Bausch & Lomb

MICROSCOPE ACCESSORIES

Optical Systems for the Microscope

Optical systems for the microscope depend for their performance upon three factors, namely, correct design, optical material that meets the rigid specifications, and manufacturing skill and experience through which the designer's calculations are translated into working instruments.

The formulae of Bausch & Lomb objectives are based upon the most precise and extended calculations. All the elements of construction, radii, thickness of component lenses, separation, etc., are determined in advance. Utilizing the wide range in choice of optical material made possible by the production of optical glass in the Bausch & Lomb Glass Plant, the designer can control more completely the effects of each element on the image-forming qualities of the entire system and apply his resources to the best advantage.

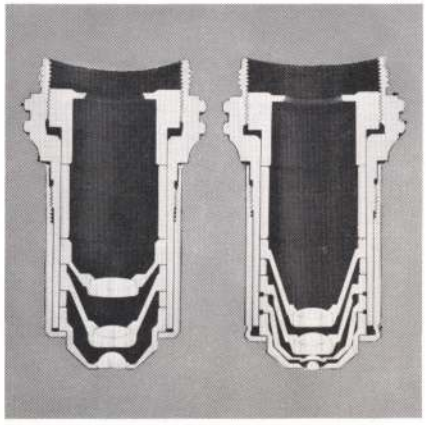
The importance of complete control of optical material can not be overestimated. Because the designer has at his disposal the resources of the Bausch & Lomb Glass Plant, he need not effect a compromise between favorable design and available material. In fact, he is in position to specify combinations of refractive index and dispersion that are required for more complete accord between optical theory and the optimum imagery in practice.

Because of their long experience and the complete technical equipment at their disposal, Bausch & Lomb engineers have been able to realize the expectations of the designer in the actual system.

As a final guarantee of uniformity and excellence each objective is subjected to a most severe test conducted on a rigid scientific basis. This final test is independent of previous steps in design or manufacture.

Bausch & Lomb objectives are mounted with the standard Society screw thread. The lens elements are precisely centered and burnished in the individual threadless metal cells, which remain unchangingly centered even though the objectives are taken apart and reassembled for any reason.

Consequently it can be safely said that Bausch & Lomb objectives are the best that can be made for the various kinds of work for which they are intended. Specifications of focal lengths are accurate to within 2%; numerical apertures are as given.



Examples of
Bausch & Lomb Threadless Cell Mounting

Balcoted Optical Elements

Bausch & Lomb now offers optical parts with Balcoted air-glass surfaces. Through wide experience with treated optics for binoculars, camera lenses and metallographic microscopes, the advantages of anti-reflection filming have been thoroughly established. In biological microscopes, Balcoted optics perform especially well where specimens contain a marked contrast between light and dark portions.

The reflection of light from a lens surface is an inherent characteristic that follows the natural laws of physical optics. This reflection, multiplied several times in a complex lens system, results in internal flare, detracting from the clarity and crispness of the image. Balcoting of the several surfaces minimizes these objectionable reflections. The result is a sharper, clearer image most truly interpretive of the tonal characteristics of the specimen.

The treatment, itself, consists of the deposition, on each air-to-glass surface, of a film, its thickness equal to one-fourth the wavelength of the color of light for which maximum transmission is desired. The refractive index of this film is the square root of the index of refraction of the glass to which it is applied.

Balcote surfacing is of about the same hardness as glass and its presence on the exposed surface of an optical part poses no special problem in handling. It can be cleaned in the same way that a glass surface is cleaned and, with the usual careful handling given fine optical parts, will last for the life of the lens.

Magnification

The objective of a microscope, when properly focused, produces, in the upper end of the body tube, an image of the object on the stage. The ratio of the size of the image to that of the object is termed initial magnification and increases with increase in tube length and with decrease in the objective's equivalent focal length (E.F.).

The eyepiece acts as a magnifier. the number of times it magnifies the image formed by the objective multiplied by the initial magnification of the latter being the total magnification. Thus an objective with an initial magnification of 43× and an eyepiece magnifying 10× will give a total magnification of 430×.

Specific magnification factors are engraved on each Bausch & Lomb objective and eyepiece. This enables their total magnification to be determined at a glance when the prescribed tube length, 160mm, for which the objectives are computed, is used.

Numerical Aperture

Resolving power is the property by which an objective shows distinctly separated two small elements in the structure of an object, which are a short distance apart. The measure for the resolving power is the numerical aperture (N.A.). The higher the N.A., the greater the resolving power of the objective and the finer the detail it can reveal. N.A. is given by the formula, N.A. $= n \sin u$ wherein n is the lowest refractive index that appears between the object and the front lens of the objective, and u is half the angular aperture of the objective.

Importance of N.A.

If a very narrow central pencil is used for illumination, the finest detail that can be shown by a microscope, with high enough magnification, is equal to $\frac{\text{w.l.}}{\text{N.A.}}$, where w.l. is the wave length of the light used. The wider the pencil, the greater the resolving power, until a maximum is reached, when the width of the pencil is sufficient to fill the whole aperture of the objective. In this case, the resolving power is twice as great, the finest detail that the objective can show being now equal to $\frac{\text{w.l.}}{2\text{N.A.}}$. This same limit is reached when a narrow pencil of greatest possible obliquity is used. For example, the wave length of the brightest part of the spectrum may be assumed to equal 0.00053mm. Consequently, an objective of N.A. equal to 1.00 will resolve two lines separated by a distance of $\frac{0.00053}{1.00} = 0.00053$mm with a narrow central illuminating cone, and $\frac{0.00053}{2 \times 1.00} = 0.000265$mm, with a cone filling the whole aperture, or with a narrow oblique cone. A 4mm, 0.85 N.A. objective should, theoretically, resolve lines separated by distances ranging between 0.00062 and 0.00031mm, dependent upon the mode of illumination employed. For a 4mm, 0.65 N.A. objective the limiting values are 0.00081 and 0.000405mm.

The N.A. can also be expressed by the equation

$$\text{N.A.} = \frac{d}{2\times \text{Equivalent Focus}}$$

wherein d is the effective aperture of the back lens.

Hence, it is evident that an objective cannot show its full efficiency if it is not used with a condenser of sufficient N.A. to fill the back of the objective with light. Whether the back of the objective is filled with light can be ascertained by removing the eyepiece and viewing the back lens of the objective with the naked eye. If the entire back lens is filled with light, the full aperture engraved on the objective comes into action.

Depth of Focus

Depth of focus (known also as depth of sharpness or penetration) is another important factor which is often not clearly understood. It depends on the N.A. and the magnification and is inversely proportional to both. The higher the N.A. and the higher the magnification, the less the depth of focus. It is beyond the power of the optician to change these conditions.

Every effort aiming at an increase of the depth of focus, for instance, by inserting diaphragms above the back lens of the objective, decreases the effective diameter of the back lens and hence the resolving power.

For example, the depths of focus of the two 4mm objectives, of N.A. 0.85 and N.A. 0.65 respectively, when used with the same magnification, are in the ratio of 3:4.

Cover Glass Thickness

Bausch & Lomb dry objectives are corrected for a cover-glass thickness of 0.18mm, the mean thickness of No. 2 cover glass, which has been found the most practical for general use. For critical work where a dry objective is expected to show all its efficiency, a measured cover glass of 0.18mm thickness should always be employed. This is very important, as when using large aperture dry objectives a variation of 0.03mm in the thickness of the cover glass may destroy the spherical correction, and with it the definition of the object.

The influence of slight differences in the thickness of the cover glass may be compensated for by increasing the tube length in case of too thin a cover glass, and shortening for one too thick. The amount of compensation thus obtainable varies with the E.F. and the N.A. of the objective. In a 4mm objective of 0.85 N.A., for instance, an increase in tube length of 30mm will balance a decrease in cover-glass thickness of 0.03mm.

The performance of homogeneous immersion objectives is quite independent of variations in the thickness of cover glass, as the refractive index of Bausch & Lomb immersion liquid (Cargille's oil) is practically the same as that of the cover glass. However, due to limitations of working distance, the cover glass used with apochromat immersion objectives should be thinner than used with achromat immersion objectives. On the other hand, the correct tube length (160mm) must be strictly adhered to, a variation of 5mm being sufficient to destroy image perfection.

