BALPHOT METALLOGRAPH

CAT. NO. 42-31-22

REFERENCE MANUAL

BAUSCH & LOMB
INCORPORATED
ROCHESTER 2, NEW YORK

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Figure 1—The Balphot Metallograph

Knowledge gained through close association with a generation of metals men has resulted in this new member of the Bausch & Lomb Line of Practical Metallographic Equipment.

BAUSCH & LOMB

Balphot

METALLOGRAPH

The Bausch & Lomb Balphot Metallograph has been designed to meet the needs of both those doing routine metallurgical analysis and those carrying out investigative studies of metals. Its ease and simplicity of operation commend its use for routine work by the laboratory technician. Its versatility as to modes of illumination makes it an excellent tool for the metallurgical microscopist.

This reference manual is intended to help the user get the most out of his equipment by giving him not only instructions as to the mechanics of manipulation but also some insight as to the most effective use of the various optical combinations at his disposal.

Naturally it would be impossible to describe here in detail all of the optical, photographic and metallurgical principles and practices involved in the microscopic study of metals. For these the reader is referred to the books and journals devoted to these subjects, some of which are mentioned in the brief bibliography on the last page of this reference manual.

THE MICROSCOPE

Stage Assembly

The stage assembly comprises a circular, centerable, ball-bearing rotating stage, a mechanical stage, a stage plate, and a specimen clamp and clamp post. Each of these units is considered separately below.

The rotating stage is provided with a vernier (Fig. 2—1) which reads to 6′ of arc. The stage rotates on a ball-bearing support, and may be secured in any desired orientation by means of the clamp screw (2). Centration of the axis of rotation of the stage to the axis of the microscope is accomplished by means of the two centering screws (3). The centering screws work against a spring-loaded pin.

The mechanical stage surmounts the rotating stage and permits traversing of the specimen over an area one inch in diameter. Duplicate controls are provided for both north-south (5) and east-west (6) movements of the stage. Vernier scales (7), reading to 0.1 mm, permit measurement of the amount of stage travel.

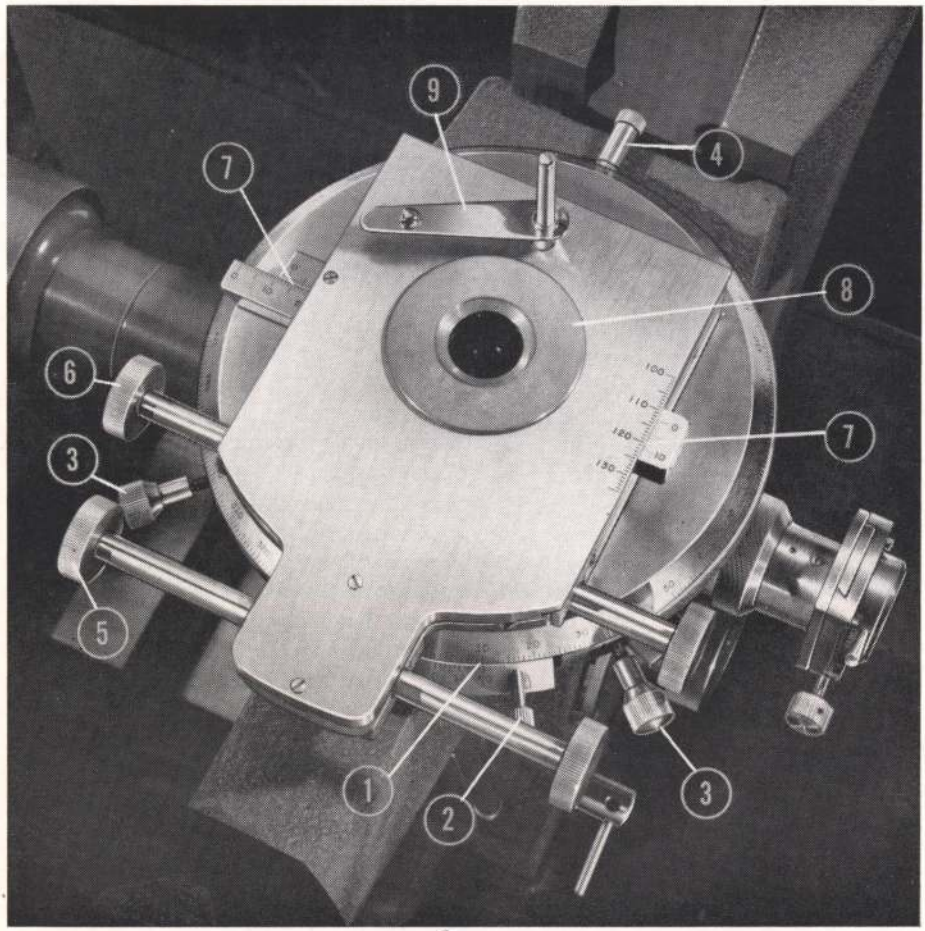
The stage plate (8) is provided to support the specimen accurately perpendicular to the optic axis. One of the stage plates provided with the instrument has a circular recess 1″ in diameter, and is meant to hold plastic mounted specimens of this size. It has a ¾″ aperture. The other stage plate has a tear-drop shaped aperture and is used primarily for unmounted specimens, the smaller specimens being placed over the narrower region of the aperture. When this stage plate is in place on the stage its full surface should be flush with the stage surface.

Two other stage plates, similar to the 1″ recessed plate described above, having 1¼″ and 1½″ recesses are available (Cat. Nos. 42-34-24 and 42-34-65) for use with plastic mounted specimens of these diameters.

When placing the stage plates in the stage aperture, care should be taken that they are not tipped in the slightest, because of either careless insertion or dust on the bearing surfaces. They should be handled with reasonable care, as any nicks or dents on the edges will result in a tipping of the specimen with respect to the nominal specimen plane, resulting in an out-of-focus image at one edge of the field.

The specimen clamp (9) serves to hold the specimen securely against the locating surface of the stage plate. To clamp the specimen, rest the ball tip of the specimen clamp on the center of

Figure 2—The Stage Assembly



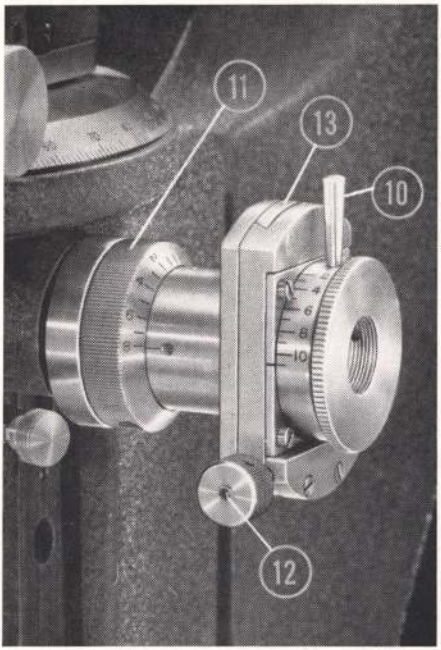


Figure 3—Field and Aperture Diaphragms

the specimen mount and press, with moderate pressure, on the hollow rod which slides on the specimen clamp post. If it is desired to place an exceptionally large specimen on the stage, the specimen clamp post may be removed by simply unscrewing it from its tapped hole in the stage.

