Professional Illuminator which incorporates a 5 volt 18 ampere ribbon filament lamp. (Other illuminators of a similar nature are of course applicable.) The first mentioned illuminator is particularly well suited for use with the cardioid condenser for ultra microscopy in which case the light reflected by the particles in the specimen preparation is a minimum. It is recommended for use with either the cardioid or paraboloid condensers when maximum image brightness is required.

The 31-33-27 Professional Illuminator incorporates a 6 volt 18 ampere ribbon filament lamp. The 31-34-60 Heat Absorbing Filter provides excellent heat protection and should be used with this lamp.

The illuminator should be adjusted to provide a beam of parallel light. To accomplish this, turn the illuminator on and direct the light beam to a wall at least 6 feet distant. Now set the illuminator focusing device to image the light source on the wall. First set the adjustable lens to its rearmost position, and then turn the lamp adjusting screw, at the rear of the lamp housing until the filament image is formed on the wall.

Place the illuminator before the microscope and direct the light beam to the center of the microscope mirror. The plane side of the mirror must be used. Now tip, or turn, the mirror in its support to direct the light beam squarely into the dark field condenser. A guide to the correct alignment between microscope and illuminator is to look for the source image reflected back, by the dark field condenser element from the microscope mirror. When the back-reflected image is centered on the front of the illuminator, alignment is practically complete.

Look into the microscope eyepiece, and, using a 10X or similar objective, focus on the specimen preparation. Now rack the dark field condenser downward and then upward slightly and note the change in appearance of

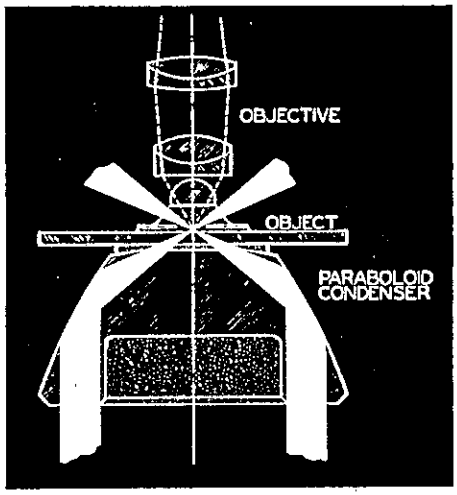
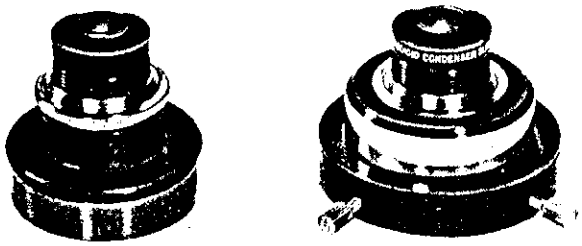


FIG. 9-2

DARK FIELD ILLUMINATION WITH THE CARDIOID CONDENSER, CAT. NOS. 31-58-26 and 31-58-60



31-58-26 31-58-60

FIG. 9-3

Cardioid Condensers are designed to be used primarily with a high power objective. The 31-58-26 Cardioid Condenser is designed for use on a centerable substage. The 31-58-60 Cardioid Condenser is designed with a built-in centering adjustment for use on a non-centerable substage.

The principle of the cardioid condenser is illustrated in Fig. 9-4. It is a reflecting form of condenser, free from both chromatic and spherical aberrations. By virtue of the curved reflecting surfaces, the rays of parallel light entering around the central stop are formed into a hollow cone and brought to a mathematically correct focus.

Light passes through the point of focus of the cardioid condenser under angles equal to numerical aperture limits of 1.20 to 1.39.

As with the paraboloid condenser, in order to achieve a dark field image, an objective with an N. A. of less than 1.20 must be used. An N. A. of about 1.00 is recommended. Oil contact between the cardioid condenser and the object slide is also required.

MOUNTING CONDENSERS

To mount the 31-58-25 or 31-58-26 Condensers, rack the substage down, loosen the clamp screw, Fig. 2-1, and remove the condenser presently in the microscope. Insert either the paraboloid or cardioid condenser firmly on the substage ring. Tighten the clamp screw.

To mount the 31-58-50 or the 31-58-60 Condensers, loosen the clamp screw, Fig. 1-8, and remove the condenser presently in the microscope. Rack the substage upward and insert the paraboloid or cardioid condenser from the bottom of the substage, seating the adapter of the condenser firmly on the substage ring. Then tighten the clamp screw.

The bodies of these condensers are threaded and provided with a lock ring, so that its height in the adapter may be adjusted and the condenser then locked in place.

After the condenser is secured in the substage, rack the substage up to its highest position (release the substage stop, Fig. 2-1), and adjust the condenser vertically by screwing it up or down until the top of the condenser is just below the top of the microscope

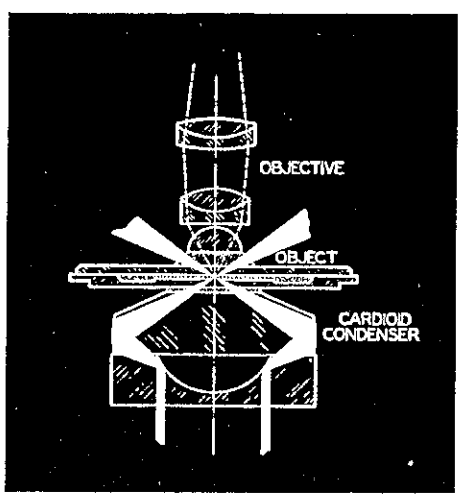


FIG. 9-4

the illuminated spot in the field. (It is assumed that preliminary centering as described in the section on the centering has been done.) If the microscope and illuminator are correctly aligned, the spot of light formed at the center of the field by the dark field condenser at focus will expand into an evenly illuminated ring as the condenser is racked above or below the proper focal setting. If the ring thus formed does not appear symmetrical and the light about coarse particles in the field of view, with the condenser set at best focus, appears unevenly distributed then slight readjustments of the mirror and illuminator are required. Make adjustments in the inclination of the illuminator (and possibly its height) and corresponding readjustments of the microscope mirror until a symmetrical distribution of light is obtained on racking the dark field condenser in and out of focus.

OBJECT SLIDES AND COVER GLASS FOR DARK FIELD MICROSCOPY

Slides for use with the dark field condensers must be no thicker than 1.35mm. Thinner slides are more desirable since some focal adjustment of the paraboloid condenser is permitted. Slides thinner than 1.0mm may however cause trouble through difficulty in maintaining adequate oil contact between the condenser and the slide. Specimen slides vary in thickness in any one box. One should select slides by actually measuring them with a micrometer caliper. The cover glass should also be carefully measured if it is intended to use a "high dry", objective. If the objective is not fitted with an adjusting collar, the cover glass should be selected for 0.18 $\pm$ 0.05mm thickness. If the objective is provided with an adjusting collar, select a cover glass of a thickness within its adjustment range. The cover glass thickness is of less importance when an oil immersion objective is employed. However, the maximum thickness that can be readily accommodated with an oil immersion objective is about .22mm.

Slides and cover glasses must be scrupulously clean and free from pits, scratches and similar defects. It is best to carefully measure and select a number of slides and cover glasses at one time and reserve them for dark field work. Slides of optical quality fused quartz, ground and polished to the desired thickness, are available and are recommended for use. They resist corrosion and abrasion better than conventional glass slides. This is particularly important for ultramicroscopy with the cardioid condenser.

SPECIMEN PREPARATION

CAUTION

DO NOT PUT A THICK OR HIGHLY CONCENTRATED SUSPENSION ON THE SLIDE. BE SURE NOT TO HAVE TO MUCH SOLID MATERIAL IN THE PREPARATION. BEST DARK FIELD RESULTS WILL BE OBTAINED FROM MOUNTS WHICH APPEAR VOID TO THE UNAIDED EYE.

Place a drop of the solution to be examined on the slide, cover with the cover glass and blot off any excess liquid with absorbent cotton, filter or blotting paper.

OBJECTIVES FOR DARK FIELD

As previously stated, the best results are obtained when using a paraboloid or cardioid condenser if the N. A. of the objective is not more than 1.0. The 43X, 0.65 N. A; 45X, 0.85 N. A. achromatic; 40X, 4.0mm, 1.00 N. A. fluorite; and the 47.5X, 0.95 N. A. apochromatic objectives are suitable. The latter objective is particularly well suited to ultramicroscopic work with the cardioid. If higher magnification is required, one of the following oil immersion objectives should be employed, along with the appropriate funnel stop:

97X, 1.8mm, 1.25 N. A. Achromat
98X, 1.8mm, 1.30 N. A. Fluorite
61X, 3.0mm, 1.40 N. A. Apochromat
90X, 2.0mm, 1.30 N. A. Apochromat
90X, 3.0mm, 1.40 N. A. Apochromat

In addition to the increase in magnification, the fluorite (semi-apochromatic) and apochromatic objectives provide an improve-

ment in image quality, compared to the achromats, due to their higher order of correction.

The funnel stop is a fixed diaphragm designed to reduce the N. A. of the objective to 0.85. The Cat. No. 31-50-15 funnel stop should be used with the 97X Achromatic and 98X Fluorite objectives. The 61X Apochromat requires the No. 31-50-16 stop. The 100X flat field objective should utilize the Cat. No. 31-49-05 funnel stop. The two 90X Apochromatic objectives use the same funnel stop, No. 31-50-17. To insert the stop, remove the objective from the microscope and screw the funnel stop into the back of the objective. The ending having the small hole goes nearest the lenses in the objective.

(When using funnel stop on objectives, the rear diaphragm must be removed before the funnel stop can be inserted.)

A 97X, 1.8mm, 1.25N. A. Objective (Cat. No. 31-10-75) with built-in iris diaphragm is also available. This objective permits adjustment of the working N. A. and control of image contrast. The iris eliminates the inconvenience attending the use of a funnel stop.

Be sure the objective does not have old immersion oil on the tip. Clean it carefully and screw it into the nosepiece of the microscope. Place a drop of oil on the cover slip, taking care to prevent the formation of bubbles. Cargille's immersion oil is recommended. It can be readily wiped off an objective or slide with lens tissue and a very little solvent such as toluol or xylene. It is better than cedarwood oil in this respect and is, in addition, non-drying, non-fluorescing, colorless and has the proper refractive index for glass.

Rack the objective down until the oil drop contacts the tip of the objective. Look into the eyepiece and carefully focus the microscope using the fine adjustment until the specimen preparation is seen clearly.

If brilliantly illuminated circles are observed, the cause may be air bubbles in the preparation, in the oil below the slide, or in the oil above the slide. When focusing any instrument used with immersion fluid, always turn the adjusting knob slowly to avoid drawing bubbles into the fluid which would obscure the vision.

After use, wipe the oil off the condenser and objective with absorbent cotton or lens paper. No further cleaning of these parts is either necessary or desirable.

ULTRAMICROSCOPY WITH THE CARDIOID CONDENSER

In the ordinary bright field microscope, Abbe has shown that resolution cannot be carried beyond a quarter-micron. Particles smaller than this, such as those existing in a colloidal solution, can be made visible by refined methods of dark field illumination. The cardioid represents the most refined form of dark field condenser. The apochromatic type of objectives are generally preferred for the examination of ultramicroscopic particles.

The 4mm Dry Apochromat, Cat. No. 31-11-81, 45X, 0.95 N. A. will be found very satisfactory. Set this objective by rotating its adjusting collar until the index line indicates, on the scale, the measured thickness of the cover glass involved. Care should be taken not to alter this setting when rotating the revolving nosepiece of the microscope to place the objective in observing position.

If the greater magnification of the oil immersion objectives is required, funnel stops must be employed. Such stops are available for use with the fluorite and apochromatic type objectives. They can be supplied by sending a description of the objective with which the stop is to be found. The 31-10-75 Achromatic objective mentioned above is also well suited to use with the cardioid condenser for studying particles in suspension.