Tube Length

The tube length for which all Bausch & Lomb objectives are computed, unless otherwise stated, is 160mm (about 6½ inches), reckoned from the upper end of the microscope tube to the shoulder of the objective screw.

Achromatic Objectives — *Balcoted*

32mm, 4×

30mm, 3.5×

16mm, 10×

4mm, 43×

1.8mm, 97× Oil

Resolution of Bausch & Lomb Achromatic Objectives is of a very high order, fitting them for a wide range of visual and photographic work. Chromatic aberration is fully corrected for two colors and the spherical aberration generally for one.

Bausch & Lomb Achromatic Objectives are corrected for cover glass of 0.18mm thickness and mechanical tube length of 160mm.

The 21× objective, 0.50 N.A., has found great favor in histological investigations where a high order of correction and great brilliancy at relatively high magnifications are desirable. Its long working distance makes it desirable for micro-projection as well as for visual work.

The 43×, 0.65 N.A. objective is distinguished by a long working distance which permits focusing through the thickest cover glass used in laboratory work. The 45×, 0.85 N.A. objective has a shorter working distance and less depth of focus, but it has as compensation a greater resolving power.

A series of Achromatic Objectives is supplied for opaque object work (as metallurgy) where the vertical illuminator in use makes necessary correction for uncovered specimen and increased tube length. Complete information is given in Catalog D-1053, "Metallurgical Microscopes." It will be sent on request.

Fluorite, or Semi-Apochromatic, Objectives

This type of objective combines with glass the crystal, Fluorite, which, because of its dissimilar index of refraction and dispersion produces an image quality approaching that of Apochromatic Objectives. When a better resolution is desired than can be obtained with the Achromatic series, the moderate cost of the Fluorites makes them preferred to the more expensive Apochromatic series. They are also excellent for use in photomicrography.

Bausch & Lomb offers two Fluorite objectives, both oil immersion, one of 40×, the other 98×.

Catalog Number Balcoted	*Type*	*Initial Magn. ×*	*E.F. in mm*	*N.A.*	*Work. Dist. mm*
ACHROMATIC OBJECTIVES					
31-10-05-01	Dry	2×	48	0.08	59.0
31-10-07-01		2.6×	40	0.08	43.5
31-10-06-01		*3.5×	30	0.09	17.8
31-10-09-01		4×	32	0.10	38.0
31-10-18-01		*6×	22.7	0.17	15.5
31-10-19		°10×	16	0.25	6.2
31-10-20-01		§10×	16	0.25	7.7
31-10-22-01		†10×	16	0.25	4.5
31-10-27-01		21×	8	0.50	1.6
31-10-24		°43×	4	0.55	0.4
31-10-29-01		43×	4	0.65	0.6
31-10-31-01		45×	4	0.85	0.3
31-10-35-01		60×	3	0.85	0.2
31-10-71-02	Oil	97×	1.8	1.25	0.13
ACHROMATIC OBJECTIVE WITH IRIS DIAPHRAGM					
31-10-72-02	Oil	**97×	1.8	1.25	0.13
FLUORITE OBJECTIVES					
31-10-59-02	Oil	40×	4.3	1.00	‡0.27
31-10-73-02		98×	1.8	1.30	0.13

*These are parfocal with higher powers.
**Intended for use in dark field microscopy.
§Non-divisible.
†Divisible—4× with lower element removed.
‡This Objective can be supplied on special order with working distances from 0.27 up to 1.5mm. Price on request.
°Without Balcote for ST Student Microscope (color-coded).

All Objectives are supplied with Balcoted anti-reflection treated lens surfaces, except as noted otherwise.
All Objectives supplied in transparent plastic boxes, except 31-10-19 and 31-10-24.

Achromatic Objective with Iris

Apochromatic Objectives — *Balcoted*

16mm, 10× *8.3mm, 20×* *4mm, 47.5×* *2mm, 90× Oil*

The superiority of Apochromatic Objectives over other types lies in their finer color correction. Chromatic aberration is corrected for three colors of the spectrum and spherical aberration for two colors, which means that practically all of the images produced by the different colors of the spectrum lie in the same plane and are equally sharp. The consequence is a higher efficiency for Apochromats, revealed by absence of color halo when focusing with central illumination on a black and white object and by the appearance of such an object (Abbe test plate) under oblique illumination.

The image of the Abbe test plate formed by an Achromatic Objective is fringed by heavy borders of color, but that produced by the Apochromatic Objective has practically no noticeable color fringes. Diatoms, plant sections, etc., are rendered in their natural black and white, while the Achromatic Objective will show them in the yellowish or greenish hue of the color for which spherical aberration is corrected.

Although differently colored images lie in the same plane, they are of different sizes which, with ordinary eyepieces, would give color fringes near the edge of the field. This difference, however, is neutralized by Compensating Eyepieces, so that the combination of Apochromatic Objective and Compensating Eyepiece gives a field free of color to the very margin.

The common designs of Apochromatic Objectives produce a field of view decidedly lacking in flatness. Bausch & Lomb engineers have remedied this condition to a remarkable degree without shortening working distance or reducing numerical aperture.

All Apochromats are mounted so as to be parfocal.

To obtain the full benefit of the superior quality of these objectives and particularly in making comparisons, it is absolutely imperative that the conditions for which they are intended are strictly adhered to. A tube length of 160mm must be constantly maintained and the 4mm dry objective with correction collar must be carefully adjusted for the thickness of the cover glass used.

APOCHROMATIC OBJECTIVES—Balcoted

Catalog Number	*Type*	*Initial Magnification*	*E.F. in mm*	*N. A.*	*Working Dist. in mm*
31-11-71-01	Dry	10×	16	0.30	4.85
31-11-78-01		20×	8.3	0.65	0.50
31-11-81-01		47.5×*	4	0.95	0.18
31-11-89-02	Oil Immersion	61×	3	1.40	0.12
31-11-91-02		90×	2	1.30	0.12
31-11-93-02		90×	2	1.40	0.07

*Adjustable for cover glass thickness from 0.15 to 0.25mm by means of graduated correction collar.
All Objectives supplied in Transparent Plastic Boxes.

Microscope Eyepieces — *Balcoted*

Huygenian Eyepiece

Huygenian Eyepieces

The simplest type of eyepiece is the Huygenian, designed principally for use with Achromatic Objectives. It consists of two plano convex lenses mounted one at each end of the eyepiece tube, with a field diaphragm between them. These eyepieces effect a certain amount of correction for chromatic difference of magnification in the Achromatic Objectives. Six Huygenian Eyepieces are listed, with the newly designed 5× providing a particularly long eye relief.

A 7.5× and a 10× eyepiece with focusing eyelens are listed, for use with micrometer discs. The disc (see page 8) is placed on the diaphragm and the eyelens can then be focused until the lines of the micrometer disc are sharp.

Each eyepiece is engraved with its magnification value when used as a simple magnifier. This value multiplied by the magnification value of the objective, gives total magnification. The cone shaped cap of B&L eyepieces provides greater viewing comfort, particularly for those who wear spectacles.

Hi-Point Eyepiece

Hi-Point Eyepiece

The 10× Hi-Point is most satisfactory for all visual applications (except photomicrography) wherever a Huygenian or Wide Field would normally be used. Eye relief, 25.0mm on a monocular microscope, and 21.1mm on a binocular, is about three times that of a 10× Huygenian. Although field coverage is slightly less, improved flatness of field offers more usable, in-focus area than any other eyepiece giving similar measured field coverage.

The Hi-Point is the ideal choice for those who wear glasses, have long lashes or otherwise prefer eyepieces with long eye relief.

Hyperplane Eyepieces

Hyperplane Eyepieces are featured by a flatter image plane than Huygenian Eyepieces. The advantage of this is especially appreciated in photomicrography.

They have a color compensation about midway between the Huygenian and Compensating Eyepieces. This makes their use with high power Achromatic and Fluorite Objectives extremely advantageous.

The Hyperplane Eyepieces have larger fields than the Huygenian.