Field and Aperture Diaphragm Assembly

The field and aperture diaphragms are located in the unit which extends from the upper right hand portion of the microscope body. The aperture diaphragm, located nearest the light source, is operated by means of the handle (Fig. 3—10), while the field diaphragm is actuated by the knurled ring (11). Both diaphragm controls are graduated in millimeter openings of the respective diaphragms. The aperture diaphragm may be decentered by turning the small knurled knob (12), and it may be rotated by turning the whole aperture diaphragm housing (13). A click stop indicates when the aperture diaphragm is centered to its axis of rotation.

The dark field stop control handle is shown in Figure 4—14. When the stop handle is pushed all the way in toward the microscope body, the stop is swung aside and the microscope is set for bright field illumination. By pulling out on the handle, in the direction of the engraved arrow, the stop is swung into position and the unit is ready for dark field illumination. (Field and aperture diaphragms must be opened wide.) It must be remembered that dark field is attainable only with the four plastic-mounted objectives.

Objective Retaining Mechanism

The objective-holder retaining spring (Fig. 5—16) serves to seat the objec-

Figure 4—Dark Field Stop

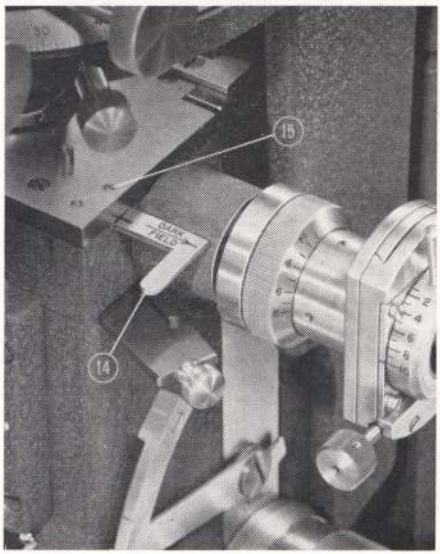


Figure 5—Placing an Objective

tive holder securely against its locating shoulder. The microscope body shoulder, as well as the objective holder shoulder, should be kept as clean and dust-free as possible. A small particle of dirt between these two locating shoulders will tip the objective with respect to the microscope axis and, particularly with the higher power objectives, will result in a decentered image. To put an objective in place, it is most convenient to hold the objective handle, objective uppermost, in the right hand, and place it on the microscope body, as shown in Figure 5. Giving the handle a clockwise turn of about 45° until it strikes the locating pin (17) will seat the objective firmly in place, as shown in Figure 6. This procedure is reversed upon removing the objective.

Axis Selector

The paddle-shaped lever (Fig. 7—18) enables the operator to direct the light to any one of the three axes, as desired, for visual observation, photomicrography or for projection on the Magna-Viewer. The selector handle is engraved for each of the positions, and a click-stop indicates when the handle is properly positioned.

Stage Elevating Mechanism

The microscope has been designed to work with parfocal objectives: that is, the relation between the stage surface on which the specimen rests and the objective shoulder remains the same, within close limits, for all objectives which are normally used on this instrument.

Figure 6—Objective in Place

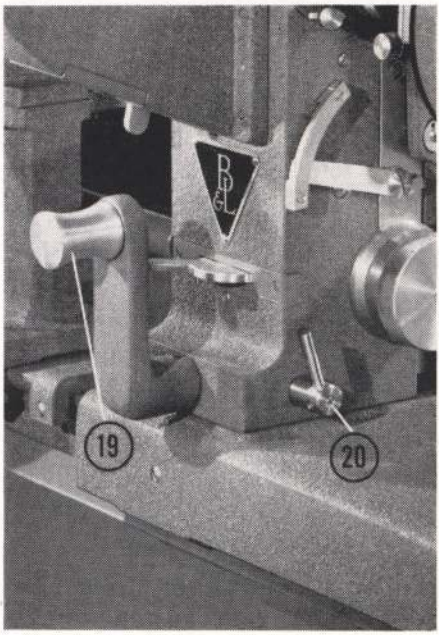
Figure 7—Axis Selector

For this reason, the normal "coarse adjustment" with its tedious cranking up and down has been eliminated and a quick-acting stage elevating mechanism has been substituted in its place. The operating handle for this mechanism is shown at 19, Figure 8. During normal observation the stage is down and the handle is pointed toward the observer's left.

To change objectives the stage must be elevated. Simply grasp the handle and rotate it about 180° clockwise. The stage will be raised sufficiently to permit easy interchange of objectives. Upon completion of the objective interchange, it is only necessary to turn the elevating handle counter-clockwise and the stage will be automatically lowered, returning to the same position it occupied before being elevated. An air-cushioned dash pot prevents the stage from dropping too rapidly and injuring the fine adjustment mechanism.

A friction clamp (20) is provided in case it should be necessary to hold the stage between the full "up" and the full "down" position. It would be necessary to use this feature if the operator should desire to use a low-power, non-parfocal objective, such as the 32mm, or if the specimen to be examined should be grossly irregular with the portion under examination protruding considerably through the stage plate aperture. When the stage is elevated in this manner the fine focusing mechanism is not effective. Therefore, it is recommended that this be done only with a low power objective,

Figure 8—Stage Elevating Controls



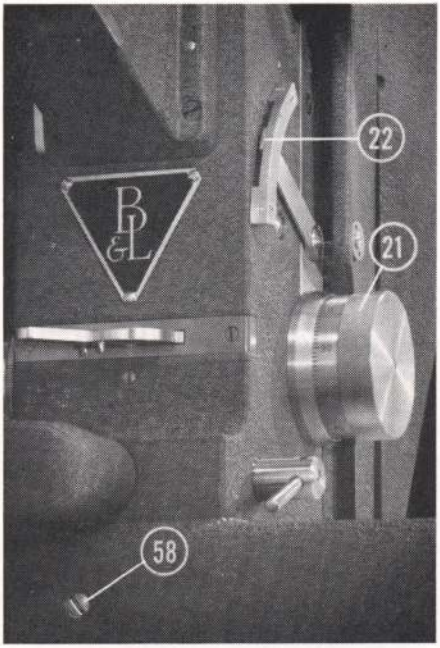


Figure 9—The Fine Adjustment

for which the depth of focus is considerable. The friction clamp mechanism is shown actuated in Figure 8—20.

Fine Adjustment

The fine adjustment mechanism is operated by the large knob located on the lower righthand side of the microscope body (Fig. 9—21). The button is graduated in 100 divisions, each division being equal to one micron (0.001 mm) of vertical motion of the stage. The total vertical travel of the stage is 4.0mm — 2.0mm above and 2.0mm below the parfocal position. A focusing index lever (22) indicates the position of the stage relative to the parfocal position. Plus and minus signs engraved on the index mark plate show whether the stage is above or below the parfocal position.

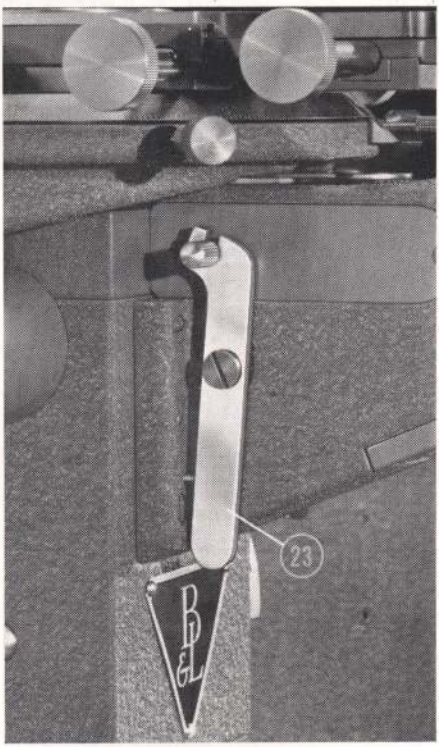
Half-Aperture Illumination

To achieve half-aperture illumination (equivalent to "prism illumination") move the lever handle (Fig. 10—23) inward to the position shown. This procedure moves the vertical illuminator plate toward the observer, and the illuminating beam is reflected from part of the aluminized portion of the vertical illuminator plate.