INTERPRETATION OF OBSERVATIONS

The question of "how large are the smallest particles visible by ultramicroscopic

means?" has been solved by Siedentopf* by a consideration of the amount of radiation from the particles and the limit of sensitiveness of the eye. The first of these factors is dependent upon the specific intensity of radiation, the character of the radiation surface and the solid angle at which the radiation is emitted from the surface. Siedentopf states that the limit of the smallest size of particle visible which the ultramicroscope is $4 \times 10^{-11} mm^2$ which corresponds to a circle with a radius about 4×10^{-6}mm, or .004μ. Svedberg** gives a formula for the radius of an ultramicroscope particle $r = (3M/4n\pi p)$ 1/3. All the particles in a known volume of the solution are counted and M is the total mass (determined analytically) in this volume; n the number of particles and p the density. It is assumed here that the density of the ultramicroscopic particles is the same as the mass material and that the particles are spheres.

*Dr. H. Siedentopf, Ann. d. Physik, 1903

**Dr. Th. Svedberg, Colloid Symposium Monograph, 1923

SECTION - 10

POLARIZED LIGHT MICROSCOPY

Polarized light is made available for the qualitative examination of crystals, fibers, minerals, etc. with the use of the Disc Polarizer, Cat. No. 31-57-16. This polarizer slips into the filter recess of the condenser and slide or the filter receptacle in the 1.30 N. A. Abbe condenser, Cat. No. 31-58-07, Fig. 1-7.

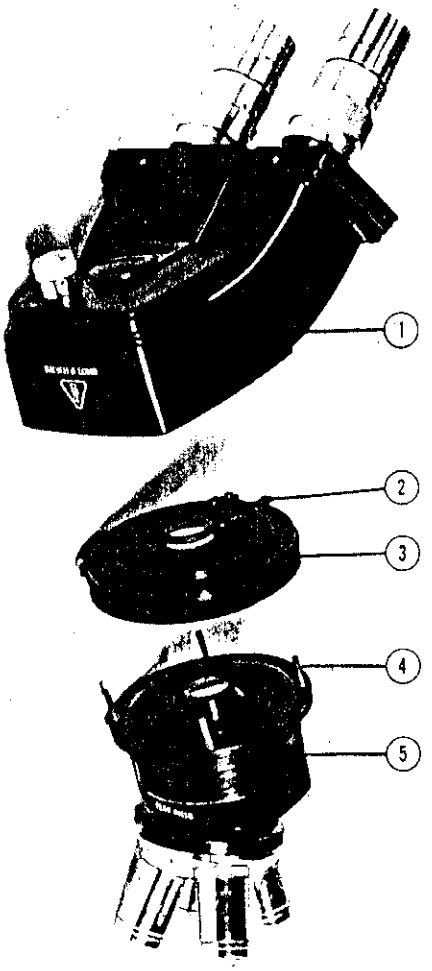
When achromatic condensers are employed, the Cat. No. 31-57-15 Disc Polarizer is recommended. Achromatic condensers require a filter holder, Cat. No. 31-58-33 to attach the Cat. No. 31-57-15 Disc Polarizer.

A Body Tube Analyzer, Cat. No. 31-57-36, must be inserted in the nosepiece for all polarized light applications. To mount this analyzer, unscrew the objective and slide the analyzer into the nosepiece from below until it comes to a stop. When placing the body tube analyzer into a DynaZoom laboratory binocular or laboratory photo binocular body, rotate the analyzer mount until the axis of vibration (indicated by slots in the analyzer mount) is at an angle of 45^{o} to the plane of symmetry of the body, or until the images in the binocular eyepieces are equally bright. Then replace the objective in the nosepiece.

The 31-57-36 Body Tube Analyzer cannot be used on the DynaZoom flat field bodies or the Dynoptic flat field bodies. The DynaZoom flat field bodies are not designed for use with polarized light.

The Dynoptic flat field bodies are designed for polarized light using the 31-57-12 Analyzer.

To install the 31-57-12 Analyzer in the Dynoptic body, remove the four screws holding lower housing to the upper housing of the microscope. (Note position of objectives in relation to eyepieces). Remove the lower housing and place the analyzer in position on the upper housing with the swing-out analyzer up, and the actuating lever extending out under the eyepieces. Place lower housing in position, with objectives in original position. Fasten the three parts together with four screws supplied with analyzer. With this design, it is not necessary to remove the analyzer from the microscope. Moving the lever to the right to the ball stop removes the analyzer from path of light. Tube length will not change when the analyzer is added to



1. Upper Housing
2. Actuating Lever
3. Swing Out Analyzer - Cat. No. 31-57-12
4. Screw (4)
5. Lower Housing

FIG. 10-1 POLARIZED LIGHT CONDENSER ASSEMBLY

the body due to the compensating lens in the body.

The vibration axis of the substage polarizer must be oriented so that it is perpendicular to the axis of the analyzer. The axis of the Disc Polarizer, Cat. No. 31-57-16, is indicated by the two white lines engraved on the mount. The axis of the Polarizer Cat. No. 31-57-15 is parallel with the mount handle.

When the Disc Polarizer, Cat. No. 31-57-16, is utilized in the filter recess, Fig. 1-7, of the Condenser and Slide, Cat. No. 31-58-82, it should be oriented so that one of the engraved lines on the polarizer mount is in alignment with one of the index marks on the slide. These index marks are spaced 90^{o} apart. With the disc in place, push the slide into viewing position. Extinction (minimum brightness) should occur. If there is no apparent extinction, the disc must be rotated 90^{o} in the recess. The final adjustment for maximum extinction is made by loosening one of the knurled screws, Fig. 1-7, on the condenser and slide, and rotating the unit slightly until minimum brightness is achieved. Retighten the knurled screw to maintain this position.

SECTION - 11

PHASE CONTRAST MICROSCOPY

Unstained, colorless, transparent microscope specimens frequently lack contrast when viewed under standard bright field illumination. Previously, time consuming methods of preparation were necessary which resulted in harmful physical or chemical changes which would destroy structural detail in the specimen.

Phase contrast microscopy overcomes this difficulty and permits the examination of living material without resorting to staining. The method can also be used with fixed and dry specimens including microtome sections. Even the selective differentiation of structure in fixed specimens is possible without staining, providing a mounting medium of the correct index is used.

PHASE CONTRAST ACCESSORY EQUIPMENT

1. Flat Field Phase Contrast equipment, Cat. No. 31-58-44-01, containing the phase contrast turret condenser for flat field objectives. This turret has interchangeable upper elements, one a standard and one a medium working distance lens. It includes two centering keys, an auxiliary eyepiece telescope, a green filter, four flat field phase contrast objectives and a bottle of immersion oil, Fig. 11-1. This equipment can be used only with flat field bodies.

2. Standard Phase Contrast equipment, Cat.

FIG. 11-1 - FLAT FIELD PHASE CONTRAST EQUIPMENT, CAT. NO. 31-58-44-01

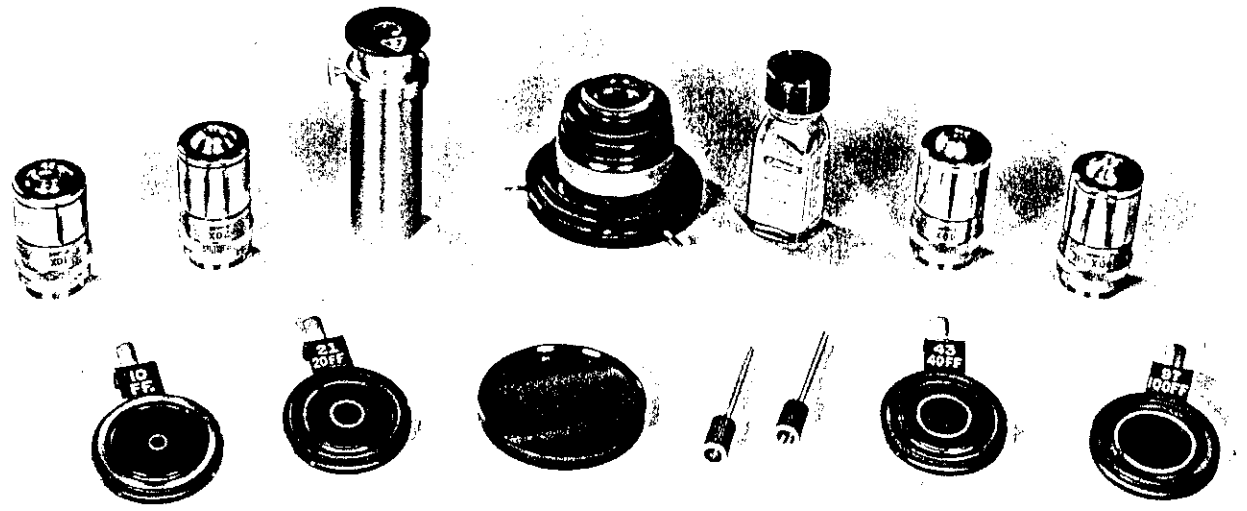


FIG. 11-2 - PHASE CONTRAST EQUIPMENT WITH L.W.D. CONDENSER AND FLAT FIELD OBJECTIVES, CAT. NO. 31-58-88-03

No. 31-58-43-01, containing the phase contrast turret condenser for standard achromatic objectives, with interchangeable upper elements, one a standard and the other a medium working distance lens. It includes two centering keys, an auxiliary eyepiece telescope, green filter, four achromatic objectives and immersion oil.

3. Flat Field Phase Contrast equipment, Cat. No. 31-58-88-03, containing the long working distance (LWD) phase contrast condenser and iris diaphragm for use with flat field objectives. It includes two centering keys, an auxiliary eyepiece telescope, green filter, four flat field phase contrast objectives, four annular stops and a bottle of immersion oil, Fig. 11-2. This equipment is for use only with flat field bodies.

4. Standard Phase Contrast equipment, Cat. No. 31-58-88-01, containing the long working distance phase contrast condenser and iris diaphragm for use with standard achromatic objectives. It includes two centering keys, auxiliary eyepiece telescope, green filter, four achromatic phase contrast objectives, four phase discs and a bottle of immersion oil.

Both phase turret condensers and the long working distance phase condenser are made to fit any Bausch & Lomb Microscope Stand having a full substage ring mount, however, the flat field objectives are usable only on the newer flat field microscope bodies and are always ordered together. All objectives are equipped with standard threads which will fit any of the standard microscope nosepieces. The objectives come in plastic containers for protection, and the entire phase contrast kit is packed in a black leatherette lined carrying case.

MOUNTING THE CONDENSERS

Turret-Type Phase Contrast Condenser

To install the turret-type phase contrast condenser:

1. Lower the substage to its lowest position (raise the specimen to the highest level if using a focusing stage model).

2. Loosen the condenser clamp screw and remove the condenser presently on the microscope.

3. Unscrew the knurled top condenser lens (marked Abbe 1.30 N. A.) from the turret condenser.

4. Fit the turret condenser into the substage ring from the top and secure it with clamp screw. Make sure that the turret is resting squarely in the ring mount and that the index window is located directly in front of the stage plate for easy viewing.

5. Replace the top lens on the turret condenser. Do this carefully to avoid marking the lens during installation.

6. Reset the substage stop for the proper working distance as directed in the OPERATING PROCEDURE section, Page 2-1 and rack the substage up to the proper position.

7. The medium working distance lens may be substituted for the Abbe 1.30 lens by racking the substage down, unscrewing the lens in use and replacing it with the other lens. Handle the lenses carefully to avoid scratching them, and make sure that the replacement lens is screwed down tightly.