Compensating Eyepieces

Compensating Eyepieces are primarily corrected for use only with Apochromatic Objectives. They are properly computed to eliminate the color fringes which are conspicuous when such objectives are used with ordinary eyepieces. The Compensating Eyepiece balances the chromatic difference of magnification of the Apochromatic Objective, hence the name.

They can, however, be used successfully with the higher powers of Achromatic and Fluorite Objectives, with good results.

Wide Field Eyepiece

These eyepieces, manufactured especially for use with stereomicroscopes are positive Achromatic Eyepieces, having a large eye lens and a high eyepoint. They may also be used with achromatic objectives on biological microscopes. The field of view is larger than with other eyepieces. These eyepieces are designed for the acceptance of a micrometer disc.

Correlation of Objectives and Eyepieces

To secure the best optical performance of standard microscope eyepieces and objectives, the table, which appears on the following page, has been prepared showing the most satisfactory type of eyepiece to use with each objective. By following this suggested combination, the complete microscope optical system exhibits a residual chromatic difference of magnification of less than 0.5 per cent, and hence the clearest image possible.

Correlation of Objectives and Eyepieces, Continued

To clearly see the detail in a specimen it is not enough to decide on a certain total magnification. More important is the selection of an objective with adequate resolving power. Having determined the objective which will serve best then select an eyepiece which will make possible the easy recognition of the detail seen by the objective. To choose a suitable eyepiece for any given objective a general rule to follow is the eyepiece magnification equals 1000× objective N.A. divided by objective magnification.* Then select an eyepiece of this magnification of the type recommended in the table below for the best visual results.

$$*\text{M.E.P.} = 1000\left(\frac{\text{N.A.}}{\text{MO}}\right)$$

CORRELATION CHART

Where Huygenian Eyepiece is indicated, Hi-Point or Wide Field Eyepiece is equally satisfactory.

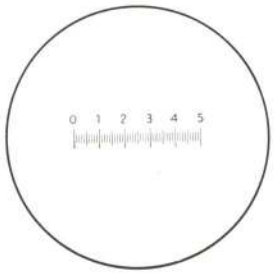
Objective Used	E.F. mm	Most Satisfactory Eyepiece
Achromatic	48.0	Huygenian
Achromatic	40.0	Huygenian
Achromatic	32.0	Huygenian
Achromatic	30.0	Huygenian
Achromatic	16.0	Huygenian
Achromatic	8.0	Hyperplane
Achromatic	4.0	Hyperplane
Achromatic	3.0	Hyperplane
Achromatic	1.8*	Compensating
Fluorite	4.3*	Hyperplane
Fluorite	1.8*	Hyperplane
Fluorite	1.8*	Compensating
Apochromatic	16.0	Compensating
Apochromatic	8.3	Compensating
Apochromatic	4.0	Compensating
Apochromatic	3.0*	Compensating
Apochromatic	2.0*	Compensating

*Oil Immersion Objective.

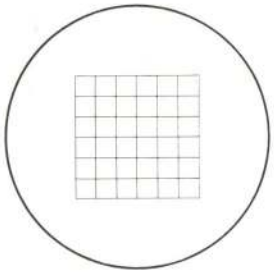
Catalog Number Balcoted	Magnification	Eyepoint in mm
	HUYGENIAN EYEPIECES	
31-15-08-02	5.0× (Paired)	11.7
31-15-08	5.0× (Single)	21.2
31-15-06-02	6.4× (Paired)	16.6
31-15-06	6.4× (Single)	16.6
31-15-07-02	7.5× (Paired)	11.8
31-15-07	7.5× (Single)	11.8
31-15-09-02	10.0× (Paired)	8.3
31-15-09	10.0× (Single)	8.3
31-15-12-02	12.5× (Paired)	6.2
31-15-12	12.5× (Single)	6.2
31-15-15-02	15.0× (Paired)	4.2
31-15-15	15.0× (Single)	4.2
31-15-17	7.5× (Standard)*	11.8
31-15-18	10× (Standard)*	8.3
	HI-POINT EYEPIECES	
31-15-14-02	10× (Paired)	21.1
31-15-14	10× (Single)	25.0
	HYPERPLANE EYEPIECES	
31-05-40-02	5.0× (Paired)	16.1
31-05-40	5.0× (Single)	16.1
31-05-42-02	7.5× (Paired)	9.4
31-05-42	7.5× (Single)	9.4
31-05-44-02	10.0× (Paired)	8.4
31-05-44	10.0× (Single)	8.4
31-05-46-02	12.5× (Paired)	5.7
31-05-46	12.5× (Single)	5.7
31-05-48-02	15.0× (Paired)	15.3
31-05-48	15.0× (Single)	15.3
31-05-50-02	20.0× (Paired)	10.8
31-05-50	20.0× (Single)	10.8
	COMPENSATING EYEPIECES	
31-05-70-02	5.0× (Paired)	15.2
31-05-70	5.0× (Single)	15.2
31-05-72-02	7.5× (Paired)	9.8
31-05-72	7.5× (Single)	9.8
31-05-75-02	10.0× (Paired)	7.7
31-05-75	10.0× (Single)	7.7
31-05-86-02	12.5× (Paired)**	21.2
31-05-86	12.5× (Single)**	21.2
31-05-88-02	15.0× (Paired)	15.7
31-05-88	15.0× (Single)	15.7
31-05-90-02	25.0× (Paired)	9.4
31-05-90	25.0× (Single)	9.4
	WIDE FIELD EYEPIECES	
31-05-51-02	10× (Paired)	12.4
31-05-51	10× (Single)	12.4
31-05-52-02	15× (Paired)	12.3
31-05-52	15× (Single)	12.3
31-05-53-02	20× (Paired)	9.0
31-05-53	20× (Single)	9.0

*Eyepiece with focusing eye lens. Particularly for use with micrometer discs, see page 8.
**This eyepiece has a high eyepoint. See page 14, Number 31-50-76.
When ordering eyepieces, give serial number of microscope.
Hi-Point, Hyperplane and Compensating Eyepieces have a rubber insert in the eye lens mount to prevent scratching of spectacle lenses.
All eyepieces are 23mm standard diameter.

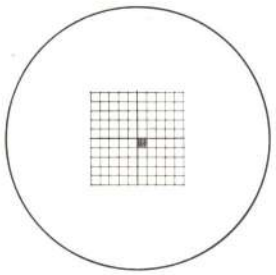
Micrometer Discs



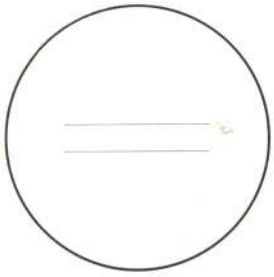
Micrometer Disc, 31-16-05



Howard Disc, 31-16-15



Whipple Disc, 31-16-13



Reticulocyte Disc, 31-16-21

Micron Disc, 31-16-09

These discs are 21.0mm in diameter, and are placed in the eyepiece, resting on the diaphragm, scale downwards. A spring ring is supplied to hold the disc in place. In this position the scale lies in the focal plane of the real image formed by the field lens. See page 9, "Measuring With the Microscope."

Howard Disc

The Howard Disc for mold counting has one square 9.96mm on a side ruled in 36 squares, each with an area equal to one-sixth the diameter of the opening in the 10× Huygenian eyepiece diaphragm, with the microscope calibrated for the Howard method.

Whipple Disc

The Whipple Disc, used for counting bacteria and dust particles, has a large square, 7.0mm, subdivided into four smaller ones, each of which in turn is subdivided into twenty-five smaller squares. One of the latter is further subdivided into twenty-five more squares.

Milk Smear Disc

A Milk Smear Disc, for the counting of bacteria in milk smears, has an 8.0mm diameter circle with cross lines dividing it into quadrants for easy and accurate counting. This disc should be used in a 6.4× Huygenian Eyepiece on a monocular microscope, and with an oil immersion objective. The draw tube of the monocular microscope should be adjusted so that the diameter of the circle has a value of 0.146mm at the specimen.* Binocular microscopes require a specially engraved disc.

*"Counting Bacteria by Means of the Microscope," Robert S. Breed and James D. Brew, Circular No. 58, N. Y. S. Exp. Sta., Geneva, N. Y.