Body Changing Mechanism

For the greater part of its use the instrument will undoubtedly be used with the binocular body for visual observation, because of the greater comfort for the observer gained thereby. However, for measuring work with

Figure 10—Half-Aperture Illumination



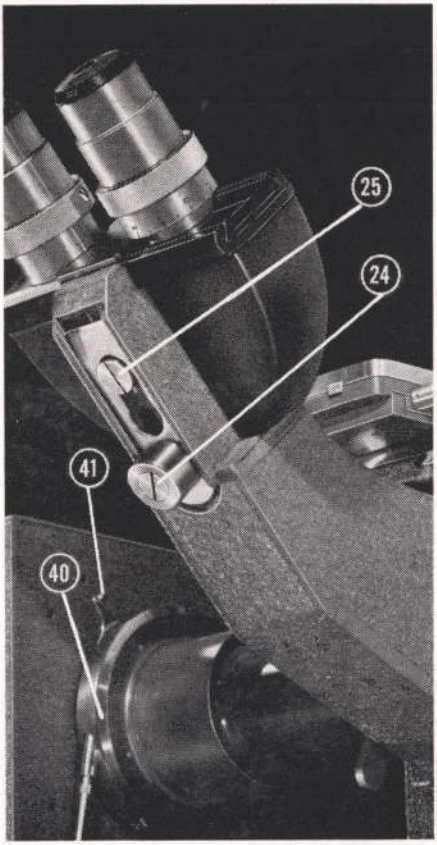


Figure 11—Body Interchange—Binocular Body

micrometer and grain size eyepieces, it is more convenient to use the monocular body tube.

The procedure for the interchange of the monocular and binocular bodies is illustrated in Figures 11 and 12, which are more or less self-explanatory. Outlined in brief, the procedure is to pull upward on the knob (24) until the locking mechanism disengages from the body retaining screw (25). Remove one body and replace it with the other, making sure that there is no dirt on the bearing surfaces to create a misalignment of the body tube with the optic axis. Push the locking knob downward to secure the body.

Visual Magnification Factor

To determine the magnification under which an object is being viewed, it is only necessary to multiply the objective magnification by the eyepiece magnification. Thus, the 40× objective used with a 12.5× eyepiece produces a total visual magnification of 500×. The above table may be referred to if desired.

Polarized Light

Polarized light accessories for use on the Balphot Metallograph include a

Figure 12—Body Interchange—Monocular Body

Objective Magnification	*Eyepiece*						
	5×	*6.4×*	*7.5×*	*10×*	*12.5×*	*15×*	*20×*
5	25	32	37.5	50	62.5	75	100
8	40	51	60	80	100	120	160
10	50	64	75	100	125	150	200
20	100	128	150	200	250	300	400
25	125	160	188	250	312	375	500
40	200	256	300	400	500	600	800
50	250	320	375	500	625	750	1000
75	375	480	562	750	938	1125	1500

Table of Visual and Magna-Viewer Magnifications

rotatable polarizer, a sensitive tint (first order red) plate, and a built-in analyzer. The polarizer and analyzer are made of high grade polaroid, the sensitive tint plate of crystal quartz.

The polarizer (Fig. 13—26) is rotatable through 100°; a white-filled index mark, with which the handle is to be aligned, indicates the position at which the polarizer is crossed with the analyzer. The Polaroid of the polarizer is protected from excessive heat from the light source by an interference-type heat-reflecting filter. This filter should always be faced toward the light source. Its color is red whereas the polaroid filter is green.

The filter holder fourth in position from the light source is specially adapted to receive the polarizer assembly. Only when the polarizer is held in this particular holder will it be possible to rotate it, by means of its handle, through its full range of motion. The sensitive tint plate must be located between the polarizer and analyzer. Its proper position, therefore, is in the filter holder immediately adjacent to the aperture diaphragm assembly. Its engraved edge should face the operator when the filter holder is swung into position.

The analyzer is carried in a sliding mount in the microscope body. Pulling out the knurled knob (Fig. 13—27), until the click stop is engaged, removes the analyzer from the optical path; pushing it in inserts the analyzer into the path of the image—forming rays of light. During normal brightfield operation of the instrument, the analyzer (as well as the sensitive tint plate and polarizer) should be removed from the light path. Figure 13 shows polarizer, sensitive tint plate, and analyzer in their operating positions.

Condenser Support

The light-source condenser support is located at the right of the microscope proper. It embodies a focusable condensing unit comprising two condensing lenses and a filter made of heat-absorbing glass, five filter holders, and a low-wattage illuminator for use during visual observation.

Condenser Unit

The condenser unit serves to image the light source (carbon arc, etc.) on the

aperture diaphragm. It is focusable by means of the handle (Fig. 14—28).

Filter Holders

The five swing-out filter holders accommodate all of the standard Bausch & Lomb 2″ square filters of the neutral density or interference type. (Gelatin type filters should not be used in this equipment as they will be damaged by the heat from the light source.) The filters may be used either singly or in combination.

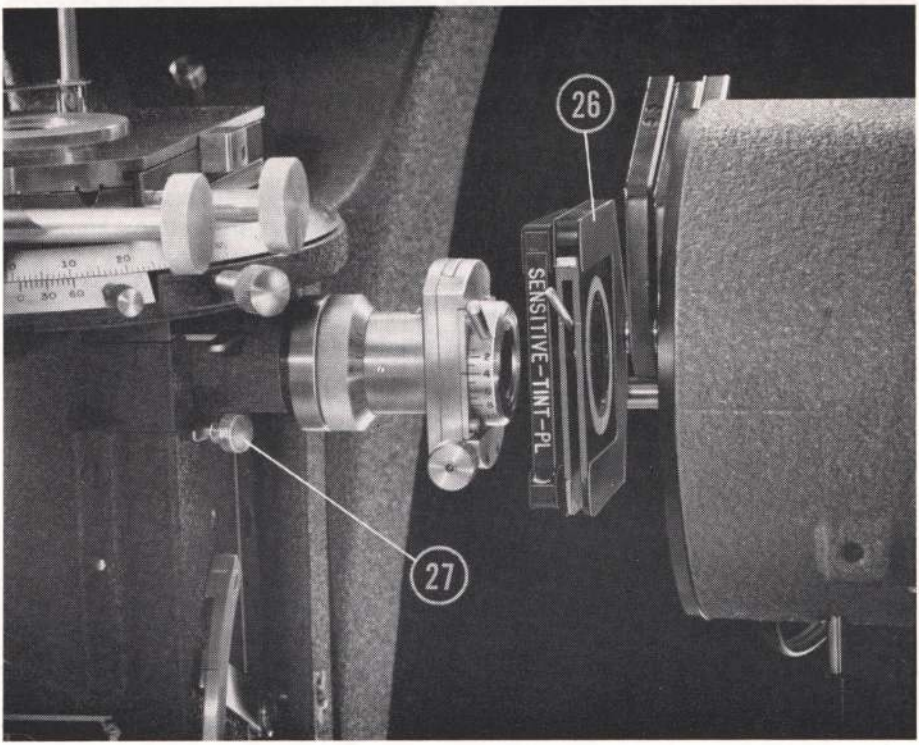
Two of the interference-type filters are supplied with this equipment. One filter transmits nearly monochromatic light in the neighborhood of 5500A (green) and the other transmits in the neighborhood of 4500A (blue).