Long Working Distance Condenser

To install the long working distance condenser:

1. Lower the substage, loosen the clamp screw and remove the condenser presently in the microscope.

2. Raise the substage and insert the condenser into the mounting ring from the underside. This is normally a tight fit, and the condenser should be firmly against the bottom surface of the ring mount. The condenser should rotate in the substage ring so that the two small centering screws are forward as shown in Fig. 11-3. This places the slot for the insertion of the annular discs to the right. Tighten the clamp screw to lock it in place.

3. Screw the 31-58-28 Iris Diaphragm onto the bottom of the condenser.

4. Reset the substage stop if necessary for the new working distance (refer to the OPERATING PROCEDURE section, Page 2-1 for procedure).

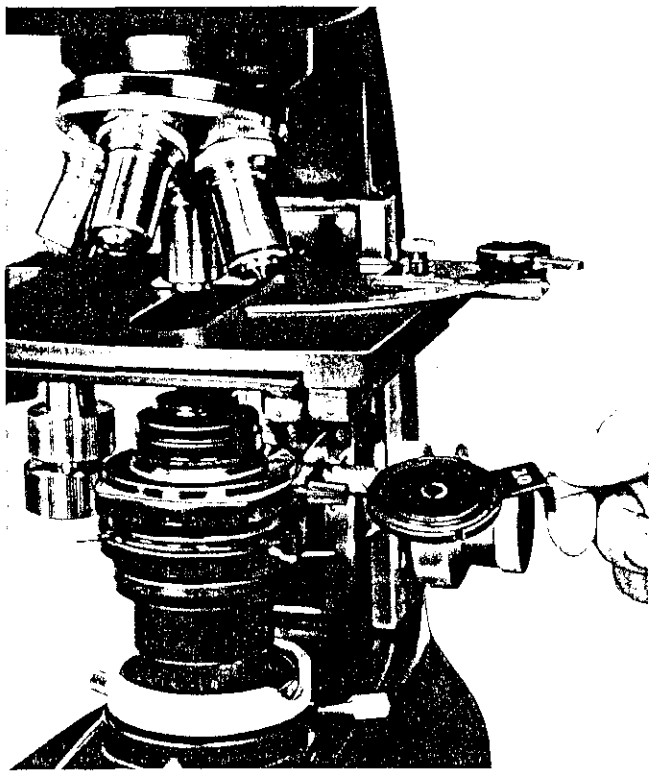


FIG. 11-3 - L.W.D. CONDENSER MOUNTED

5. Insert the appropriate annular disc with its index number upward into the slot on the side of the condenser, Fig. 11-3. It is correctly positioned when you feel it fall into its proper click-stop position. (The number engraved on the disc handle must correspond to the magnification factor on the objective in use.)

The long working distance condenser has an unusually long working distance (from 8 to 10mm in air) which makes possible the use of phase contrast microscopy in such laboratory applications as cell growth and tissue culture chambers.

Alignment and Operation Turret-Type Condenser

The microscope is set up for phase contrast operation by removing the regular objectives from the nosepiece and replacing them with the flat field or standard achromatic phase contrast objectives. Place the illuminator (if one is used) at a convenient distance from the microscope and make sure that the

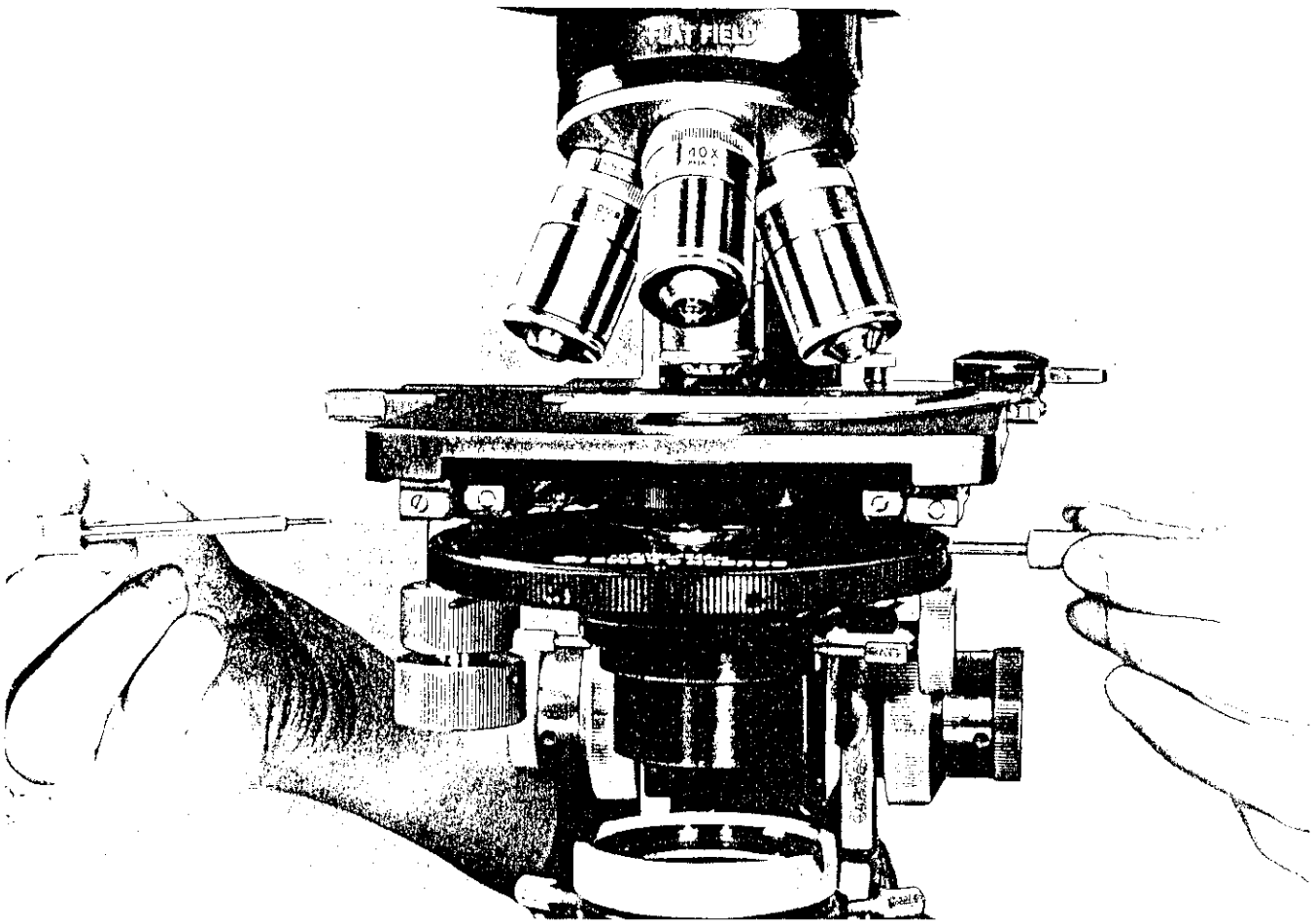


FIG. 11-4 - CENTERING AN ANNULUS

iris diaphragm on the phase turret condenser is completely open. Rotate the turret disc until the figure "0" appears in the index window. Close down the substage iris as necessary to focus on object detail within the stained specimen. If the intensity of the illumination must be reduced for better observation, insert a neutral density filter in the illuminator. The green filter may also be used if desired. Now rotate the turret disc until the appropriate annular disc number appears in the index window. The substage iris should now be fully opened. Do not use the substage iris diaphragm to control the illumination level after the proper condenser annulus has been selected and adjusted for use.

Centering The Phase Annulus

Replace the microscope eyepiece with the telescopic eyepiece and focus on the grey ring pattern appearing in the field of view. This is done by loosening the clamp screw on the telescope eyepiece, adjusting the eyepiece tube on the telescope, and then tightening the screw. Make sure that the telescope is resting with its positioning ring firmly against the eyepiece shoulder. The brightly illuminated image of the condenser annular disc and the phase ring in the objective will be superimposed in the field of view. The image of the condenser annulus should be completely overlapped by the grey ring. Adjust the substage condenser height until the bright ring becomes sharply defined and is in focus along with the grey ring. The bright image must now be adjusted so that it overlaps the grey ring. This is done by means of two centering screws located within the turret assembly. The procedure is as follows:

Insert the two centering keys into the two rear most holes on the knurled ring of the

turret, Fig. 11-4, and turn the keys alternately while observing the movement of the bright ring until it is concentric with and completely covered by the grey ring. Fig. 11-5 illustrates the overlapping annular ring patterns when they are in typical position.

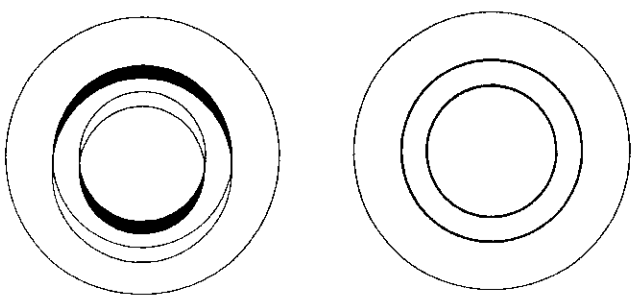
The phase altering pattern is intentionally made slightly broader than the image of the condenser annulus to insure that the latter is completely covered, which prevents leakage of light around the phase ring. Any such light leakage would reduce the degree of contrast attainable.

The centering procedure should be necessary only once for each objective when the equipment is first installed. When properly done, objectives and discs may be interchanged at leisure without the need of repeating the disc-centering procedure each time.

If necessary, raise or lower the condenser slightly to perfect the registration of the two annular patterns. If the image of the condenser annular diaphragm is not uniformly bright, a slight readjustment of the substage mirror (when using a separate illuminator) may be made to produce the desired image.

With the 100X FF or the 97X phase contrast objectives, there are two positions of the substage condenser, separated by approximately 3mm in which the substage annulus appears to be focused on the objective annulus. Only in the upper position, however, can the bright substage ring be centered to the dark objective ring.

To make examinations under ordinary bright field conditions, rotate the condenser revolver disc until the figure "0" appears at the index window. This permits use of the condenser at full aperture. Aperture illumination is then controlled by use of the substage iris diaphragm.



A - Not Centered B - Centered

FIG. 11-5 - OVERLAPPING RING PATTERN

ALIGNMENT AND OPERATION

The L.W.D. Condenser

Remove the regular objectives from the nosepiece and replace them with the flat field or standard achromatic phase contrast objectives. Place the illuminator at a convenient distance from the microscope and open the iris diaphragm on the condenser all the way. Place a stained specimen under the microscope and bring it into sharp focus for good object detail, reducing the intensity of the illumination if necessary by adding filters.

Insert the appropriate annular disc corresponding to the objective in use into the slot on the LWD condenser, making sure that it clicks into the proper position. Open the substage iris diaphragm all the way.*

*NOTE: The LWD phase condenser can be satisfactorily used as a bright field condenser for almost all application including the use of oil objectives by removing the annular stop.

Centering The Phase Annulus

Use the same procedure for centering the phase annulus as was described when using the turret-type condenser and the telescope eyepiece. Use the centering keys to adjust the two centering screws protruding from the front of the LWD condenser, Fig. 11-3, until the bright ring overlaps the grey rings as illustrated in Fig. 11-5. This procedure will be necessary for each of the four annular stops when used with their corresponding objectives.

The Annular Stops

The four annular stops supplied with the LWD condenser equipment have been factory pre-centered to their slide carriers, which are properly notched to ensure proper positioning in the condenser mount. For this

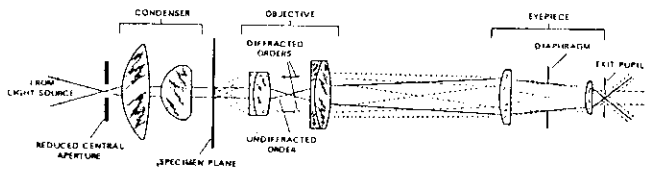


FIG. 11-6 - PRINCIPLE OF IMAGE FORMATION IN CONVENTIONAL BRIGHT FIELD MICROSCOPE

reason, centering adjustments are minimized once the initial alignment procedure is performed.