Reticulocyte Disc

For the study of the rate of red blood corpuscle production, a rapid method of counting reticulocytes in seriatim has been worked out by Doctor F. M. Johns of Tulane University School of Medicine, which calls for the use of a specially ruled Reticulocyte Disc, in conjunction with a 10× eyepiece, an oil immersion objective, and a mechanical stage.** The space between the two lines is 2mm.

**"An Inexpensive Ocular Ruler to Facilitate Reticulocyte Counting." F. M. Johns, M.D., *American Journal of Clinical Pathology*, Vol. II, No. 4.

Micron Disc

A budget priced stamped metal disc for approximate measurements, the Micron Disc projects a saw-tooth pattern at the margin of the field. The disc does not obstruct the field of view. When used with B&L 10× Huygenian eyepiece and achromatic objectives, the value between divisions of the pattern is 50 microns with the 10× objective, 12 microns with the 43× objective and 5 microns with the 97× objective.

Catalog Number	Specifications
31-16-01	Micrometer Disc, scale 5mm long, ruled to 0.05mm, with every twentieth line numbered
31-16-02	Micrometer Disc, scale 10mm long, ruled to 0.1mm, with every tenth line numbered
31-16-03	Micrometer Disc, ruled to measure 0.001" divisions on the specimen, when used with calibrated combination of 16mm objective, and 10× eyepiece
31-16-05	Micrometer Disc, scale 5mm long, ruled to 0.1mm with every tenth line numbered
31-16-08	Micrometer Disc ruled to measure 0.001" divisions on the specimen when used with calibrated combination of 10× widefield eyepiece and 3.0× paired widefield objective
31-16-09	Micron Disc, with instructions for use
31-16-11	Micrometer Disc, ruled in 196 squares, each 0.25 square mm in area, with every second line on two adjacent sides numbered
31-16-12	Micrometer Disc, ruled in 49 squares, each 1.0 square mm in area, with every line on two adjacent sides numbered
31-16-13	Whipple Micrometer Disc, as described, for counting bacteria
31-16-15	Howard Micrometer Disc, as described, for mold counting
31-16-20	Milk Smear Micrometer Disc, as described
31-16-21	Reticulocyte Disc, as described
31-16-30	Cross Line Disc, 21mm in diameter
31-16-57	Eyepiece pointer, wire, projecting a pointer into the field of view

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 either glass plates of a diameter which permits introducing them into standard eyepieces or they are mounted permanently in an 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 of which the plate is fixed in position and in the other movable laterally by means of a screw.

Before measurements can be made with any eyepiece micrometer 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 in 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. Then 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 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.

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 ($1.86 \div 0.1 = 18.6$). If an object subtends 0.25mm in the eyepiece, its actual size is $0.25\text{mm} \div 18.6 = 0.0134\text{mm}$.

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 instance, 0.1mm on the stage micrometer scale covers 18.6 divisions in the eyepiece scale. Therefore, one division of the eyepiece scale equals $0.1\text{mm} \div 18.6$ or 0.00537. The size of an object subtending 2.5 divisions in the eyepiece will be $2.5 \times 0.00537 = 0.0134$ mm.

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 careful attention to focusing.

The Necessity for Practice

Facility in the manipulation of an instrument so complex as the compound microscope cannot be acquired by reading once through a simple set of "instructions." No matter how simple or how elaborate your equipment may be, you should learn what its capabilities are and be able to use the instrument without hesitation in such a manner as to exhaust these capabilities. To this end it is suggested that you obtain access to any of the several treatises on Microscopy in order to learn what the capacity of various objectives is in resolving fine detail in various classes of objects, and that you then practice adjusting illumination, perfecting focus, etc., until you make your instrument yield these results. Begin with low powers first and proceed gradually to the higher powers.

For such practice work certain well known preparations serve excellently and have been standard for many years.

For *low powers,* use the proboscis of the blow fly (this should be flat and transparent), or the scales from Lepisma saccharina.

For *medium powers,* the diatom Pleurosigma angulatum mounted dry, stained bacteria, and micrococci.

For *high powers,* the diatoms Amphipleura pellucida and Surirella gemma mounted in balsam or styrax, stained bacteria, and micrococci.

These objects, especially the diatoms, are characterized by definite markings of fairly uniform size. The character and size of these markings will be found described in almost every treatise on microscopy, together with statements of the equipment required to resolve them. A study of such specimens, therefore, offers you means of judging your proficiency in the use of a microscope.

Micrometer Eyepieces — *Balcoted*

The Filar is the most accurate of the micrometer eyepieces. It is a Ramsden 12.5× focusable on the movable crossline, actuated by a micrometer screw. One revolution of the drum, which has 100 graduations, moves the crossline 1.0mm. Estimations to one-tenth of each interval are easily made.

A fine line through the center of the field parallel to the screw axis serves as a guide in orienting the object with reference to the direction of movement of the crossline.

In the lower section of the field a scale ruled in 0.5mm with every second interval numbered serves for counting the screw revolutions.

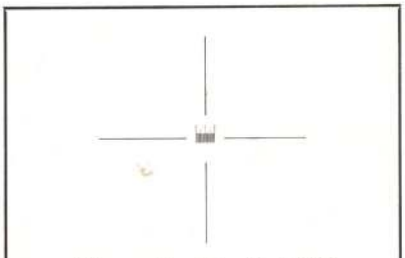
Two 7.5× Huygenian eyepieces have scales divided into 0.1mm with every fifth and tenth lines numbered. The eyelens focuses on the scale, which is fixed in one and movable in the other by a screw on the side.

To determine the absolute value of each graduation on these micrometer eyepieces it is necessary to calibrate the eyepiece with a stage micrometer. (See section below.)

Filar Micrometer Eyepiece, No. 31-16-50

Micrometer Eyepiece, No. 31-16-66

Catalog Number	Specifications
31-16-50	Filar Micrometer Eyepiece, 12.5×, without case
31-16-50-01	Filar Micrometer Eyepiece, 12.5×, in case
31-16-56	Micrometer Eyepiece, 7.5×, with fixed scale
31-16-66	Micrometer Eyepiece, 7.5×, with movable scale

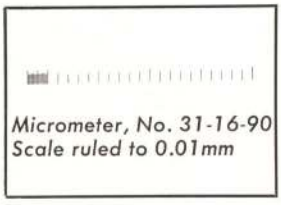


Micrometer, No. 31-16-99
Scale ruled to 0.01mm

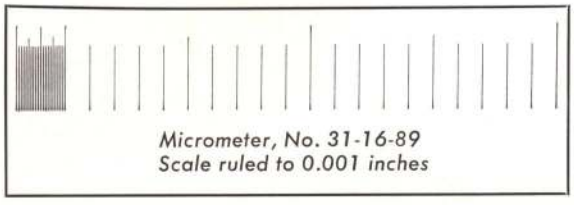
Stage Micrometers

Stage Micrometers, of which there are three, consist of glass slides 25mm x 75mm with scales ruled directly upon them. One, No. 31-16-90, has a scale 2.2mm long, with .2mm of the scale divided into 0.01mm, which divisions appear uniformly spaced at 200 magnification, and the remaining 2mm divided into 0.1mm. The second, No. 31-16-99, is a precision scale with twenty 0.01mm divisions, certified ±0.05 micron, and the complete scale does not have an accumulated error greater than 0.1 micron when used at 68°F. The third, No. 31-16-89, has a scale 0.22″ long, the smallest division of which is 0.001″.

The scale on each stage micrometer is protected by a cover glass cemented over it. Reflected or transmitted light may be used, and the scales are clearly visible. Each Stage Micrometer is supplied in a leatherette case.