The three filter holders nearest the light source are ordinarily used for the neutral and interference filters; the two filter holders nearest the microscope are reserved for the polarizing accessories.

Electrical Wiring System

The supporting stand of the Balphot Metallograph contains an internal wiring system for use with a motor driven carbon arc and the low wattage visual light source. Refer to the "Unpacking and Assembly" instructions at the back of this manual for information concerning the initial connections to be

Figure 13—Polarizing Accessories



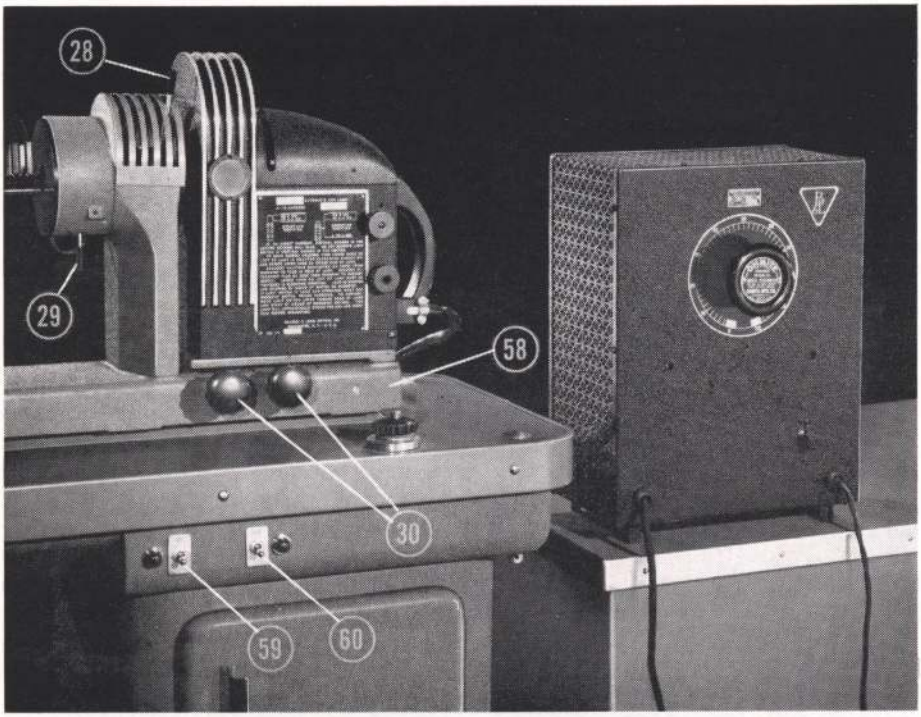


Figure 14—Condenser Support

made upon assembly of the instrument.

Two switches, with pilot lights, (Fig. 14—59 and 60) will be noticed on the right front of the supporting stand. The switch marked "Vis," (Fig. 14—59) when turned on, energizes the circuit to the visual light source. This visual source utilizes a 6.5v, 2.75 amp. prefocused lamp (Cat. No. 31-31-79) and is intended for use during visual observation when the more intense illumination of the larger light sources is not needed. It operates through a small transformer located in the right hand accessory cabinet of the supporting stand.

The switch marked "Arc" (Fig. 14—60) when turned on, energizes the circuit of the motor driven arc lamp. Both of these switches feed through a microswitch located in the condenser support, this latter switch being controlled by the position of the visual lamp. As the visual light source is brought into position by means of the handle (Fig. 14—29), the arc lamp circuit will be opened and the arc lamp will be automatically turned off. Returning the visual lamp to its ineffective position turns the visual lamp off and the arc lamp on. Thus, although both switches may be turned on and both pilot lights lit, only one circuit will be in operation at any time. Needless to say, if the one switch is not turned on, that circuit will not operate, regardless of the position of the visual light source.

The automatic cut-off of the larger light source does not apply to any source other than one of the motor

driven arc lamps, although the visual light source will always go off and on as it is moved out of or into position.

Adjusting the Illumination

To check the illumination for proper centration of the light source, it is easiest to direct the light to the Magna-Viewer, defocus the condenser lenses until the field is only partially illuminated, and observe the location of the spot of light. Using the knobs (30) bring the spot of light to the center of the field. Then focus the condenser lenses until the field is evenly lighted.

An alternative method is to direct the light to the camera axis and hold a piece of white card about 6″ away from the camera eyepiece so that it intercepts the full field transmitted by the eyepiece. Center and focus the light source, as directed above, until the field is evenly and symmetrically illuminated.

MAGNA-VIEWER

The Magna-Viewer, Figure 15, comprises an eyepiece holder, a 10″ focal length lens, a first surface aluminized mirror, a plastic Fresnel-type lens, and a high contrast projection screen. In addition, a Grain Size Chart is provided for quick and convenient grain size determinations.

The Fresnel-type lens makes the projected beam somewhat directional in nature; that is, an observer located at an angle to the screen considerable from the normal will see little of the projected image. However, an observer located approximately centered to the screen will receive the full benefit of the image, the projected image being evenly illuminated from center to edge. The "hot-spot" commonly associated with ordinary rear-projection systems is thus eliminated.

The projection screen provides an image of high contrast due to the fact that room light, upon entering the screen from the observer's side of the screen, is trapped, and cannot scatter about, washing out the image and making the blacks appear gray.

The Grain Size Chart is a replica of portions of the Grain Size Chart for Classification of Steels—ASTM Designation E-19-Plate 1. In order that proper magnification may be obtained, so that a direct comparison may be made between the projected image on the Magna-Viewer screen and the Grain Size Chart, it is necessary to use a combination of objective and eyepiece which will give a total magnification of 100×. One may use the 8× objective and 12.5× eyepiece, the 10× objective and 10× eyepiece or the 20× objective and 5× eyepiece. The 10× objective and 10× eyepiece combination is recommended.

To put the Grain Size Chart on the Magna-Viewer simply grasp it by the two knurled knobs, (Fig. 15—31), hold

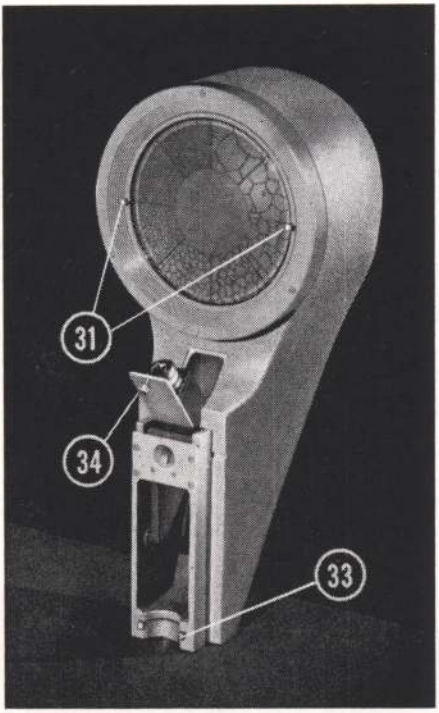


Figure 15—The Magna Viewer

the screen vertical and with the knobs in a line parallel with the floor, and insert it in front of the Magna-Viewer projection screen. Two spring loaded plungers will hold the chart securely in place.