When the phase objectives and their corresponding stops are ordered together with a microscope, the stops will be accurately centered to the phase patterns in the objectives, so that after initial adjustment is made, no further centering will be required with the interchange of objectives and stops.

In other cases, when necessary items are ordered in broken lots, individual centering of the stops to the phase altering pattern of the objectives being used may be necessary.

IMAGE FORMATION WITH A PHASE MICROSCOPE

The schematic diagram in Fig. 11-6 is intended to show the principle of image formation in a conventional bright field microscope system, and suggests how the direct light, passing undeviated through the object structure, and the diffracted beams, deviated in passage through the object by the object structure and entering the objective, are made to recombine and form, through their interference effects, a representative image of the object in the final image plane.

Fig. 11-7 illustrates the principle of the phase contrast microscope. (The eyepiece, which primarily serves as a viewing magnifier, has been omitted.) An annular aperture to control the illumination on the object is placed in the lower focal plane of the substage condenser, and is imaged by the condenser and objective at the rear focal plane (exit pupil) of the objective. An annular phase altering pattern ("phase plate") is placed in this plane. As shown by the solid lines, light from the controlling annular diaphragm which is undeviated by the object structure and enters the objective will pass through this annular phase altering region and will effectively acquire an advance in phase of one-quarter of a wavelength of green light over that part of the light diffracted by the object structure (shown by broken lines), gathered by the objective, and passing through that region not covered by the phase altering pattern. The final image will be formed through the resulting interference effects between the two portions of light, and alterations in phase relations in the illuminating rays, introduced by elements of the specimen material which otherwise would be invisible, are translated into brightness differences by the phase pattern (plate). The resulting phase contrast image reveals structural details under enhanced contrast.

ILLUMINATION

In general, the only requirement for adequate illumination with the phase accessories is that the annular diaphragm of the condenser be fully and evenly illuminated when the condenser itself is properly adjusted with respect to the specimen plane and the objective. It is possible, therefore, to use any one of the common forms of microscope illuminators in connection with the phase accessories. However, an illuminator incorporating a fairly intense light source, such as the 6 volt, 18 ampere ribbon filament lamp, and employing a collector lens will be found the most desirable. For maximum rendition of contrast and detail it is recommended that the Koehler form of illumination be employed. The Bausch & Lomb Phase Hi-Intensity Illuminator is ideally suited for use with

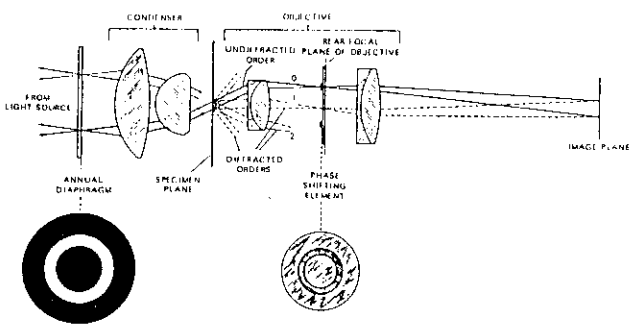


FIG. 11-7 - PRINCIPLE OF IMAGE FORMATION IN PHASE CONTRAST MICROSCOPE

phase contrast optics and is the illuminator normally supplied when the complete phase contrast microscope is purchased. If a separate illuminator must be used, the Bausch & Lomb PG-26 and PG-27 Professional Illuminators will be suitable.

In the Koehler method of illumination the collector lens of the illuminator is adjusted to focus an image of the light source on the annular diaphragm of the phase condenser. The phase condenser in turn is positioned with respect to the object slide, so as to focus an image of the illuminator lens in the object plane. The collector lens of the illuminator then effectively becomes the light source. If an adjustable diaphragm is placed directly in front of the collector lens of the illuminator, the diaphragm will act as the field stop of the system, and it may be conveniently used to control the size of the illuminated field in the object plane. The phase condenser must be adjusted so that the image it forms of the illuminator diaphragm, when the latter is closed sufficiently, can be seen in the object plane with the microscope in proper focus. For strict Kohler illumination, either the 31-33-69 Hi-Intensity Illuminator or the 31-33-20 Research Base Illuminator are required if one needs a built-in source. When the 31-33-69 is used with a phase turret condenser, a 31-58-80 Auxiliary Condenser must be used. When a 31-33-69 is used with a LWD condenser, a 31-58-22 Auxiliary Condenser and Iris must be used. If a separate illuminator is required, the PG-26 and PG-27 models can be easily adjusted for conformance to the Kohler principles.

FIELD AND APERTURE

For a given combination of objective and eyepiece, the area of the illuminated field will further depend upon the focal length of the microscope substage condenser, the opening of the illuminator diaphragm (or the diameter of collector lens or illuminator window, where no diaphragm is involved) and on the distance between the illuminator and the substage condenser of the microscope.

In some instances where low power combinations of objectives and eyepieces are used, it may be found that the image of the illuminator lens formed in the object plane does not completely fill the field of view. In such a case the substage condenser unit of the phase contrast accessories must not be racked up or down in an effort to fill the field. A diffusing screen should be introduced between the microscope and illuminator if it is necessary to fill the entire field of view. The use of such a screen, however, cannot meet the requirements for more critical conditions of illumination.

In any case, the illumination at the diaphragm plane of the substage condenser unit must be adequate to fill the annular stop fully and evenly. Where the light source itself is imaged on the stop, the image must be large enough in its smallest dimension to cover the annulus completely. Fulfilling this condition ensures coverage of the objective aperture with even illumination over the entire region of the phase ring.

The full aperture of the phase objective contributes to the formation of the final image since the diffracted rays of light gathered by the objective pass through on either side of the phase ring.

PHASE CONTRAST OBJECTIVES

These objectives are specifically intended for use in the method of phase microscopy, and because they are fitted with a special annular phase altering pattern, they are not ideally suited for use apart from this system. Although they can be used for routine examinations in ordinary bright field microscopy without serious risk, it is of considerable advantage to use the standard objectives designed to yield optimum performance in demanding situations.

Other restrictions which apply to the conventional microscope objectives, such as correct tube length, cover glass thickness, and refractive index of immersion oil, must similarly be met for the phase contrast systme. Specimen slides must be of a thickness compatible with the working distance of the substage condenser. Slides thicker than 1.3mm cannot be used successfully.

TYPE OF CONTRAST

The Bausch & Lomb Phase Contrast Objectives are designed to give positive, or dark, contrast. In the resulting phase image, regions of greater optical path in the object will appear darker than those of less optical path. Since the optical path for light passing through a medium of refractive index n, and of thickness t, is given by n t, regions of equal thickness having a higher refractive index will appear darker than equally thick regions of lower refractive index. Regions of equal refractive index, but having greater thicknesses, will likewise be darker than those having equal refractive index, but of less thickness.

USE OF FILTERS

Since the phase contrast objectives introduce one-quarter wavelength of light phase shift when using green light as provided by the Wratten B (No. 58) filter, the use of other colored filters, although not restricted, will normally result in a departure from this amount of shift. In a few cases, where the object has undergone light, selective staining, for example, the use of proper color filters may prove of some advantage in enhancing contrast.

Use of white light is also permissible. When using white light one can expect some loss of image crispness and slight coloration effects which are characteristic of the objective, light source, and specimen structure and mounting.

USE OF OIL WITH CONDENSER

The condenser should be used "dry" for all phase observations. Since the requirements on the numerical aperture to be filled by the condenser for any of the phase contrast objectives never exceed 1.00 N. A., including the oil immersion objective, there is no advantage to be gained through the use of oil with the condenser. If the condenser is immersed in oil, special precautions to ensure optimum performance with Koehler Illumination must be taken.

SECTION - 12

FILTERS

Colored filters are useful in controlling the contrast in an image, where various contrasting colors are present in the specimen. If, for example, a specimen has faint red and blue areas, a red filter will make the blue areas dark and the red areas light. Conversely a blue filter will reverse this contrast pattern. A set of 2" square interference filters is available, (Cat. No. 42-47-44-01), for use in microscopy. These optical glass filters give relatively narrow pass bands and are more resistant to light and heat than the traditional gelatin filters.

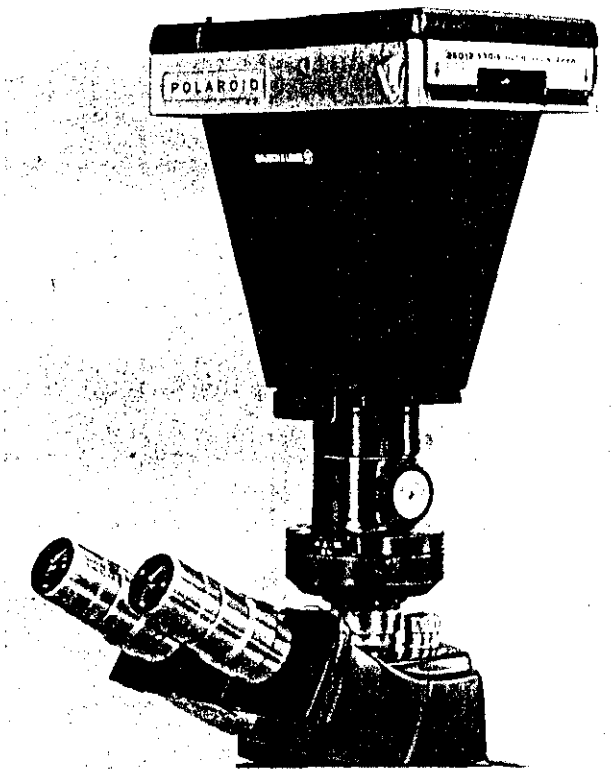
To reduce light intensity, neutral density filters are available. These come in various densities and sizes. The 3" diameter set, Cat. No. 31-34-66-01, contains 3 neutral density filters and a daylight blue filter. The 2" square set, Cat. No. 31-34-88-01 contains 4 neutral density filters and a daylight blue filter. The base illuminator has an opening for 2" round neutral density or daylight blue filters. The set of 2" round filters, comprising 1 neutral density filter and 2 daylight filters, is supplied as standard equipment for these illuminators. Available filters are listed in the Accessories Section, Page 15-1.

A ground glass filter is a simple expedient for reducing the light level in a microscope. It should be located far enough from a field plane so that no graininess is apparent in the field of view.

PHOTOMICROGRAPHY

Color and black and white photomicrography with a DynaZoom Photomicroscope, or a Dynoptic Laboratory Photomicroscope, becomes a relatively simple matter when equipped with base illuminator and one of the new attachable or separately supported cameras. Each of the following cameras have separate reference manuals and will be described only briefly here.

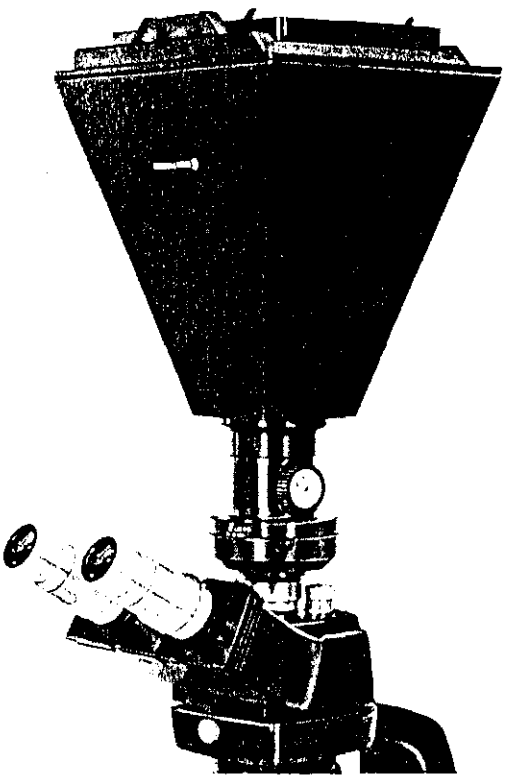
3-1/4 x 4-1/4 (POLAROID®) CAMERA (7.5X MAG.), Cat. No. 42-12-27



The intermediate size Camera Body utilizes a Polaroid, series 100, 3-1/4 x 4-1/4 Film Pack Back. Polaroid Film Packs in black & white and in color permit instant photomicrographs of suitable size for normal viewing. Included with this Camera is a Viewfinder Adapter Plate which permits the use of a Standard Eyepiece or a Viewfinder Eyepiece to help in parfocalizing the film plane image.