Micrometer, No. 31-16-90
Scale ruled to 0.01mm



Micrometer, No. 31-16-89
Scale ruled to 0.001 inches

Catalog Number	Specifications
31-16-89	Stage Micrometer, glass, ruled to 0.001″
31-16-90	Stage Micrometer, glass, ruled to 0.01mm
31-16-99	Stage Micrometer, precision ruled to 0.01mm with certificate of accuracy

Revolving and Centering Nosepieces

Revolving Nosepiece

For rapid change from one objective to another a revolving nosepiece is used. Bausch & Lomb has engineered the finest revolving nosepiece that can be obtained. It will fit the new line of Dynoptic Laboratory Microscopes as well as many of the earlier models. This Rotosphere Ball Bearing Nosepiece is available to carry two, three or four objectives. Its precise action is achieved by ball bearings located around the periphery. A compensator distributes the weight equally to all bearing pressure points and automatically adjusts for any wear that might develop. As the nosepiece is revolved the objectives are accurately positioned on the axis by a ball stop engaging a slot. Repeat settings are identical.

Single Nosepiece, No. 31-19-01, on microscope tube with objective

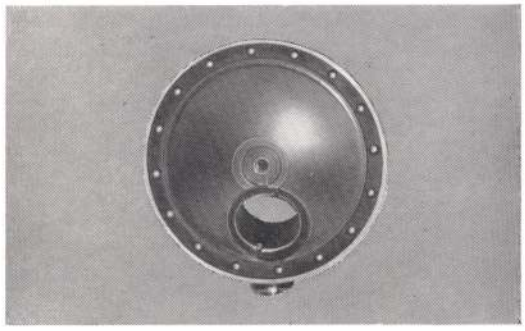
A single nosepiece is offered for use in special applications and wherever the need for frequent change of objectives is not encountered.

Catalog Number	Specifications
31-19-01	Single Nosepiece
31-19-22	Double Nosepiece, revolving
31-19-23	Triple Nosepiece, revolving
31-19-24	Quadruple Nosepiece, revolving
31-19-31	Centering Nosepiece Tube part
31-19-32	Objective part (one for each objective)
	Wrench for Interchanging Revolving Nosepieces

Centering Nosepiece

This sliding nosepiece for a single objective permits quick interchange of any number of standard objectives. It also provides means for accurate and rapid centering of the individual objective so that each may be replaced by another without disturbing the centering accomplished. It consists of two parts: the tube part, and the objective part. The tube part has the usual Society screw thread and attaches to the body tube. The objective part, one for each objective, contains the centering device worked by two keys. Of extremely sturdy construction, the nosepiece will provide many years of trouble-free service.

Centering Nosepiece, No. 31-19-31 and 31-19-32



Roto-sphere nosepiece with top removed to show ball bearings

Double Nosepiece, No. 31-19-22

Triple Nosepiece, No. 31-19-23

Quadruple Nosepiece, No. 31-19-24

Eyepiece Holders

Inclined Monocular Eyepiece-Holder, No. 31-19-72

Inclined Eyepiece-Holder

The Inclined Eyepiece-Holder can be attached to any monocular microscope in place of the regular eyepiece-holder and permit the observer to sit at the microscope in an upright natural position without the necessity of inclining the microscope from the vertical position, a valuable feature when observing specimens in liquids. The Holder is quickly and easily fitted to current Bausch & Lomb microscopes with 35mm and 39mm body tubes (see listing) by simply removing the existing Holder and screwing the Inclined Holder into its place. A standard tube length of 160mm is rigidly maintained.

Binocular Bodies—Balcoted

Parallel eyepiece tubes are used on Bausch & Lomb binocular bodies. This permits full relaxation of normal eye muscles. The right eyepiece tube may be focused by a rotatable collar to effect acuity balance of the user's eyes. A graduated scale on the collar enables resetting quickly to the user's established position. The left eyepiece tube is rotated to adjust for interpupillary distances from 50 to 75mm. The binocular bodies are available either inclined or vertical, and for use only on microscopes manufactured by Bausch & Lomb since 1941 of the convertible body type. If you are in doubt as to whether your microscope will accommodate a Bausch & Lomb binocular body simply send in the instrument's serial number. The Company will be glad to advise you whether your model is of the convertible type.

Inclined Binocular Body on C Type Microscope

Monocular Tubes

Monocular tubes for Bausch & Lomb microscopes of the convertible body type made since 1941 are available either fixed length or with graduated adjustable draw tube.

Monocular Tube Adjustable, 145-175mm

Specifications	
Catalog Number	***BINOCULAR BODIES—BALCOTED***
31-19-61	Vertical Binocular Body for microscopes Type C (cat. no. 31-20-53, 31-20-60, 31-20-63, 31-21-81, 31-21-82, 31-21-83, 31-21-85, 31-21-86, 31-21-88, 31-21-90, 31-21-91) Type CC (cat. no. 31-22-02, 31-22-03, 31-22-08, 31-22-09) and Type T (cat. no. 31-20-55, 31-20-61, 31-20-62, 31-20-65)
31-19-55	Inclined Binocular Body for same microscopes as above
31-19-78	Inclined Binocular Body for research microscopes Types E and R
	MONOCULAR TUBES
31-19-26	Monocular Tube, fixed length for microscopes Type C (cat. no. 31-20-53, 31-20-60, 31-20-63) and Type T (cat. no. 31-20-55, 31-20-61, 31-20-62, 31-20-65)
31-19-26-91	Monocular Tube with graduated adjustable draw tube, graduated 145-175mm, for same microscopes as above
31-19-83	Monocular Tube, fixed length for microscopes Type C (cat. no. 31-21-81, 31-21-82, 31-21-83, 31-21-85, 31-21-86, 31-21-88, 31-21-90, 31-21-91) and Type CC (cat. no. 31-22-02, 31-22-03, 31-22-08, 31-22-09)
31-19-83-91	Monocular Tube with graduated adjustable draw tube, graduated 145-175mm, for same microscopes as 31-19-83, above
31-19-84	Monocular Tube, with graduated adjustable draw tube, graduated 145-172mm, for research microscopes Types E and R
31-19-72	Inclined Monocular Eyepiece-Holder for B&L 39mm dia. monocular tube (Balcoted)
31-19-74	Inclined Monocular Eyepiece-Holder for B&L 35mm dia. monocular tube (Balcoted)
	Adapters, for attaching this holder to other models and makes of microscopes, can be supplied

Polaroid Accessories

Triocular Bodies — Balcoted

Comfortable visual use with inclined binocular eyepieces and the convenience of a built-in monocular tube for photomicrography are combined in the Triocular Body.

Time-saving, short exposures are assured by the B&L design delivering 80% of the source illumination to the camera tube. The remaining 20% gives ample light for visual work, which is continuous, even during the photographic exposure.

The observer can rotate the body a full 360° for orienting the specimen in relation to the picture frame, and quickly lock the body for most comfortable viewing.

The Triocular Body doubles normal magnification without extending the bellows to its limit. If used with the B&L Model N eyepiece camera, the Triocular records normal (eyepiece times objective) magnification at the film plane.

Catalog Number	Description
31-19-54	Triocular Microscope Body, Balcoted: without eyepieces. For Laboratory microscope models T, C, CSA, CTA and CC.
31-19-56	Triocular Microscope Body, Balcoted, with attachment screws; without eyepieces. For research microscope models E and R.

The Bausch & Lomb Polaroid Microscope accessories are available for B&L Laboratory and Research microscopes. They serve as inexpensive substitutes for Nicol Prisms in certain types of work.

The analyzers and polarizers are made from selected sextant grade Polaroid, mounted between plane glass plates without strain.

Disc Polarizer, No. 31-57-15, fits in the filter holder which is part of the iris diaphragm on the substage Condenser. Disc Polarizer, No. 31-57-38, fits in the aperture of the rotating, swing-out iris diaphragm of some B&L Research Microscopes. Each polarizer is so mounted that rotation of more than 180° is possible.

Cap Analyzer, No. 31-57-11, is a Polaroid disc which fits snugly over the eye lens of B&L standard diameter eyepieces and does not restrict field size.

The Body Tube Analyzer, No. 31-57-37, fits in the aperture of the nosepiece adapter of B&L Laboratory and Research Microscopes having binocular bodies. This eliminates the elliptical polarization caused by the use of a cap analyzer on each eyepiece of binocular microscopes.

The plane of vibration for each of the preceding accessories is parallel to the index lines engraved on their mounts, except 31-57-15 polarizer in which it is parallel to the handle, permitting quick determination of the positions for extinction and maximum transmission.