The Grain Size Chart is reproduced on a photographic plate and should be treated with care. Avoid scratching or fingerprinting the emulsion surface (the surface next to the projection screen when on the Magna-Viewer). The glass surface of the screen may be wiped with a damp cloth but the emulsion surface is best left untouched.

To Attach the Magna-Viewer

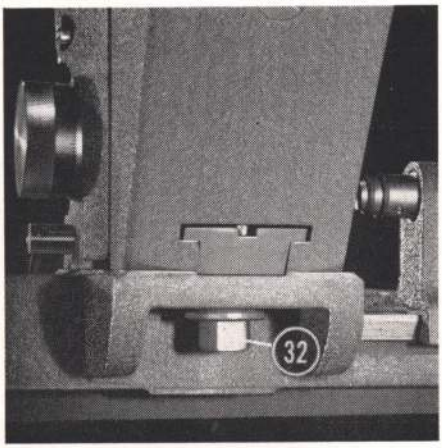
Note: before attaching the Magna-Viewer one should be sure to remove the projection hole cover from the microscope. This cover is located at the rear of the microscope, on the stage support, and serves to cover the hole through which the light ordinarily passes when the Magna-Viewer is in use. It is readily removed simply by pulling it out.

Loosen the bolt (Fig. 16—32) located on the under side of the microscope slide base until the T-shaped clamp block is free to rise slightly. Slide the Magna-Viewer into the microscope base, the flanges of the clamp block engaging the slots (Fig. 15—33) in the bottom portion of the Magna-Viewer, pushing it all the way forward. Tighten the bolt (32), clamping the Magna-Viewer securely to the microscope base. The slight amount of adjustment available may be used to insure that the image of the field diaphragm centers with the viewing screen.

To Insert an Eyepiece

To insert an eyepiece in the Magna-Viewer, it is only necessary to raise the

Figure 16—Magna Viewer Clamp Bolt



eyepiece holder cover by means of the small knob (Fig. 15—34) and place the desired eyepiece in the eyepiece holder. Be sure that the eyepiece holder is fully returned to its proper location upon completion of the insertion of the eyepiece.

Magnification

The magnification of the image projected on the ground glass screen is given by the product of the magnification values of the objective and eyepiece. Refer to the Table of Visual and Magna-Viewer Magnifications on page 12 for tabulated values of various combinations of objectives and eyepieces.

The carbon arc is by far the most satisfactory light source to use when viewing the projected image on the Magna-Viewer and is recommended for this purpose. The brightness of the image depends upon the brightness of the light source, the reflecting characteristics of the specimen, the numerical aperture of the objective used, and the magnification. Since the latter three factors will be subject to considerable variation from case to case, it is best to have as bright a source of light as possible. It is for this reason that the carbon arc is recommended.

Dark field and polarized light observation should be done through the visual eyepiece alone as the low level of the image brightness does not permit good projection for observation.

PHOTOMICROGRAPHY

Camera

The horizontal camera which extends to the left of the observer is more or less self-explanatory. The front and rear supports are held by the clamping screws (Fig. 17—35) in the positions desired. The front camera support is movable to permit interchange of eyepieces in the camera eyepiece tube, and the rear camera support is movable in order to vary the magnification of the image. In use, the front board of the camera should be brought up to the camera eyepiece tube, so that the male and female portions of the light-tight connector are well engaged.

Make sure that the eyepiece is positioned against its shoulder so that the shutter leaves will not be damaged by contact with the eyepiece.

The camera back is reversible in that the long dimension of the 5″ x 7″ photographic plate can be positioned either vertical or horizontal. To accomplish this, press down on the two leaf springs (36), thus disengaging the two bottom retaining studs. Turn the camera back 90° and replace it, making sure that all four studs engage their retaining holes.

The ground glass holder should be inserted in the camera back in such a way that the ground surface of the glass faces the interior of the camera.

When the camera is not to be in use for a considerable length of time, it is best to keep the front and rear supports of the camera fairly close together to avoid unnecessary sag of the bellows. A wire bellows support (37) is supplied with the camera but it is best to avoid letting the bellows remain extended over a long period of time.

Reversible Eyepiece Adapter

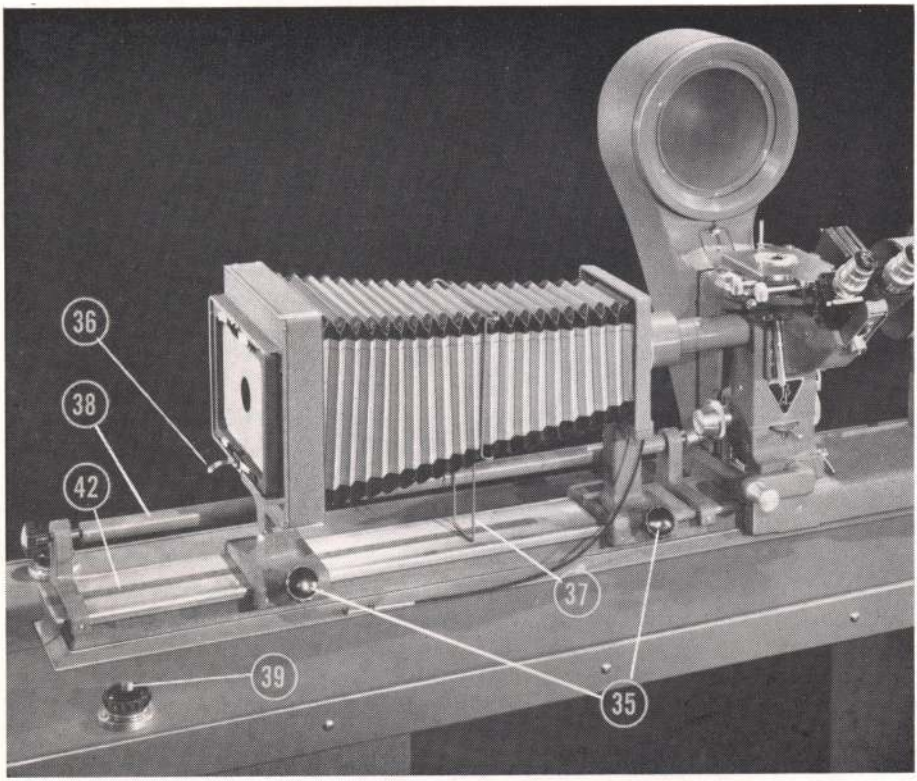
The camera eyepiece tube has a reversible eyepiece adapter to hold the various eyepieces used for photomicrography. When using the Huygenian, hyperplane, and compensating eyepieces, the adapter should be inserted with the small diameter out. When using the 10× negative amplifier, the adapter should be pulled out and reversed from the usual position.

The negative amplifier should be pushed into the large end of the adapter until it seats against the inside shoulder of the adapter, at which position it will protrude about ½" beyond the small end of the adapter. Do not use the negative amplifier with the adapter in the position for conventional type eyepieces (i.e. with the small end out), since this will cause the objectives to be working at the wrong tube length.