Total magnification at the film plane is the product of the objective and zoom magnification (if any) multiplied by the 7.5X camera factor.

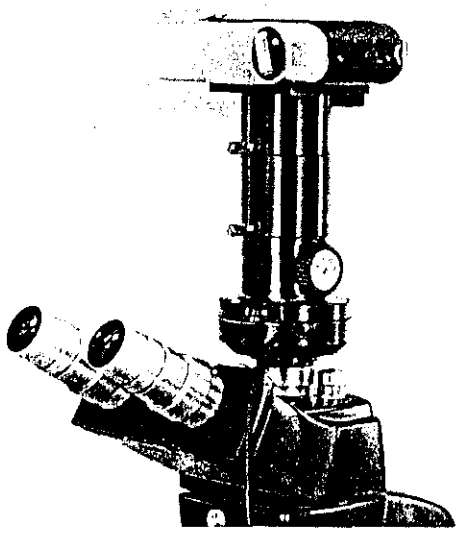
4 x 5 CAMERA (10X MAG.), Cat. No. 42-12-28



The largest unit takes 4 x 5 film or plates. This Body will accommodate any plate or Film Holder or other accessory which will fit a 4 x 5 Graphic or Graflex Back. 4 x 5 sheet films and plates are available in a wide variety of emulsions in both black & white and in color. Polaroid film packets are also available in color or black & white.

Total magnification at the film plane is the product of objective and zoom magnification (if any) multiplied by the 10X camera factor.

35mm CAMERA (3X OR 5X MAG.), Cat. No. 42-12-29



The 35mm Camera Body uses standard cartridges (cassettes) of the many emulsions offered in black & white or in color in this universally available size. The useful negative area is 24 x 36mm (about 1 x 1-1/2). As with the 3-1/4 x 4-1/4 Polaroid Camera Back, a Viewfinder Adapter Plate is furnished to aid in parfocalizing. 35mm film is especially suitable in situations where a large number of negatives are required or where color transparencies for projection are desired. In either case, compactness, rapidity of film transport and economy are important advantages.

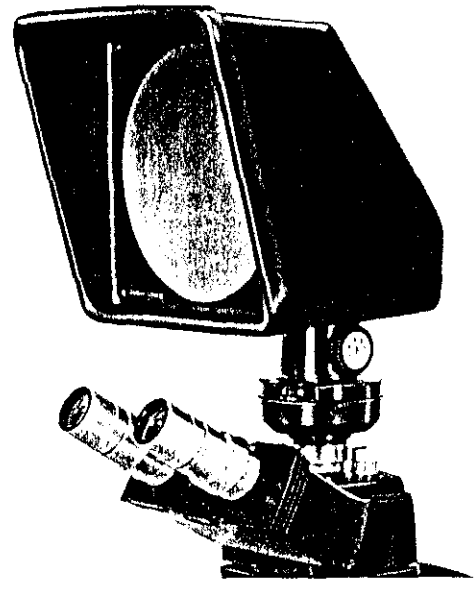
Total magnification at the film plane is the product of the objective and zoom magnification (if any) multiplied by the 2.5X camera factor.

EXPOSURE METER, Cat. No. 42-12-40

The Exposure Meter consists of a Light Sensor permanently connected to a Metering Unit by means of a flexible cord. The Metering Unit has been factory-calibrated to provide readings within the range of .02 to 100 foot-candles. A circular Exposure Computer is supplied to convert from meter reading to exposure setting relative to Film Speed and Camera Magnification being used.

The unit is designed principally to be used in conjunction with the Bausch & Lomb Integrated Camera System II which has an accessory slot for insertion of the Sensor. However, an auxiliary Sensor Holder is available permitting usage of the Sensor either at the Microscope Eyepiece position or at a Film Plane location.

VIEWING SCREEN, Cat. No. 42-12-20



The Viewing Screen is designed for use on the DynaZoom and Dynoptic Microscopes, Bench Metallograph and the StereoZoom 7 Microscope with Camera Adapter. It may be purchased as a complete unit consisting of a Viewing Screen (42-12-20), Optics Tube (42-12-21) and Screw Adapter (42-12-23) or the Viewing Screen may be purchased separately for use with the Focusing Tube of the New Integrated Camera Series.

The unit has a magnification factor of 7.5X so Total Magnification at the Screen = Objective Mag. x Zoom Setting (if applicable) x 7.5.

The lens system is focusable thus allowing the image on the Screen to be parfocaled to the image in the right Eyepiece of the instrument it is being used on.

SECTION - 14

CARE OF THE MICROSCOPE AND ITS ACCESSORIES

Your Bausch & Lomb Microscope has been constructed with skill and care to provide you with an instrument which will give years of satisfactory service. It must be remembered, however, that even with its rugged construction, it is a precision instrument and should be given fitting care. When treated with respect, and given reasonable care, your microscope will show little if any signs of wear after even the most protracted use.

Care should not be confined to the optical elements alone. Your microscope is a combination of optical and mechanical excellence, one complementing the other. Of what value is the most perfect objective if the fine focusing mechanism cannot bring it precisely into perfect focus?

An excellent rule to observe is to permit no unauthorized person to manipulate your microscope. One person may be an expert in the manipulation of one type of instrument but will be completely unfamiliar with another. If it should be necessary for someone else to use your microscope, be sure to instruct him thoroughly in its proper use.

The primary rule to follow with respect to proper care of the microscope is to keep it as free from dust and dirt as is possible. Dusty lenses will result in foggy images while dust in the focusing mechanisms will give rise to excessive wear of these parts. When not in use, cover the microscope with the plastic dust cover which accompanies it. If the microscope is not to be used for some time, keep it in its case.

When handling the stand, it is best to carry it by the arm and base. It would be wise to use two hands rather than risk dropping the instrument.

Avoid sudden jars, such as placing the microscope on the table or into the case with undue force.

CLEANING OF OPTICS

The experienced microscopist keeps the optics of his microscope clean and free from fingerprints and dust.

Every installation should be provided with a camel's hair brush, syringe, and a well washed piece of linen. On account of its fine texture, a piece of linen that has been washed several times is the most desirable cleaning material. No dust should be permitted to settle upon the lenses nor should the fingers come into contact with any of the surfaces.

The lens system (especially objectives and eyepieces) should never be disassembled, even though they can be unscrewed, since it is almost impossible to re-establish their precision factory alignment.

Avoid all violent contact of the front lens of the objective with the cover glass. The oil immersion objectives particularly require the best care.

Occasionally examine the rear surface of the objective by removing the eyepiece and looking down the tube. If dust has accumulated there, remove it with a camel's hair brush, or blow it off with air from a syringe.

Keep eyepieces in the microscope at all times to keep dust from seeping in. Despite all of the normal precautions, optics do become dirty. Dust generally does little damage to image contrast, unless it becomes excessive. A fingerprint or smear, on the other hand, will degrade an image badly, giving a milky, washed-out appearance. To remove

dust, try to blow it off with a syringe, or dust it off with a camel's hair brush. Avoid hard wiping, as dust is often hard and abrasive.

To remove fingerprints, wipe lightly with a clean soft cloth or absorbent cotton, lightly moistened with soap and water, alcohol, or Xylol. A small amount of absorbent cotton wound on the end of a tapered stick makes a handy cleaning tool for recessed optical surfaces. Avoid excessive use of solvents as this may cause run-ins in cemented optics, or the flowing solvent may pick up grease from the mounts, making cleaning a tedious job.

Clean immersion objectives immediately after use by removing the fluid with lens paper.

Visible defects in the field of view are frequently traceable to impurities on the eyepiece, not in the objective, and are easily recognized by revolving the eyepiece. Indistinctness in the image or loss of light may be due to soiled surfaces in either eyepiece or objective.

Dust, if on either the eye lens or field lens of the eyepiece, is apparent as dark, indistinct spots.

To clean the surfaces, first blow upon them or, preferably, blow the dust away with a gentle blast of dry air from a syringe. Then remove the remaining particles with a camel's hair brush. If dirt or grease is still evident, remove it by gently wiping with a soft, lintless cloth moistened with Xylol.

MECHANICAL MAINTENANCE

Should the microscope become dirty, it may be cleaned with a soft cloth moistened in Xylol. Avoid the use of excessive solvent which might run into bearings and dilute their lubricant.

Remove any immersion oil which may adhere to any part of the stand with a cloth moistened with Xylol and wipe dry with a soft lintless cloth or chamois.

Lubrication of the microscope is rarely required, due to the use of ball-bearings and nylon bushings in all critical friction points. The coarse and fine adjustment mechanism is completely enclosed and uses self-lubricated ball-bearings for both thrust and slide bearings. The zooming system cams are enclosed and self-lubricated. The same is true of the movable prism in the photo binocular.

Mechanical stages use ball-bearing slides, which require no lubrication. The racks and pinions should be kept clean, but should never be lubricated. Use a small stiff brush, such as a toothbrush, to clean the racks.

The above applies also to the rack and pinion of the substage focusing mechanism. Should the slide become sticky, a few drops of light machine oil wiped on the bearing is recommended.

The glide stages depend for their action on a controlled drag in the greased bearing surfaces. This grease layer should be replaced if the stage motion becomes too stiff. The recommended grease is available in a 1 oz. jar from Bausch & Lomb, specify Cat. No. 31-50-04.

SAFETY CLUTCH ADJUSTMENT

The focusing motion safety clutch is set at the factory to provide an optimum balance of forces which will prevent the stage from slipping downward under normal usage conditions and, at the same time, prevent slide or objective damage should the stage be focused too far upward. An adjustment of this clutch setting is available if it is desirable to place a heavy object on the stage, or should the clutch force become too great due to unusual atmospheric conditions. The clutch adjustment nut is accessible through a hole in the back of the arm located about 4-3/8" above the table top. A threaded plug seals this hole from dirt seepage and must first be removed. A bent paper clip, inserted in two pinholes of the plug will make a handy tool to aid in its removal. Using a 5/16" socket nut driver, available at most hardware and radio supply houses (the outside diameter should not exceed 7/16"), the adjustment nut can be engaged. A clockwise turn will tighten the clutch; counterclockwise

rotation will loosen it. Always remember that too loose an adjustment will permit the stage to drop out of focus upon the slightest shock or additional weight (possibly even of its own weight); too tight an adjustment will cause damage to specimen slides and objectives if the stage should inadvertently be focused too high.