The minimum equipment for work with polarized light is an analyzer and polarizer, while the addition of retardation plates greatly extends the range and variety of interesting work possible. Two retardation plates are available for use with the cap analyzer as used on a monocular microscope. These plates fit inside the

31-51-11 *31-57-15*
31-57-37 *31-57-38*

mount of the No. 31-57-11 Cap Analyzer and are provided with pins for proper positioning. No provision can be made for using retardation plates when the body tube analyzer is used in the microscope.

Retardation Plate, No. 31-57-45, is red of the first order. It is used to detect weak double refraction, to estimate the order of interference color in Newton's scale and to determine the fast and slow axes of the specimen. This is also a very attractive addition to the microscopist's outfit, due to the vivid color effects provided.

The Quarter Wave Retardation Plate, No. 31-57-44, is used to determine whether a crystal is positive or negative. This retardation plate is also used to determine whether optically active substances are dextrorotatory or laevorotatory.

Polaroid is covered by United States Patents Nos. 1918848; 1989371; 1951664; 1956867; 2011553 and others pending.

Catalog Number	Specifications
31-57-15	Disc Polarizer
31-57-11	Cap Analyzer
31-57-37	Body Tube Analyzer
31-57-38	Disc Polarizer
31-57-45	First Order Red Retardation Plate
31-57-44	Quarter Wave Retardation Plate
31-57-02-15	Disc Polarizer and Cap Analyzer, in case

Demonstration Eyepiece

The Demonstration Eyepiece permits two people to view a specimen at the same time. A movable pointer in the vertical eyepiece allows one observer to indicate to the other, interesting parts of the field. The magnification of 6.4× is the same in both the vertical and horizontal eyepieces, the latter of which is focusable in a spiral mount. This fits any standard 23mm eyepiece.

Comparision Eyepiece

The Comparison Eyepiece permits examination and comparison of two microscope fields through the same eyepiece. The circular field of view is divided vertically, the right half being from the right microscope and the left half from the left, image unreversed.

This eyepiece can be used only with any two standard microscopes, and, since its magnification is unity it does not change the magnification of the microscope's optical system.

Demonstration Eyepiece No. 31-15-95 *Comparison Eyepiece No. 31-15-99*

Diaphragm Cap

For people who do not wear spectacles, diaphragm cap No. 31-50-76 is useful in reducing the otherwise desirable high eyepoint of the 12.5× Compensating Eyepiece.

Lens Paper

This paper gives an extremely high polish to lenses, leaving them free from lint or fine scratches. It is supplied in packages of 100 sheets, size 9 x 12 inches, and book form, 50 sheets, 4 x 5¼ inches.

Immersion Oil

Cargille's Immersion Oil, No. 31-50-95, in glass bottle with applicator is available with refractive index (n_D = 1.5150) and in medium viscosity.

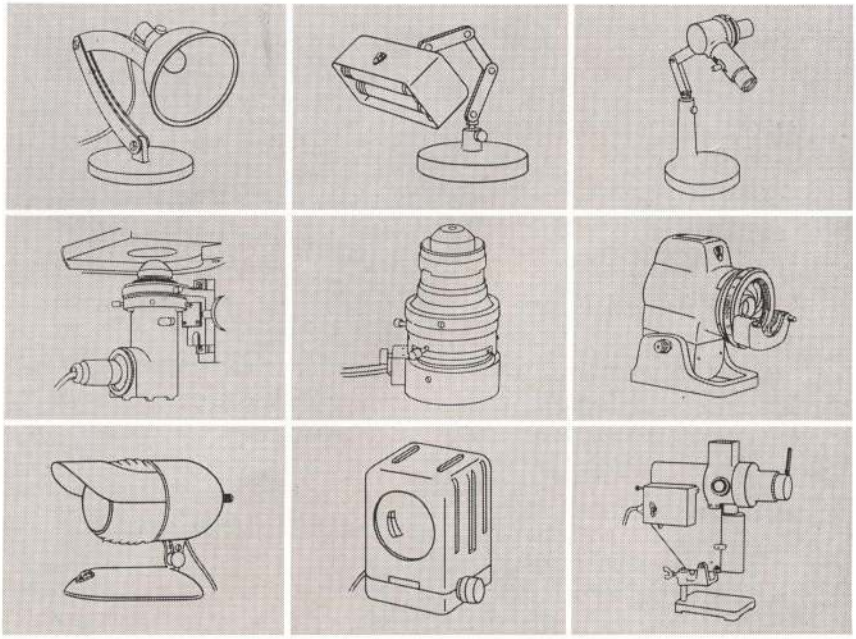
Catalog Number	Specifications
31-15-95	Demonstration Eyepiece, in case
31-50-60	Lens Paper, 100 sheets 9" x 12"
31-50-62	Lens Paper, Book Form
31-50-76	Diaphragm Cap for 12.5× Compensating Eyepiece
31-50-95	Cargille's Immersion Oil, 7 ml
31-15-99	Comparison Eyepiece, 1×

You Will Get More Out of Your Microscope with the Right Illuminator

The finest microscope is only as good as the light poured into it. So Bausch & Lomb makes a full line of Illuminators to provide the proper light source at the price you want to pay. They are gathered together in one catalog, D-119, which we would like you to have.

Here you will find just the right one for the work you are doing—Reflector, Fluorescent, Nicholas, Dark Field, Panfocal, Professional, Micro-Lite, Opti-lume, Mechanical Feed Arc. Also all complementary accessories including electrical controls and filters of all kinds. Some are designed for use as attachable illuminators, others as separate sources.

Please ask us for your copy of D-119, today.



Attachable Mechanical Stages

Mechanical stages are available with or without graduations and verniers. The graduations permit the making of records of particular fields on a slide, for convenient relocation. The adjustments are made by well-fitted rack and pinion, giving equal speed in two directions at right angles one to the other.

Mechanical Stage No. 31-59-59 is graduated in millimeters reading to tenths by verniers. It can be used on plain rectangular stage microscopes such as the A, B, C, H, and G models. The slide brackets, one spring actuated, accommodate standard specimen slides up to 50 x 75mm. Pinion heads are close together in constant relative position. It is securely attached by a double screw clamp.

Mechanical Stage No. 31-59-59-01 (graduated) is similar to No. 31-59-59 except that it has a centering slide. The centering slide has cross lines within a circle and is used to relocate selected fields when using a different mechanical stage, or when transferring the stage to another microscope.

Mechanical Stage No. 31-59-53 (plain) is similar to No. 31-59-59 but has no graduations.

Mechanical Stage No. 31-59-19 (graduated in millimeters reading to tenths) is made to fit microscopes such as the A, B, C, H, G and Dynoptic Laboratory models with plain rectangular stage. It will hold the standard 50 x 114mm slides used in making bacteria counts according to the Breed method. (See Circular No. 53, N. Y. State Agricultural Experimental Station, Geneva, N. Y.)

Mechanical Stage, No. 31-59-66-01, is ungraduated. It is designed for attachment to the Bausch & Lomb Dynoptic Laboratory Microscopes. While being an attachable type, when installed on a microscope it becomes so completely a part of the instrument that for all practical purposes it is integral. Yet, if removal is desired the simple turning of two screws releases the mechanical stage.

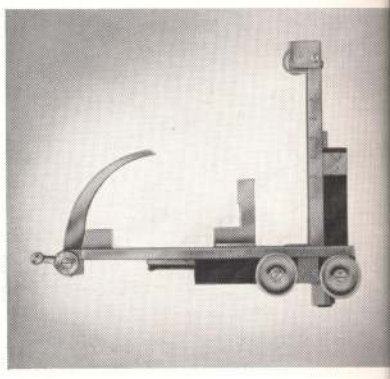
Contributing to smooth operation and long wear are the stainless steel slides. Racks and pinions used are fitted individually. The knobs are so attached to the pinions that the operator can easily adjust the bearing pressure to obtain the freedom of motion he prefers. In their position below the stage the knobs are comfortably manipulated and the hand is close to the fine adjustment knob of the Dynoptic microscope.