Fine Focusing with the Camera

When working with the camera bellows extended considerably, it would be impossible to reach the fine adjustment buttons on the microscope body and still view the image on the ground glass. To facilitate camera ground-glass focusing there is a remote-control, fine-focusing rod (38) extending along the back of the camera bed. By pushing this rod gently toward the

Figure 17— The Camera



microscope, a friction contact is established between the beveled fine-adjustment knob on the left-hand side of the microscope body and the two neoprene rings of the beveled end of the rod. A click stop arrangement maintains this contact and the image may be brought to sharp focus by turning the rod. There is a 2:1 reduction between the microscope fine adjustment knob and the camera focusing rod; i.e., one revolution of the camera focusing rod is equivalent to 0.05 mm vertical travel of the stage.

To obtain the most critical focus for photography it is best to use the focusing magnifier, resting it on the clear central portion of the camera ground glass, viewing the image through it and critically focusing on the center of the field.

A refinement of the focusing technique which arises from the fact that an objective has a certain depth of focus (see page 27) may be advantageously employed to obtain a photomicrograph which exhibits maximum field flatness. If one focuses critically in the center of the field several times and notes the reading of the fine adjustment knob graduations, it will undoubtedly be found that these readings will differ slightly. The greater the numerical aperture, the less these readings will vary. The optimum focusing setting is that for which the specimen is closest to the objective while still being in sharp focus at the center of the field. For this setting, one will obtain a photomicrograph having the largest possible area in focus with no loss of definition in the center of the field.

Upon obtaining sharp focus one should leave the focusing rod engaged until after the exposure is made, as it is difficult to disengage the rod without imparting some slight rotary motion to it, thus destroying the critical focus setting. Needless to say, great pains should be taken to avoid touching the rod in any way once it is set for a particular exposure.

When the instrument is in focus and ready to make a picture, gently remove the ground glass holder and slide in the plate holder. Be sure that the shutter is closed before the dark slide is withdrawn.

Shock Absorbers

To eliminate the effects of the vibration which is normally found in any manufacturing installation, a 16-spring shock absorbing suspension is provided. To let the instrument float on this suspension, partially unscrew the four knurled heads, one of which is visible (Fig. 17—39), until it is evident that the instrument bed is floating freely without touching any part of the supporting stand. With the instrument thus suspended, long photographic exposures at high magnifications may be made even under conditions of excessive vibration.

For partial shock absorption, the knurled heads may be tightened until the sponge rubber damping cushions under the knurled heads become effective. This stiffens the swinging of the instrument and makes manipulation easier.

It may even be found that, particularly for visual observation, it is feasible to tighten the knurled heads completely and not use the spring suspension, as the supporting stand itself rests on rubber shock absorbers.

Camera Shutter

The camera is equipped with an Eyepiece shutter, which has provision

for making instantaneous, time, and bulb exposures. The figures T., B., 50, 25, 10, 5 and 2 which are engraved on the face of the shutter indicate time, bulb, 1/50, 1/25, 1/10, 1/5, and 1/2 second exposures. To make an exposure of the desired duration, turn the knurled ring (Fig. 11—40) until the index mark engraved on it is over the proper exposure figure, then either press down on the trip lever (Fig. 11—41) or press on the cable release plunger. It is preferable to use the cable release, as this will impart less vibration to the instrument. When set for a bulb exposure, the shutter will stay open as long as the trip lever or cable release plunger is actuated. Upon the release of the actuating mechanism, the shutter will close. When making a time exposure, the trip lever or cable release plunger must be pressed twice—once to open the shutter and once to close it.

It must be remembered that there is no camera lens with the shutter, and none is to be used. The microscope objective and eyepiece form the image on the photographic plate.

Camera Scale and Photographic Magnification

The camera scale (Fig. 17—42) is graduated in tenths of inches and is used to measure the bellows extension of the camera. The scale reads the distance of the ground glass or photographic plate from the exit pupil of the microscope when using a Huygenian, hyperplane, or compensating eyepiece. To compute the approximate photographic magnification one should use the formula

$$M = \frac{m\ BD}{10}$$

where

M = total photographic magnification

m = microscope magnification (product of objective magnification and eyepiece magnification)

BD = bellows draw in inches, read from the camera scale.

Thus, with a 10× objective, a 5× Huygenian eyepiece, and a bellows draw of 20.0″, the magnification of the photographic image will be

$$10 \times 5 \times \frac{20}{10} = 100\times.$$

When using the 10× Negative Amplifier, a correction factor must be applied to the above formula as the exit pupil is formed within the camera eyepiece tube, 2.68″ to the right of the exit pupil position of the other eyepieces. (It is for this reason that the Negative Amplifier cannot be used as an eyepiece for visual observation).

Therefore, the magnification formula given above becomes

$$M = m\ \frac{BD + 2.68}{10}$$

when calculating the magnification in using the Negative Amplifier. For example: a 40× objective in combination with the 10× Negative Amplifier and a bellows draw of 9.82″ will give a total magnification of

$$40 \times 10 \times \frac{9.82 + 2.68}{10} = 500\times.$$

The magnification values as obtained from the above formulae are only approximate because of variations in eyepiece and objective magnifications which arise from necessary manufacturing tolerances. To obtain exact magnifications one should use a stage micrometer and measure its magnified image on the ground glass.

Photographic Magnification	*OBJECTIVES*						*EYEPIECES*			*Approximate Bellows Draw in inches*
	Achromatic		*Fluorite*		*Apochromatic*					
	Mag.	*N.A.*	*Mag.*	*N.A.*	*Mag.*	*N.A.*	*Huyg.*	*Hyper.*	*Amp.*	
25×	5×	0.10					5×			10.0
50×	5×	0.10					5×			20.0
75×	5×	0.10					10×			15.0
	8×	0.20					7.5×			12.5
100×	8×	0.20					10×			12.5
	10×	0.25					10×			10.0
150×	10×	0.25					10×			15.0
200×	20×	0.40						10×		10.0
250×	20×	0.40						10×		12.5
	25×	0.50						10×		10.0
500×	40×	0.65							10×	9.8
750×	50×	0.85							10×	12.3
			50×	0.85	50×	0.95			10×	12.3
			50×	1.00					10×	12.3
1000×					50×	0.95			10×	17.3
			50×	1.00					10×	17.3
	75×	1.25							10×	10.6
1500×			75×	1.25	75×	1.40			10×	17.3
2000×					75×	1.40			10×	24.0

ASTM Standard Magnifications and Recommended Optical Combinations for Photomicrography