SECTION - 15

ACCESSORIES AND REPLACEMENTS

Catalog No.	
31-05-03	Hi-Point Eyepiece, 5X for Variable Power
31-05-22	Eyepiece Wide Field 10X for DynaZoom Flat Field Bodies
31-05-23	Eyepiece Wide Field 10X for Dynoptic Flat Field Bodies
31-05-24	Eyepiece Huygenian 10X for Dynoptic Flat Field Bodies
31-05-60	Eyepiece Wide Field for Standard Bodies
31-05-72	Eyepiece, Compensating, 7.5X
31-15-08	Hi-Point Eyepiece, 5X for Fixed Power Standard Bodies
31-15-14	Hi-Point, 10X for Standard Bodies
31-19-01	Nosepiece, Single
31-19-20	Quadruple Nosepiece w/individually centerable apertures
31-19-22	Nosepiece, double, revolving
31-19-23	Nosepiece, triple, revolving
31-19-24	Nosepiece, quadruple, revolving
31-19-39	Binocular Body, MicroZoom 1X - 2X
31-19-41	Inclined Photomicrographic Monocular Body, 2X
31-19-42	Inclined Monocular Body, Fixed Power
31-19-43	Vertical Monocular Body
31-19-59	Photobinocular MicroZoom 1X - 2X Body
31-31-15	Replacement Lamp 120V, for 31-33-86, -87, -88, and -89 Optilumes
31-31-18	Replacement Lamp 240V, for 31-33-62 & -65 Optilumes
31-31-37	Replacement Lamp 20V, for 31-33-20, -38, -68 & -69, -07 & -08 Illuminators
31-33-07	Phase Hi-Intensity Base Illuminator
31-33-20	Research Base Illuminator

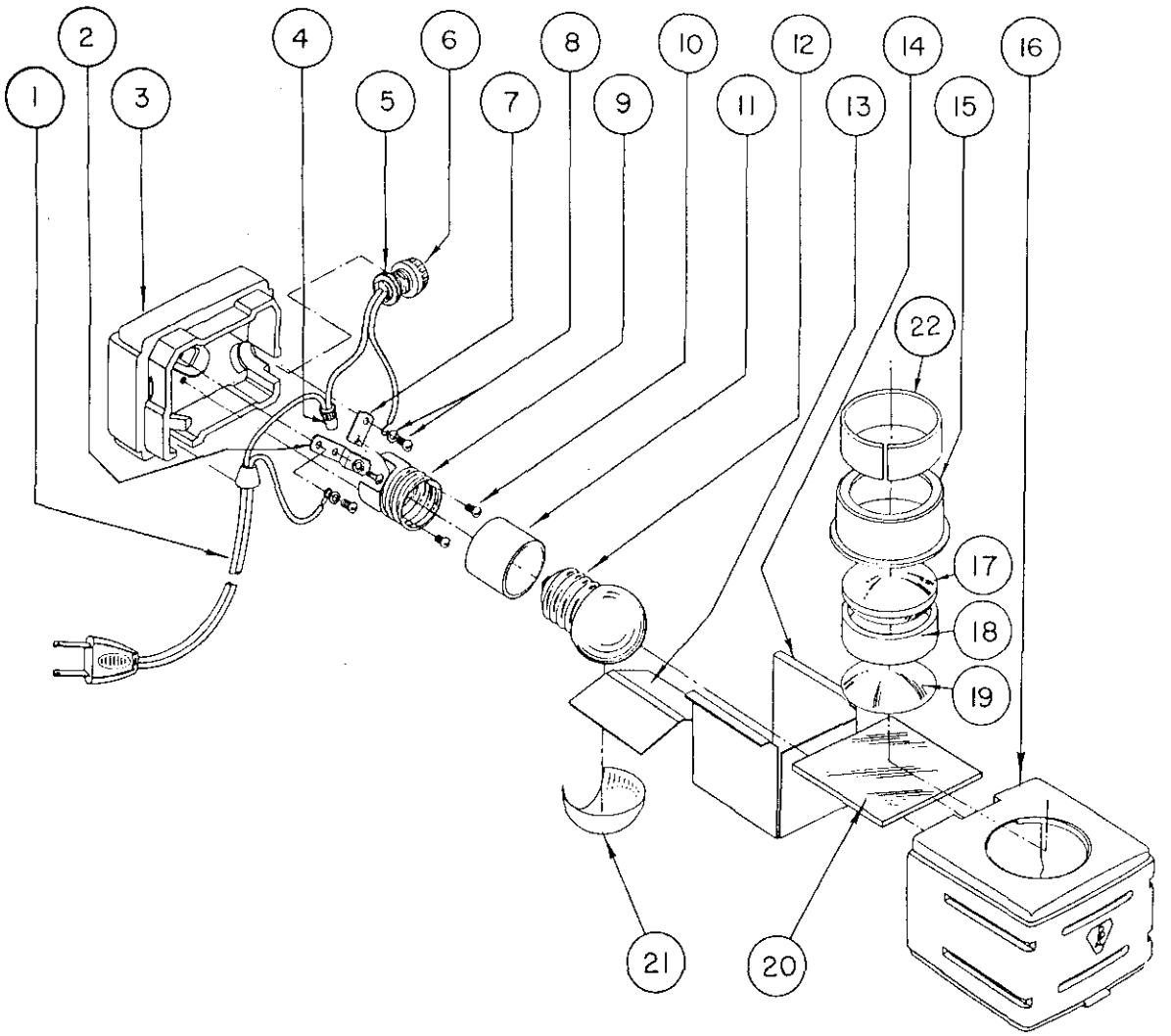
Catalog No.	
31-33-69	Hi-Intensity Base Illuminator
31-33-69-37	Base Illuminator and Set of four filters
31-33-86	Optilume with blue glass filter and condenser (for monocular microscopes)
31-33-62	Optilume with blue glass filter and condenser 240V (Export)
31-33-87	Optilume with ground glass and condenser (for monocular microscopes)
31-33-88	Optilume with blue glass, condenser and reflector (for binocular microscopes)
31-33-65	Optilume with blue glass, condenser and reflector (240V)
31-33-89	Optilume with ground glass, condenser and reflector (for binocular microscopes)
31-34-11-04	Set of 2" Round Filters (3 neutral density; 1 daylight blue)
31-34-38-01	Set of 2" Square Filters (3 neutral density; 1 daylight blue)
31-34-66-01	Set of 3" Round Filters (4 neutral density; 1 daylight blue)
31-34-71	Daylight Filter, 2" round, thin
31-34-73	Neutral Filter, 0.7 density, 2" round
31-34-74	Neutral Filter, 1.0 density, 2" round
31-34-75	Neutral Filter, 1.3 density, 2" round
31-34-88	Daylight Filter, 2" round, thick
31-35-48	Transformer 120V, 60 Hz AC 2-Wire
31-35-49	Transformer 120V, 60 Hz AC 3-Wire
31-35-50	Transformer 240V, 50/60 Hz AC, 3-Wire (Export)
31-40-35	Leatherette microscope carrying case with lock and handle
31-50-04	Grease, 1 oz. jar

Catalog No.	
31-49-60	Dust Cover, plastic
31-50-21	Plano-Concave second surface mirror
31-50-21-02	Mirror and Mount Assembly (31-50-21 & 31-50-90)
31-50-62	Lens Paper 50 Sheets 4" x 5-1/4"
31-50-71	Dark Field Stop Set
31-50-86	Cargille's Immersion Oil, A. (low viscosity)
31-50-90	Mirror Mount for 31-50-21
31-57-12	Analyzer for Dynoptic Flat Field Bodies
31-57-15	Disc Polarizer (for Achromatic Condensers)
31-57-16	Disc Polarizer
31-57-36	Body Tube Analyzer (for Standard Bodies)
31-58-07	Abbe Condenser 1.30 N. A. with Iris
31-58-22	Auxiliary Condenser with Iris
31-58-25	Paraboloid Condenser (for Lab Research)
31-58-26	Cardioid Condenser for Lab Research
31-58-27	Auxiliary Condenser Lens
31-58-28	Iris Diaphragm
31-58-31	Decenterable Iris
31-58-34	Simplified, Sleeve-mount Abbe Condenser, 1.30 N. A.
31-58-50	Paraboloid Condenser
31-58-56	Achromatic Condenser with Iris, 1.40 N. A. for Lab Research

Catalog No.	
31-58-60	Cardioid Condenser
31-58-43-01	Phase Contrast Accessories, Turret-type
31-58-44-01	Flat Field Phase Contrast Accessories, Turret-type
31-58-04	Condenser Sleeve
31-49-05	Funnel Stop (for 31-10-65)
31-50-15	Funnel Stop (for 31-10-69-71)
31-50-16	Funnel Stop (for 31-11-16)
31-50-18	Funnel Stop (for 31-11-91-93)
31-34-70	Daylight Filter
31-40-31	Cherrywood Case, DeLuxe, for Lab Research Microscope
31-58-80	Auxiliary Condenser
31-58-82	Condenser and Slide Assembly
31-58-85	Achromatic Condenser, 1.40 N. A.
31-58-87	Verti-Slide Condenser, 1.25 N. A.
31-58-88-01	Phase Contrast Accessories, L.W.D. type
31-58-88-03	Flat Field Phase Contrast Accessories, L.W.D. type
42-12-27-10	3-1/4 x 4-1/4 Polaroid Camera Kit
42-12-28-10	4 x 5 Camera Kit
42-12-29-10	35mm Camera Kit
42-12-02	10X Viewfinder Eyepiece for 42-12-27 & 42-12-29 Camera Kits