Another unique feature of this mechanical stage is the slide holder. The finger contacting the object slide is actuated by a vacuum-spring combination which is positive but gentle in its action. Positioning of the object slide is positive and consistent due to the three-directional force exerted—down, across, and cornerwise—by the pressure of the finger and its shape. Slides 75mm long and from 25mm to 50mm wide can be accommodated.

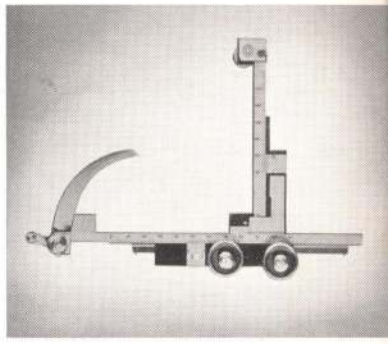
The same mechanical stage is also available with graduations in millimeters and verniers reading to tenths of a millimeter. It is listed by catalog number 31-59-67-01, including a leatherette covered, plush lined case.

Catalog Number	Specifications
31-59-59*	Mechanical Stage, with graduations, for 50 x 75mm Slides, in case
31-59-59-01*	Mechanical Stage, with graduations, for 50 x 75mm Slides, with centering slide, in case
31-16-95	Centering Slide, in case
31-59-53*	Mechanical Stage, without graduations, for 50 x 75mm Slides, in case
31-59-19*	Breed Mechanical Stage, with graduations, for 50 x 114mm Slides, in case
31-59-66	Mechanical Stage, without graduations, for 50 x 75mm Slides, used on Dynoptic Laboratory Microscopes only, without case
31-59-66-01	Mechanical Stage, without graduations, for 50 x 75mm Slides, used on Dynoptic Laboratory Microscopes only, with case
31-59-67	Mechanical Stage, with graduations, for 50 x 75mm Slides, used on Dynoptic Laboratory Microscopes only, without case
31-59-67-01	Mechanical Stage, with graduations, for 50 x 75mm Slides, used on Dynoptic Laboratory Microscopes only, with case

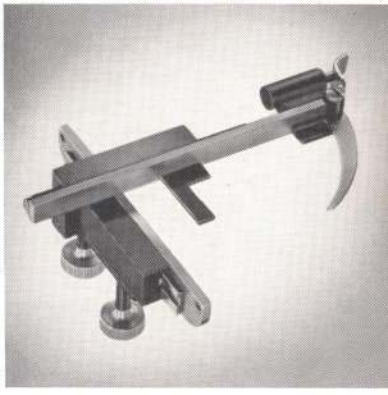
*May be ordered without case. See price list for deduction.
NOTE: When ordering a mechanical stage, give serial number of Bausch & Lomb microscope or exact size of stage to which it will be attached.



Mechanical Stage, No. 31-59-59



Mechanical Stage, No. 31-59-19



Mechanical Stage, No. 31-59-66

Substage Condensers — *Balcoted*

Abbe 1.25 N. A. *Variable Focus 1.25 N. A.* *Abbe 1.40 N.A.* *Achromatic 1.40 N.A.*

The outside diameter of these condensers is 1.528".

Variable Focus Condenser

For Bausch & Lomb microscopes originally supplied with the Variable Focus condenser replacement parts are listed. It is not advisable to apply this special type condenser to microscopes which were factory equipped with any other type condenser or with none at all. When ordering parts for replacement purposes it is necessary to inform the factory of the serial number of the microscope on which the parts are to be installed.

Abbe Condensers

0.70 and 1.25 N.A. Condensers may be used on any Bausch & Lomb microscope designed to accept a condenser. The 0.70 N.A. Condenser is effectively used with 32mm to 4mm objectives because no refocusing is necessary to fill respective fields with light. The 1.40 N.A. Condenser may be used on rack and pinion substages, either simple or research type.

Achromatic Condensers

These two Condensers, consisting of three separable elements, have an optical correction comparable to an objective lens system and therefore provide the best form of illumination, particularly as required for maximum efficiency of apochromatic objectives. They are best used in a substage which is centerable. No. 31-58-83 is used only in a complete research substage and applied by means of the sliding condenser plate, No. 31-58-09. No. 31-58-85 is designed for ring type substages as on Bausch & Lomb laboratory microscopes.

If an iris diaphragm is required for any of these condensers it must be ordered separately by the No. 31-58-28. The iris diaphragm includes a slot for the insertion of the 33mm diameter blue glass disc.

For Dark Field Condensers, see Catalog No. D-122.

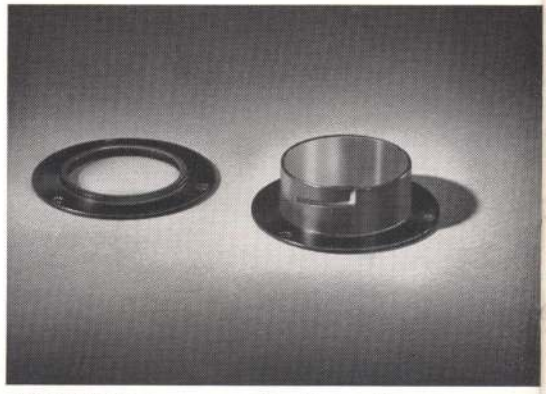
CONDENSERS

Catalog Number Balcoted	Style Condenser	N.A.	Slide thick.	N.A. top off	N.A. both uppers off
31-58-72	Abbe	1.40	1.0	0.70	0.40
31-58-74	Abbe	1.25	1.3	0.30	×
31-58-76	Abbe	0.70	1.6	×	×
31-58-79	Variable Focus*	1.25	1.3	×	×
31-58-83	Achromatic**	1.40	1.55	0.59	0.20
31-58-85	Achromatic	1.40	1.55	0.59	0.20

SUBSTAGE ACCESSORIES

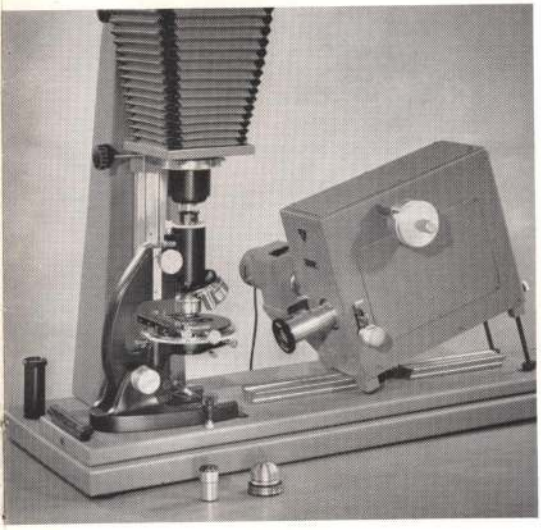
Catalog Number	Specifications
31-50-01	Microscope Mirror 50mm diam.—plano and concave
31-50-18	Microscope Mirror, concave, for ST Elementary and Intermediate Microscope
31-50-21	Microscope Mirror 55mm diam.—plano and concave
31-50-22	Microscope Mirror 55mm diam.—plano, aluminized on front surface
31-58-04	Condenser Sleeve, spiral focusing type
31-58-09	Sliding Condenser Plate
31-58-18	Mirror support for ST and STA Series Student Microscopes
31-58-19	Mirror Support for Dynoptic Laboratory Microscopes
31-58-28	Iris Diaphragm
31-59-04	Ring Adapter, for attaching Variable Focus upper lens or iris diaphragm to underside of stage
	Blue Glass Disc, 33mm diam., frosted one side

*For use only on B&L Laboratory Microscopes since 1947
**For use on B&L Research Microscopes with 31-58-09 sliding condenser plate



Ring Adapter No. 31-59-04 *Condenser Sleeve No. 31-58-04*

Accessories for Ultra-violet Microscopy



Ultra-violet microscopy is hastening major advances in cancer research, in living-cell studies, in all bio-chemistry. B&L ultra-violet equipment reveals differential absorption of biological materials at high numerical aperture, with twice the resolving power attainable in the visible portion of the spectrum.

While not listed here, the B&L 250mm and 500mm Grating Monochromators, when used with the high intensity mercury arc light source, provide satisfactory illumination for microscopy and photomicrography in the ultra-violet, where a line spectrum is desirable. It is only necessary to substitute the UV condenser lens for the collective lens at the exit slit of the monochromator, and put the reflecting UV optics on the microscope. For complete information and prices on B&L Monochromators and Photomicrographic equipment write for Catalogs D-259 and E-21.