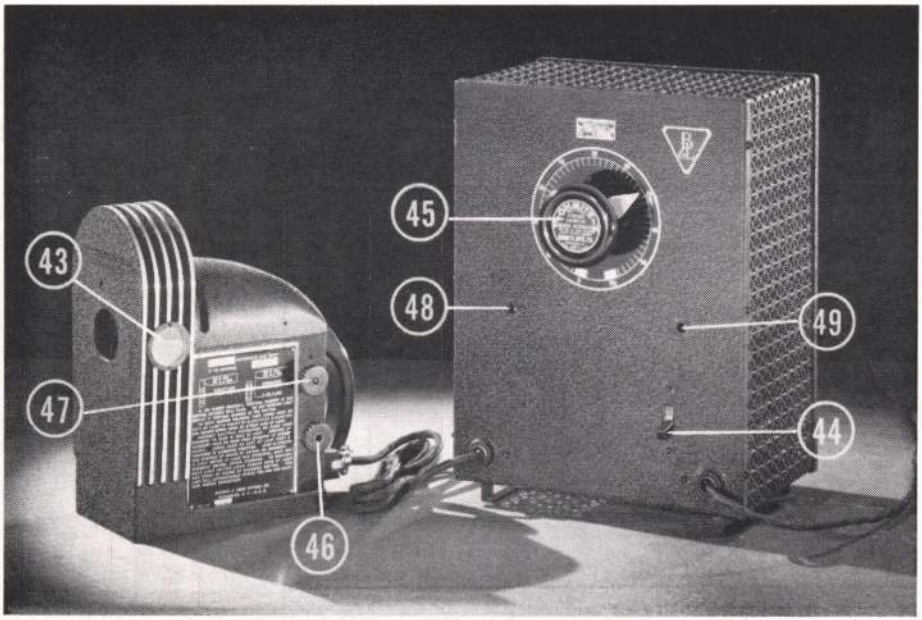


Figure 18—The Carbon Arc Illuminator

LIGHT SOURCES

While the low wattage visual illuminator before mentioned is ordinarily satisfactory for visual observation, it does not provide sufficient illumination for projecting the image on the Magna-Viewer or for use during photomicrography, unless longer exposures are of no consequence. For this reason, two larger light sources are made available. They are, in order of decreasing intensity, the automatic motor-driven carbon arc illuminator, and the zirconium oxide illuminator. The lamp housings are interchangeable on the microscope.

Carbon Arc Illuminator

The motor-driven carbon arc can be supplied for use on 115v or 230v, A.C. or D.C. Precautions should be taken against attempting to operate the unit on the wrong current or using the wrong carbons. For D.C. operation, an 8mm diameter carbon should be used horizontally and a 5.6mm diameter carbon vertically. A.C. operation requires the use of 6.4mm diameter carbons both vertically and horizontally.

The 115v, D.C. carbon arc illuminator is illustrated in Figure 18. This illuminator is similar in appearance and operation to all of the arc illuminators. Refer to the Unpacking and Assembly instructions at the rear of this manual for directions as to the proper electrical connections between the illuminator, the rheostat, the microscope, and the source of supply. The connection to the wall plug should be such that the horizontal carbon burns

the brighter. This may be ascertained by observing the inverted image of the carbons which is formed on the ground glass window (Fig. 18—43). If the vertical carbon should be burning brighter, simply reverse the wall plug connection, thus reversing the polarity of the D.C. input.

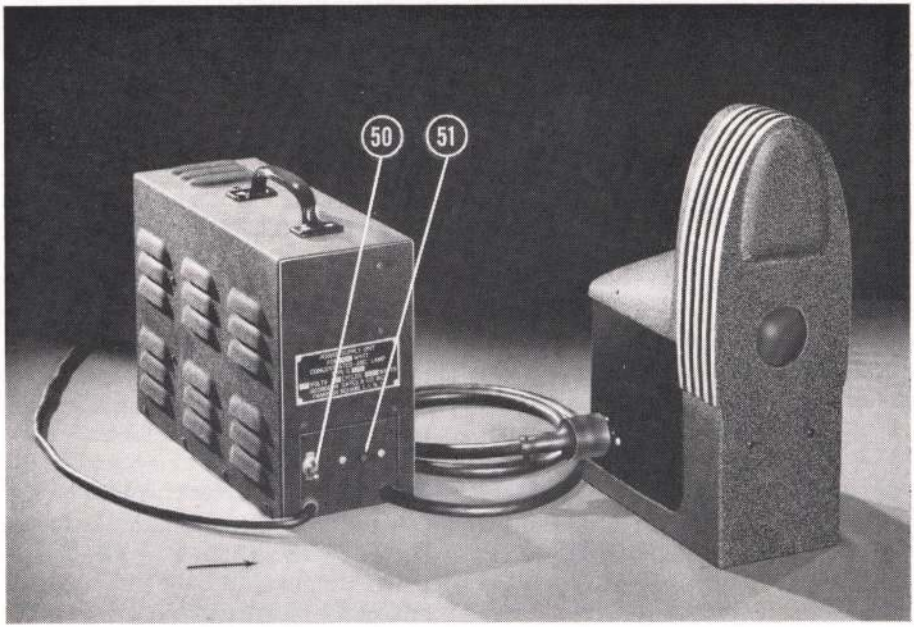
The switch (Fig. 18—44) turns the rheostat on and off. When used in connection with the internal wiring of the supporting stand, this switch should be left on at all times and the "Arc" switch on the stand (Fig. 14—60) used to turn the illuminator on and off. The rheostat knob (Fig. 18—45) may be used to vary the current between 5 and 10 amperes.

To move the carbon holders to permit the insertion of carbons, turn the clutch knob (46) counter-clockwise, and then move the carbon holders by turning the knob (47). The carbons should be set so that, when they make contact, the center of the horizontal carbon lines up with the tip of the vertical carbon. Avoid setting the vertical carbon so high that it cuts into the illuminating beam, or so low that it causes the horizontal carbon to have a tilted or overhanging crater. Reengage the clutch mechanism after changing the carbons by turning the knob clockwise.

NOTE: Be sure that the "Arc" switch (Fig. 14-60) is turned off before attempting to change carbons.

A limit switch inside the lamp housing, which is actuated by movement of the horizontal carbon holder, turns the current off when the carbons are burned to their permissible limits. This switch must be reset, after inserting the new carbons, by turning the limit switch lever in the direction of the horizontal carbon holder. Leave

Figure 19— The Zirconium Oxide Illuminator



the lever approximately perpendicular to the direction of travel of the horizontal carbon.

Carbon Arc Rheostat: The rheostat unit for 115 volt operation (Cat. No. 42-46-30) has two rheostats for controlling the carbon separation in the lamp. These rheostats are set at the factory but may require some slight readjustment due to a slightly different line voltage at the point of installation.

Adjustment may be made by inserting a screw driver in the two holes (48) and (49) and engaging the slots in the ends of the rheostat shafts. With the screwdriver, turn the left rheostat (48) clockwise as far as it will go, and turn the right rheostat (49) counter-clockwise. Start the arc lamp and allow it to burn about three minutes and then observe the carbon separation.

For a D.C. lamp this separation should be about ½" and not more than ¾"; for an A.C. lamp the separation should be ¼" to ½".

If it is too short, turn the left rheostat (48) in a counter-clockwise direction about 15 degrees and observe the carbon separation after about three more minutes of operation. If the separation is still too short, continue the adjustment in the counter-clockwise direction until satisfactory separation is attained.

If the carbon separation is too great when both rheostats are set against their stops as described above, it can be shortened by adjusting the right rheostat (49) in a clockwise direction.

The rheostat for use with 230 volt (Cat. No. 42-46-31) has but one adjustment for controlling the carbon separation. This is in the same relative position as the left rheostat (48) for the 115 volt unit, and its adjustment is the same.

Zirconium Oxide Illuminator

This provides a source having small area and high brilliance. The source brightness is less than that of the carbon arc being 1/5 as bright. The zirconium oxide illuminator operates at a color temperature of 3200°K. Inasmuch as type B Kodachrome is corrected for 3200°K color temperature, this lamp is an excellent source for use in color photomicrography. The long life of the lamp, plus the fact that no adjustments need be made during operation, make this a very convenient and economical source.