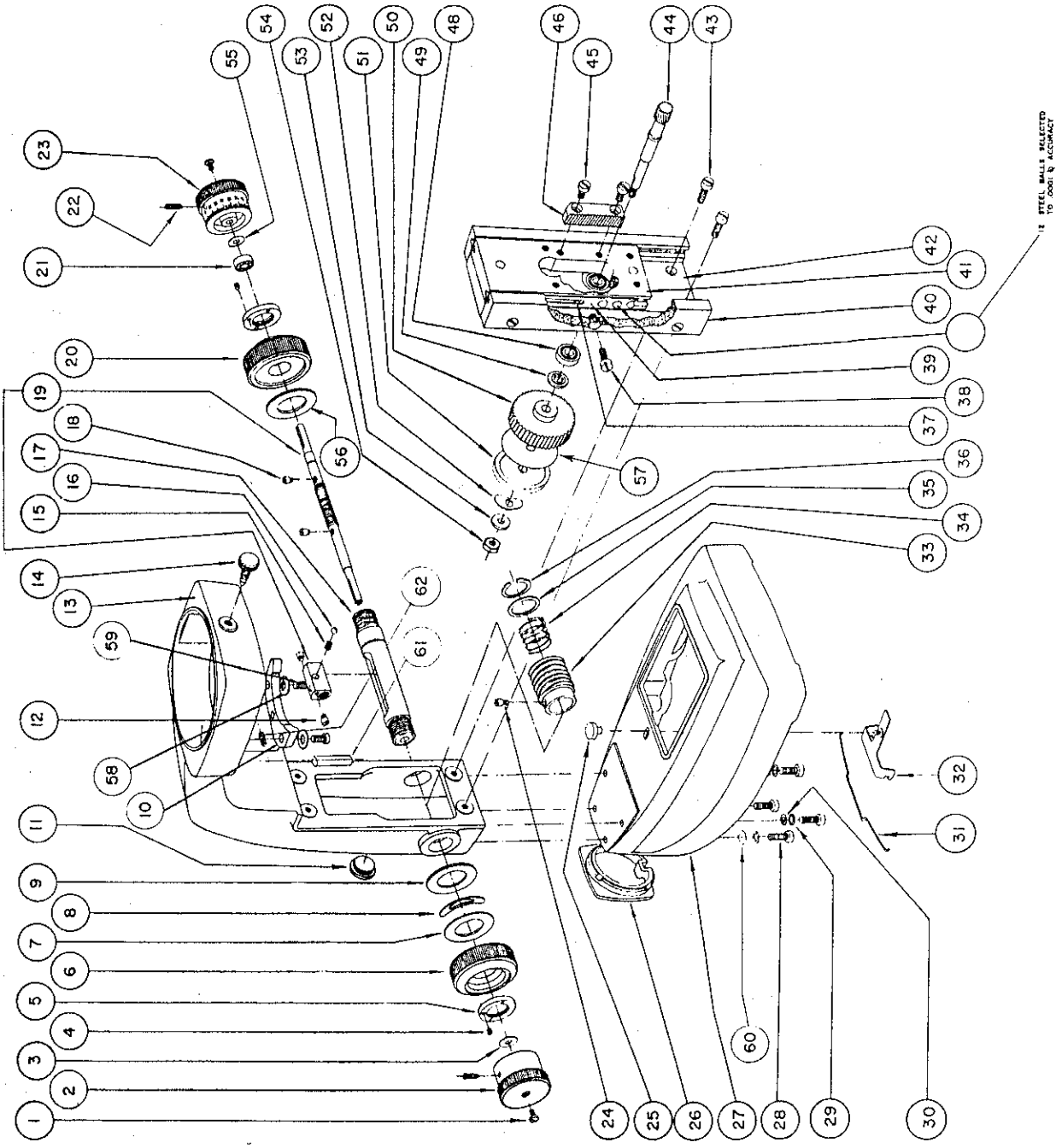
SECTION - 16

PARTS AND EXPLODED VIEWS



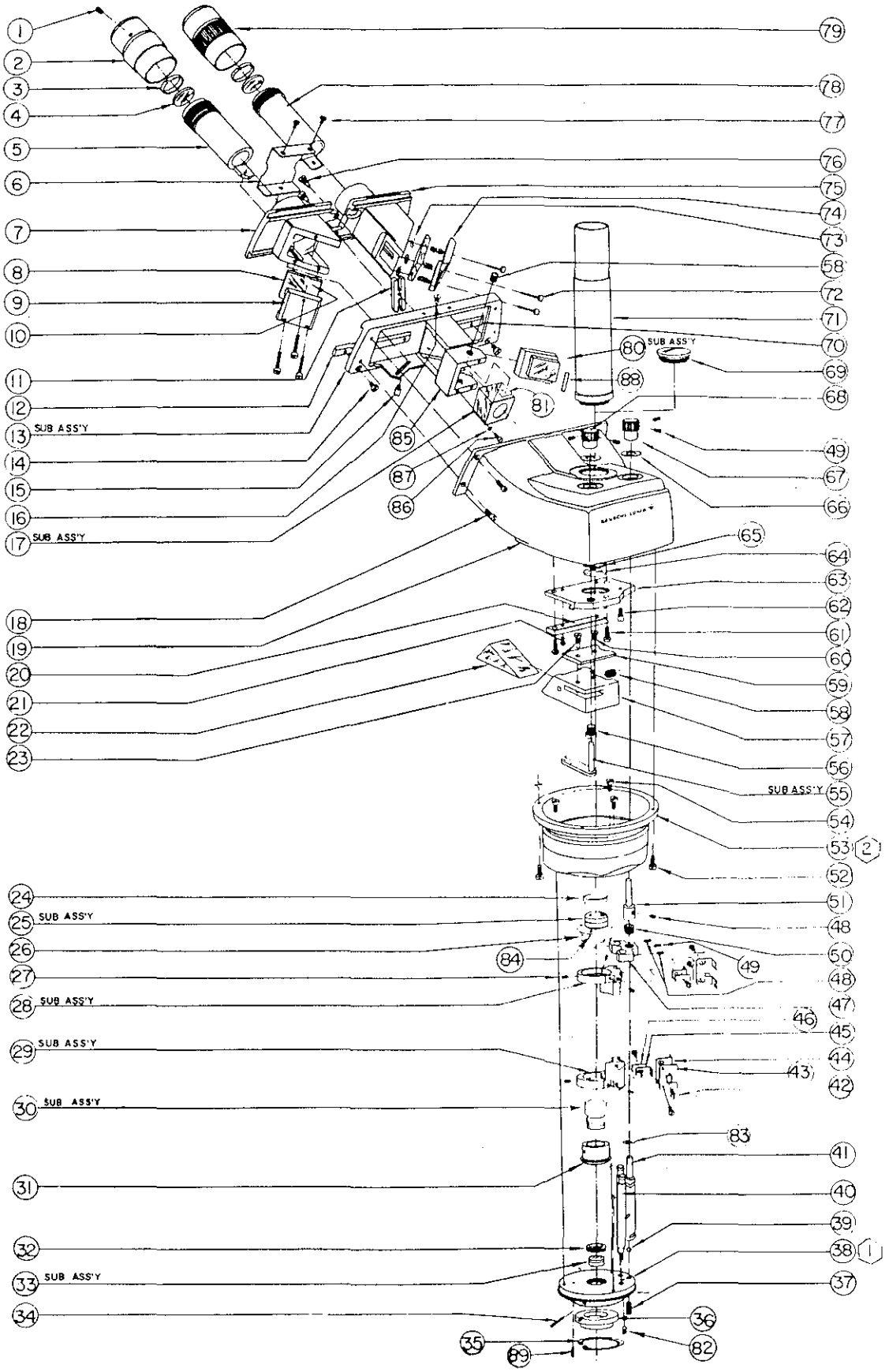
OPTILUME ILLUMINATOR 31-33-88

Legend	Description	Drawing No.
1	Cord Set	313390-128
2	Terminal Set	313390-103
3	Base	313386-113
4	LC-19 Connector	714901-555ND
5	Switch Nut	313390-122
6	Switch	313386-107
7	Terminal B	313390-104
8	#4-1/4 lg. Self-Tap Screw	313353-204ND
8	F-240 Washer	90008-263
9	LY-115 Lampholder	313302-107ND
10	#4-.187 lg.Self-Tap Screw	313386-108ND
11	Insulator	313390-105
12	Lamp(15W.115V.S11.MSB)	313115-101ND
13	Filter Support Spring	313390-121
14	Filter Support	313390-111
15	Lens Adapter	313388-110
16	Cover	313386-114
17	Lens	313388-022
18	Spacer	313388-112
19	Lens	313479-021
20	Filter	313388-021
21	Reflector	313477-102
22	Shield	313388-113


12 STEEL BALLS SELECTED TO .0001 Ø ACCURACY

BASE AND ARM 31-01-05

Legend	Description	Drawing No.
1	SD-62 Screw	90047-120
2	F.A. Drum B	310105-167
3	F-39 A Washer	90008-398
4	2-64U4S Screw	96226-1218
5	Lock Nut	310105-110
6	C.A. Button B	310105-135
7	F-252 Washer	90008-382
8	Washer	310105-178
9	F-252 Washer (Plastic)	90008-384
10	Body Mount	310105-222
11	Plug	310105-219
12	SB-15 Screw	90045-20
13	Arm	310105-275
14	Lock Screw	310105-186
15	F.A. Nut Spring	310105-240
16	.0937Ø Steel Ball	512108-122ND
17	F.A. Nut Housing	310105-172
18	SB-20 Screw	90045-25
19	F.A. Screw	310105-269
20	C.A. Button A	310105-112
21	#R-3 Ball Bearing	310102-129ND
22	Knob Screw	310105-169
23	F.A. Drum A	310105-113
24	Drive Screw	310105-108
25	Button C	310105-158
26	Base Plug	310105-221
27	Base	310105-259
28	8-32T x .500 lg. Cap Screw	338640-185ND
29	Lockwasher	532301-119ND
30	F-21 Washer	90008-38
31	Spring B	310105-155
32	Spring A Assy	310105-211
33	F.A. Worm	310105-111
34	F.A. Spring	310105-109
35	F-312 Washer	90008-381
36	Tru-Arc Retainer	310105-129ND
38	8-32T x .375 lg. Mach. Screw	310105-251ND
39	Ball Spacer	310105-120
40	Gib	310105-250
41	Slide	310105-243
42	Slide Adapter	310105-216
43	8-32T x .375 lg. Mach. Screw	310105-220ND
44	Pinion	310105-268
45	8-32T x .500 lg. Mach. Screw	310105-137ND
46	Rack	310105-121
48	R-4 Ball Bearing	310105-170ND
49	Washer	310105-132
50	F.A. Gear	310105-266
51	Clutch Wheel	310105-267
52	Spring Washer	310105-241ND
54	6-40T Stop Nut	310105-165ND
55	F-21 Washer	90008-269
56	F-252 Washer (Plastic)	90008-384
57	Clutch Washer	310105-209
58	F-24 Washer	90008-429
59	6-32 x .500 lg. Cap Screw	310105-224ND
60	Washer	310105-232
61	Dowel Pin	315936-154ND
62	6-40 Set Screw Nylock	310105-271ND
	Wrench (Not Shown)	533103-796ND
63	I-285 Pin	90011-269
64	Pad	310105-253
65	F.A. Nut	310105-263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DYNAZOOM PHOTO BINOCULAR 31-19-59