The condenser lens is constructed of quartz and fluorite lens elements. Highly corrected for both chromatic and spherical aberrations, it eliminates the need to refocus the lens for different wave lengths. An iris diaphragm is provided which acts as a field stop when Koehler illumination is used.

Objectives

Two UV objectives are available — a 53× dry objective and a 94× water immersion objective (at 160mm tube length). Each is adjusted to provide the best images with a quartz object slide 1.0mm to 1.3mm thick and a 0.18mm thick cover slip.

The two objectives are similar in construction. Two spherical reflecting surfaces are combined with refracting lens elements of quartz and fluorite. One refracting element serves as a support for one of the reflectors and combines with the other refracting element to complete the correction of the optical system. While complete achromatism is not obtained with these objectives (partially due to dispersion in the cover slip over the specimen) a focal setting made in visible light will usually suffice for photography throughout the ultraviolet region. Any shift from precise focus in the visible to that at some region in the ultraviolet is slight and can be determined readily.

Substage Condensers

A matching condenser is available for use with each objective. These condensers will work through quartz object slides 1.0mm to 1.3mm thick. The high N.A. condenser must be contacted to the underside of the slide with distilled water.

Both condensers are 1.528″ diameter so that they can be used in the ring substage of B&L Laboratory microscopes without adapters. For use in the ring substage of the new B&L R Research Microscopes they can be supplied with adapter, at slight extra cost.

Eyepieces

For the purpose of projecting the UV image to a film or spectrophotometer, a 3.5× and a 10× eyepiece are offered. The 3.5× eyepiece provides the smaller field desirable for UV photomicrography on 35mm film. The lower magnification results in greater intensity at the image plane — an advantage when UV energy is at a minimum.

OBJECTIVES					
Catalog Number	E.F.	N.A.	Occluded N.A.	Magnification (160mm TL)	Working Distance
31-10-02	2.8mm	0.72	0.20	53×	0.8mm
31-10-03	1.65mm	1.00	0.16	94×	0.19mm
CONDENSERS					
31-58-02	0.72 N.A.	To match 31-10-02 objective			
31-58-03	1.00 N.A.	To match 31-10-03 objective			
EYEPIECES					
31-15-13	3.5×	Huygens Type (Fused Quartz and Fluorite)			
31-15-02	10×	Ramsden Type (Fused Quartz)			

Magnifications and Real Fields

ACHROMATIC AND FLUORITE OBJECTIVES—HUYGENIAN EYEPIECES

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

OBJECTIVES		EYEPIECES						
Equivalent Focus Numerical Aperture	Objective Magnification	5×	6.4×	7.5×	10×	Micrometer Value* with 10× Eyepiece	12.5×	15×
48mm 0.08 N.A. Achro.	2×	10× *10.2*	12.8× *9.6*	15× *9.2*	20× *7.8*	0.076mm	25× *6.9*	30× *5.65*
40mm 0.08 N.A. Achro.	2.6×	13× *8.0*	16.6× *7.25*	19.5× *7.1*	26× *5.9*	0.058mm	32.5× *5.25*	39× *4.25*
30mm 0.09 N.A. Achro.	3.5×	17.5× *5.9*	22× *5.4*	26× *5.2*	35× *4.3*	0.044mm	44× *3.9*	52× *3.4*
32mm 0.10 N.A. Achro.	4×	20× *5.25*	25.6× *4.80*	30× *4.63*	40× *3.87*	0.038mm	50× *3.43*	60× *2.82*
22.7mm 0.17 N.A. Achro.	6×	30× *3.48*	38.4× *3.20*	45× *3.08*	60× *2.56*	0.024mm	75× *2.26*	90× *1.87*
16mm 0.25 N.A. Achro.	10×	50× *2.05*	64× *1.90*	75× *1.80*	100× *1.50*	0.0149mm	125× *1.33*	150× *1.10*
8mm 0.50 N.A. Achro.	21×	105× *1.01*	134× *0.93*	157× *0.89*	210× *0.74*	0.0072mm	262× *0.65*	315× *0.55*
4.3mm 1.00 N.A. Fluorite	40×	200× *0.51*	256× *0.47*	300× *0.45*	400× *0.37*	0.0037mm	500× *0.33*	600× *0.27*
4mm 0.65 N.A. Achro.	43×	215× *0.48*	275× *0.44*	322× *0.42*	430× *0.35*	0.0034mm	537× *0.31*	645× *0.26*
4mm 0.85 N.A. Achro.	45×	225× *0.47*	288× *0.43*	337× *0.41*	450× *0.35*	0.0034mm	562× *0.31*	675× *0.26*
3mm 0.85 N.A. Achro.	60×	300× *0.35*	384× *0.32*	450× *0.30*	600× *0.25*	0.0025mm	750× *0.225*	900× *0.185*
1.8mm 1.25 N.A. Achro.	97×	485× *0.205*	620× *0.19*	727× *0.18*	970× *0.15*	0.0015mm	1212× *0.135*	1455× *0.11*
1.8mm 1.30 N.A. Fluorite	98×	490× *0.21*	627× *0.195*	735× *0.185*	980× *0.155*	0.0015mm	1225× *0.14*	1470× *0.115*

*Value in plane of specimen corresponding to 0.1mm in plane of eyepiece diaphragm.

Magnifications and Real Fields (Cont.)

ACHROMATIC AND FLUORITE OBJECTIVES—HYPERPLANE EYEPIECES

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

OBJECTIVES		EYEPIECES						
Equivalent Focus Numerical Aperture	Objective Magnification	5×	7.5×	10×	Micrometer Value* with 10× Eyepiece	12.5×	15×	20×
16mm 0.25 N.A. Achro.	10×	50× 2.05	75× 1.90	100× 1.60	0.0127mm	125× 1.33	150× 1.20	200× 0.85
8mm 0.50 N.A. Achro.	21×	105× 1.00	157× 0.93	210× 0.79	0.0063mm	262× 0.65	315× 0.60	420× 0.43
4.3mm 1.00 N.A. Fluorite	40×	200× 0.50	300× 0.47	400× 0.40	0.0032mm	500× 0.33	600× 0.29	800× 0.21
4mm 0.65 N.A. Achro.	43×	215× 0.47	322× 0.44	430× 0.38	0.0030mm	537× 0.31	645× 0.28	860× 0.20
4mm 0.85 N.A. Achro.	45×	225× 0.47	337× 0.44	450× 0.38	0.0030mm	562× 0.31	675× 0.28	900× 0.20
3mm 0.85 N.A. Achro.	60×	300× 0.35	450× 0.32	600× 0.27	0.0022mm	750× 0.23	900× 0.20	1200× 0.145
1.8mm 1.25 N.A. Achro.	97×	485× 0.205	727× 0.19	970× 0.16	0.0013mm	1212× 0.13	1455× 0.12	1940× 0.09
1.8mm 1.30 N.A. Fluorite	98×	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						
Equivalent Focus Numerical Aperture	Objective Magnification	5×	7.5×	10×	Micrometer Value* with 10× Eyepiece	12.5×	15×	25×
16mm 0.30 N.A.	10×	50× 2.13	75× 1.80	100× 1.50	0.0132mm	125× 1.33	150× 1.15	250× 0.65
8.3mm 0.65 N.A.	20×	100× 1.08	150× 0.91	200× 0.76	0.0067mm	250× 0.68	300× 0.59	500× 0.33
4mm 0.95 N.A.	47.5×	237× 0.44	356× 0.37	475× 0.31	0.00275mm	594× 0.275	712× 0.235	1187× 0.135
3mm 1.40 N.A.	61×	305× 0.355	457× 0.295	610× 0.25	0.0022mm	762× 0.22	915× 0.19	1525× 0.108
2mm 1.30 N.A.	90×	450× 0.23	675× 0.195	900× 0.16	0.00142mm	1125× 0.145	1350× 0.125	2250× 0.070
2mm 1.40 N.A.	90×	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.

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