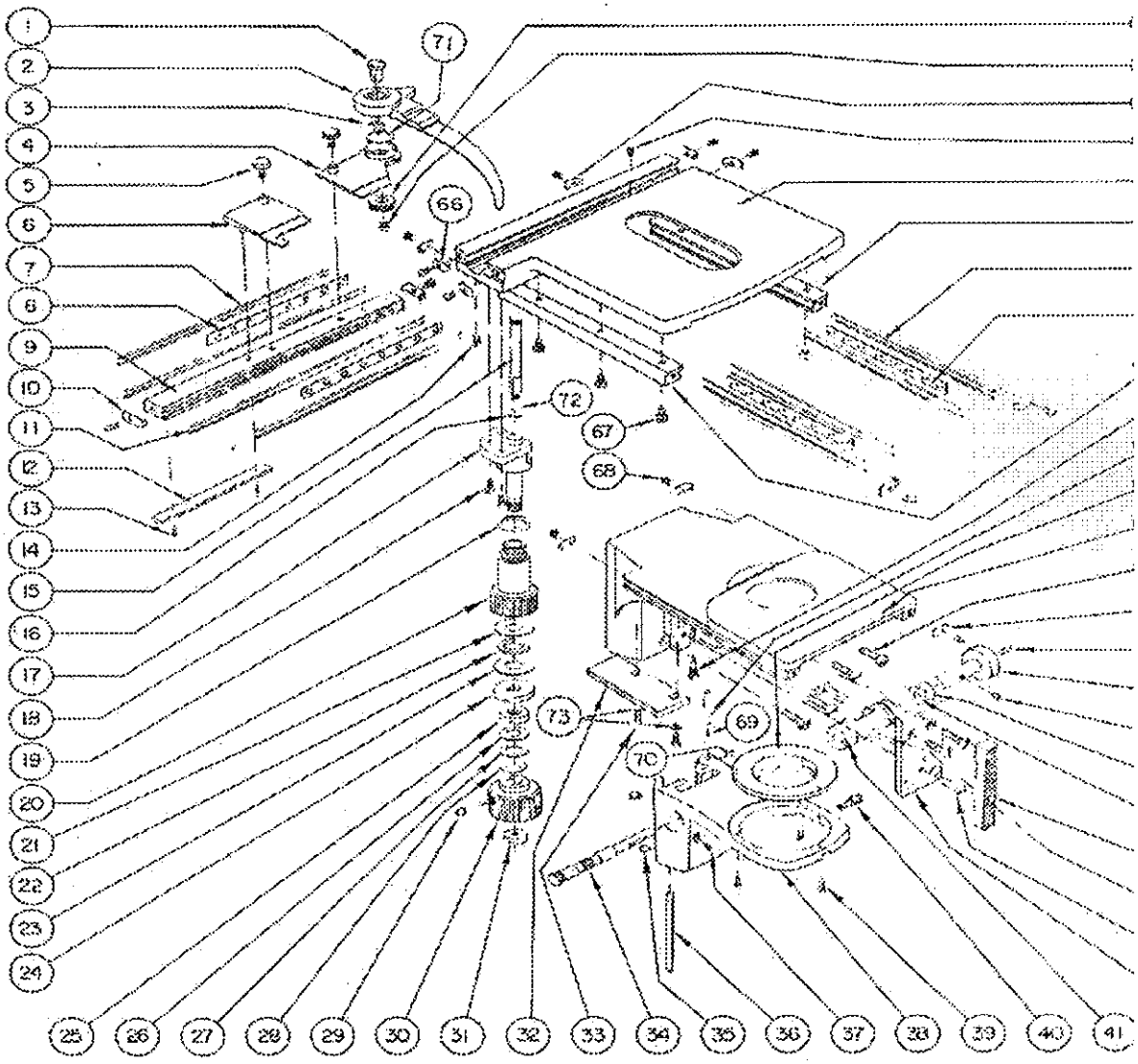
Legend	Description	Drawing No.
1	2-64T2S Screw	96224-1200
2	Eyepiece Tube Adapter (right)	311959-357
3	Spring Ring	311959-319
4	Dust Cover "B"	311959-078
5	Eyepiece Tube (right)	311959-354
6	Top Dust Cover	311959-388
7	Eyepiece Slide Right	311959-330
8	Mirror A	311959-021
9	Mirror Mount Right	311959-139
10	Spring	311959-237
11	Link	311959-147
12	Right Gib	311959-332
13	Top Plate Assy.	311959-392
14	4-40F5S Screw	96206-0405
15	Actuating Screw	311959-303
16	2-5F8S Screw	96206-0204
17	Diaphragm Assy	311959-362
18	4-40T x .187 lg. Mach. Screw	311959-343ND
19	Housing	311959-387
20	Prism Support A.	311959-206
21	4-40F6S Screw	96206-0406
22	Prism A	311959-067
23	Screw A	311959-183
24	AB Retainer	311959-372
25	Lens AB Assembly	311959-065
26	AB Lens Mount	311959-371
27	4-40T x .187 lg. Set Screw.	311959-222ND
28	Top Lens Slide Assy.	311959-376
29	Lens Slide Assy	311959-282
30	CD Lens Cell Assy	311959-399
31	CD Lens Mount.	311959-315
32	EF Retainer	311959-309
33	Lens EF Assy	311959-073
34	4-48T x .375 lg. Set Screw	311959-299ND
35	Tru-Arc Retaining Ring.	311959-300ND
36	Insert	311959-291
37	Adjusting Screw	311959-105
38	Nosepiece Support	311959-340
39	.1562 Ø Steel Ball	312694-152ND
40	Post	311959-263
41	Lead Screw	311959-101
42	4-40T x .187 SEMS Screw.	370106-354ND
43	Spring B	311959-296
44	Spring B	311959-108
45	Spring A	311959-107
46	Spring A	311959-297
47	Tie Block.	311959-115
48	2-56T x .125 lg. Set Screw	311959-128ND
49	2-56T x .156 lg. Set Screw	311959-242ND
50	Bushing	311959-113
51	Lead Screw Shaft	311959-241
52	6-32T x .281 Mach. Screw	311959-180ND
53	Lower Housing	311959-359
54	4-40T x .312 lg. Mach. Screw	311959-178ND
55	Soldered Assy.	311959-261
56	Shaft Bearing	311959-236
57	Prism Mount	311959-294
58	Retaining Ring Small	311955-175
59	Prism Slide	311959-307
60	4-40F7S Screw	96206-0407
61	4-40F8S Screw	96206-0412
62	SC-83 Screw	90046-136
63	Prism Support B	311959-302
64	Dust Cover B	311959-078
65	Retainer.	311959-311
66	F-218 Washer.	90008-224
67	Prism Shift Knob	311959-269
68	Magnification Knob	311959-270
69	Plug	311853-108
70	Left Gib	311959-334
71	Triocular Tube	311959-305
72	2-56T x .500 lg. Cap Screw	311959-216ND
73	F-5 Washer	90008-391
74	Mirror Mount Left	311959-228
75	Eyepiece Slide Left	311959-328
76	Screw C.	311959-190
77	Cover Screw.	311959-326
78	Eyepiece Tube Left	311959-355
79	Eyepiece Tube Adapter Left	311959-358
80	Mirror B Assy	311959-383
81	BC Pressure Plate	311959-306
82	2-56T x .375 lg. Set Screw.	311959-217ND
83	F-187 Washer.	90008-296
84	Screw	311959-373
85	Prism Mount	311959-390
86	2-56 x 3/4 lg. Cap Screw (3)	311959-393ND
87	F-119 Washer (3)	90008-124
88	Shim (as req'd)	311959-394, 395 or -396
89	Pin I-287	90011-301

DYNAZOOM FLAT FIELD PHOTO BINOCULAR 31-18-03

(All Parts Similar to 31-19-59 Except Items Listed & Designated with a ⬡.)

Legend	Description	Drawing No.
1	Nosepiece Support	311803-106*
2	Lower Housing	311803-103*
	Lens AB Assy (Not Shown)	311811-028*
	Retainer (Not Shown)	311803-104*

*Must be factory installed and collimated.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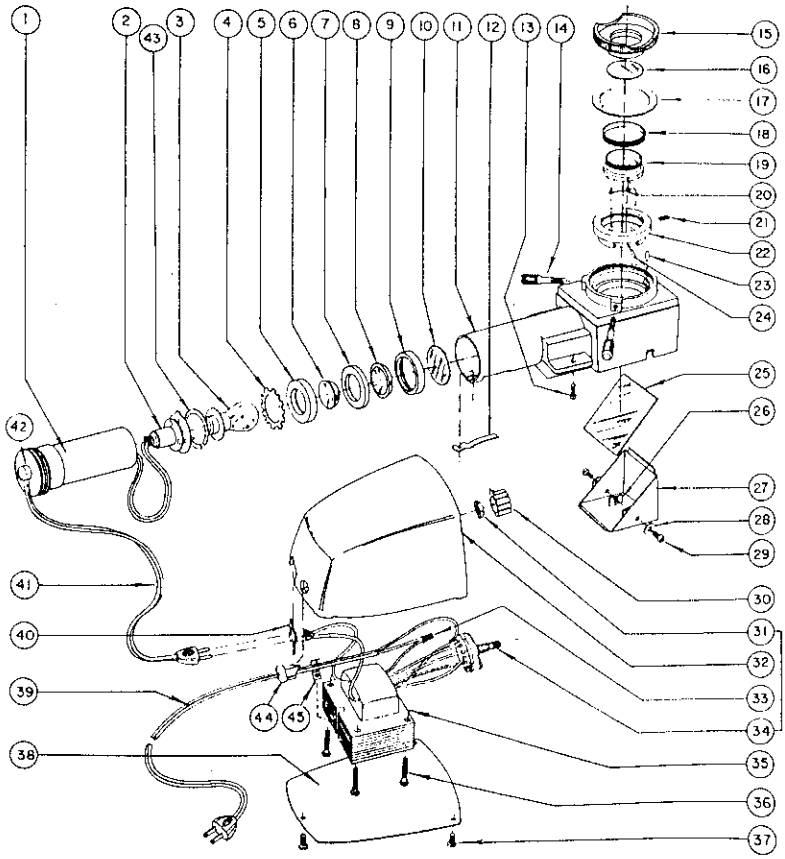
MECHANICAL STAGE 31-59-38

Legend	Description	Drawing No.
**1	Finger Pivot	315938-178
**2	Finger Assy	315938-203
**3	Finger Spring	315938-161
**4	Right Slide Holder	315938-190
**5	Slide Holder Screw	315938-145
**6	Slide Holder Assy	315938-201
7	Cross Gib Rod	315938-120
8	Cross Slide Ball Spacer Assembly	315938-116
9	Cross Slide	315938-125
10	Slide Retainer	315938-129
11	Cross Slide Rod	315938-119
12	Transverse Rack	315938-101
13	2-64F6S Screw	96206-1209
14	SD-80 Screw	90047-142
*15	Transverse Pinion	315938-111
*16	Upper Pinion Washer	315938-138
*17	Sleeve & Block Assy	315938-105
*18	4-40F7S Screw	96206-0407
*19	B. F. Washer	315938-154
*20	B. F. Pinion Knob	315938-110
*21	F-76 Washer	90008-395
*22	Washer 3515-18-06 Shakeproof	315938-157ND
*23	F-76 Washer	90008-395
*24	Upper Lock Nut	315938-112
*25	Pinion Lock Nut	315938-109
*26	F-287 Washer	90008-374
*27	Washer	315938-195
*28	F-251 Washer	90008-275
*29	Set Screw	315938-156
*30	Inner Pinion Knob	315938-174
*31	Lower Lock Nut	315938-108
32	B. F. Rack	315938-102
33	6-32G12T Screw	97208-0605
34	Pinion	315936-120
35	Nylok Set Screw	315936-150ND
36	Gib	315936-149
37	6-40 x 3/16 Soc. Set Screw	315936-158ND
38	Sub-Stage Support	315936-153
39	Screw	315936-138
40	Screw	315936-152
41	Eccentric Sleeve	315936-144
**42	Finger Bushing	315938-172
**43	Screw	315938-171
44	B & F Retainer	315938-127
45	2-64F3S Screw	96206-1215
46	Cross Slide Assy	315938-151
47	Retaining Gib Right	315938-186
48	Retaining Gib Rod	315938-117
49	B. F. Bearing Assy	315938-115
50	Retaining Gib Left	315938-187
51	B. F. Stop Screw	315938-189
52	Dowel Pin	315936-154ND
53	Sub-Stage Ring	315936-157
54	Stage Support	315938-210
55	8-32F30S Screw	96206-0805
56	Stage Retainer	315938-126
57	SD-123 Screw	90047-187
58	Sub-Stage Pinion Knob	315936-121
59	4-40T x .125 lg. Set Screw	715713-195ND
60	F-22 Washer	90008-23
61	F-317 Washer	90008-401
62	Rack	315936-146
63	4-48F12S Screw	96206-1412
64	8-36F12T Screw	97206-1826
65	Slide	315936-155
66	Gib Retainer	315938-128
67	6-40F13S Screw	96206-1614
68	2-56B4T Screw	97200-0202
69	Spring	315936-140
70	6-40 Set Screw	315936-143ND
**71	Washer	315938-207
*72	Washer	315938-196
73	F-306 Washer	90008-369

*Available as: Pinion Cluster Assembly 315928-130

**Available as: Right Slide Holder Assembly 315938-910



BASE ILLUMINATOR 31-33-69 & 31-35-48 TRANSFORMER

Legend	Description	Drawing No.
1	Lampholder Tube	313369-134
2	Lampholder	313359-106
3	Lamp (GE #1634)	313137-102
4	Lens Retainer	313359-120
5	Lens Cell Washer	313359-117
6	Lens A	313369-021
7	AB Spacer	313359-103
8	Lens B	313359-022
9	BC Spacer	313359-104
10	Lens C	313359-023
11	Housing	313369-102
12	Spring	313359-148
13	8-32T x .375 lg. Mach. Screw	313369-132ND
14	Screw	313369-108
15	Ring	313369-103
16	Cover Glass	313320-024
17	Lock Nut	313369-106
18	Retainer	313369-105
19	Slotted Ring	313369-104
20	Leaf Assy Need 10	423372-111
21	Spring	313320-139
22	Drilled Ring	313369-110
23	I-287 Pin	90011-301
24	I-316 Pin	90011-332
25	Mirror	313320-023
26	4-40T Speed Nut	313359-113ND
27	Mirro Mount	313320-112
28	F-24 Washer	90008-25
29	4-40F9S Screw	96206-0402
30	Selector Knob	313353-146
31	Switch Nut	313359-136
32	Transformer Housing	313548-101
33	LC-18 Wire Connector	334575-123
34	Switch	313359-136
35	Transformer	313359-124
36	6-32T X 1.250 lg. Mach Screw	313359-128ND
37	SE-114 Screw	90048-158
38	Cover	313548-112
39	Cord Set	313539-101
40	LC-14 Interlock Connector	313548-103
41	Cord Set Assy	313369-136
42	Strain Relief SR-13-1	313369-127ND
43	Spring Ring	313320-144
44	Strain Relief SR-4K-1	313369-118ND
45	Cable Clamp LX 70-C	412340-236ND