The zirconium oxide illuminator consists of a No. 42-44-78 lamphouse having a No. 42-42-06 300-watt zirconium oxide lamp, operated through a No. 42-46-78 power supply unit. It is illustrated in Figure 19.

To operate the illuminator, first plug the lamp into the socket inside the lamphouse. The base of the lamp has two large-diameter and four small-diameter prongs fitting into corresponding holes in the socket. This arrangement insures the proper orientation of the lamp in the lamphouse, so that the source is directed toward the microscope. The power supply unit can now be connected to the lamp by a similar plug located on the outside of the lamphouse. The connections having been made, connect the power supply unit to a 115 v A.C. line by means of the ordinary two-prong plug. The small wire protruding from the side of the plug is for grounding purposes, and should be attached under the head of the screw at the wall outlet.

CAUTION: Do not attempt to use this illuminator on direct current.

To start the illuminator, snap the toggle switch (Fig. 19—50) on the power supply unit to the "on" position and press the starting button (51) for a

few seconds until the erratic blue arcs in the lamp give way to a fairly steady yellow-white light, then release immediately. The lamp should continue to burn after releasing the start button. If it fails to do so, repeat this starting procedure.

NOTE: The Zirconium Oxide illuminator equipment cannot be connected to the supporting stand wiring circuit.

MICROSCOPE MANIPULATION

The various components and mechanisms of the microscope having been described in detail, a few words are in order as to how to use them in combination to the best advantage. The reader is referred to the preceding text for specific details concerning subjects which are covered in general here.

Bright Field Illumination

To study a specimen by visual observation with bright field illumination the following procedure is suggested, roughly in the order listed.

1. Turn on the light source.
2. Check to see that the dark field stop lever is pushed all the way in, that the analyzer is completely withdrawn, that the polarizer is swung out of the illuminating beam, that the half-aperture lever is pulled back, and that the aperture diaphragm is not decentered.
3. Using the fine adjustment, bring the stage to the focus position as indicated by the focusing index lever.
4. Elevate the stage, place the desired objective in position, and lower the stage.
5. Center the stage plate aperture roughly to the objective axis, using the mechanical stage controls.
6. Place the specimen on the stage plate and secure it with the specimen clamp.
7. Insert the desired eyepiece in the binocular body (or monocular body).
8. Turn the axis selector lever to the "Micro" position, thus delivering the light to the visual observation system.
9. Using the fine adjustment, bring the image into sharp focus.
10. Swing in any filters desired.
11. Adjust the openings of the aperture and field diaphragms.
12. In order to rotate the specimen, it will be necessary to see that the center of rotation of the stage coincides with the center of the field of view. Release the rotating stage clamp and rotate the stage while observing the image. If a spot central to the field of view does not revolve about its own center, centering of the stage will be necessary. This is accomplished by means of the stage centering screws, moving the stage until the center of rotation does coincide with the center of the field. A good way to judge when exact centration is obtained is to see whether or not an object near the edge of the field remains a constant distance from the field diaphragm as the stage is rotated.

Other Methods of Illumination

Once bright field illumination has been obtained, it is a simple matter to switch to dark field, polarized light, oblique or half-aperture illumination. The plastic mounted bright field-dark field objectives may be used to obtain any of these types of illumination, but they are the only objectives with which dark field illumination may be obtained.

In the following four paragraphs it will be assumed that the instrument has first been set up for bright field

illumination according to the above instructions and returned to bright field illumination each time before trying the next type of illumination.

To change to dark field, fully open both aperture and field diaphragms, and pull the dark field stop lever out in the direction of the engraved arrow. Adjust field and aperture diaphragms until the highest contrast in the image is obtained.

Polarized light is obtained by swinging in the filter holder which contains the rotating polarizer and sliding in the analyzer. Rotate the polarizer until maximum extinction of the light is obtained near the index line. At this orientation of the polarizer and analyzer, their axes are crossed. By rotating the stage you can determine whether or not the specimen is optically active.

Upon swinging the sensitive tint plate into position when the polarizer and analyzer are crossed, the field of view will become predominantly magenta in color. Evidence of weak birefringence in the specimen can be detected by rotating the specimen and observing if any change of color occurs.

To obtain oblique illumination, simply decenter the aperture diaphragm. It may be desirable to close the diaphragm somewhat in order to emphasize the relief structure of the specimen. The decentered diaphragm may be rotated through 360° in order that the oblique illuminating beam may strike the specimen at any desired azimuth.

Half-aperture illumination is readily obtained by pushing in on the half-aperture lever. It must be kept in mind that the use of half-aperture illumination involves the loss of resolving power in one direction, since half of the objective aperture is prevented from contributing to the formation of the image. When using the lower power objectives this effect is not serious, but the use of half-aperture illumination is not recommended for the higher powers.

Trouble Shooting

If a satisfactory image is not obtained, the following points should be checked. It will almost invariably be found that the defect is due to one or more of these conditions:

1. Light source not centered.
2. One of the filter holders interfering with the illuminating beam.
3. The aperture diaphragm decentered when oblique illumination is not desired.
4. Specimen and/or stage plate tipped.
5. Mechanical stage decentered so much that a high power objective strikes the stage plate before focusing on the specimen.
6. Objective holder not firmly seated and properly located.
7. Dark field stop handle not accurately set at either its full "in" or its full "out" position.
8. Half-aperture lever intermediate between "in" and "out," or pushed "in" when half-aperture illumination is not desired.
9. Analyzer neither "in" or "out," or "in" when polarized light is not desired.
10. Axis selector lever not positioned so that the click stop is properly locating it.

It should be realized that no microscope, no matter how perfect, can produce a satisfactory image of a specimen which has not been properly prepared or mounted. The proper preparation of metallographic specimens is an art, and should be given as much attention as any other phase of metallography.

THEORY OF THE MICROSCOPE

A brief discussion of the optical principles which should be considered in the use of the microscope are given here. For a more complete and detailed treatment of the various subjects one should consult one of the many books devoted to microscopy.

The optical system of the compound microscope may be sub-divided into three units: the condensing system, the objective, and the eyepiece.

Condensing System

The condensing system is provided to ensure that the light energy emitted by the light source is so directed that the aperture and field of the objective are completely and evenly filled with light. In the usual metallurgical microscope the lenses of the condensing system are an integral part of the unit and are not subject to interchange at the discretion of the operator. The field and aperture diaphragms, which are also part of the condensing system, are subject to the control of the operator. Their function and use will be discussed in a later section.

Objectives

The objective forms an enlarged image of the object. The degree of magnification depends on two factors: the focal length of the objective and the tube length of the microscope. All of the objectives to be used on current Bausch & Lomb Metallographic Microscopes should be corrected for use with an uncovered object (no cover glass) at 215mm tube length. Under such conditions the image formed by the objective will display the minimum amount of aberration.

One other characteristic of the objective, of even greater importance than the magnification, is the numerical aperture.

Numerical Aperture

The numerical aperture of an objective is a measure of its resolving power, which is its ability to separate the fine details which may exist in the specimen structure. An objective of a given numerical aperture (usually abbreviated to N.A.), whose full aperture is filled with light, is capable of resolving specimen structure which is separated by a distance $\frac{\lambda}{2\ \text{N.A.}}$, where λ represents the wavelength of the illuminating light. Assuming that light of wavelength 5500A (0.000022″) is used, two lines separated by a distance of approximately $\frac{1}{3600\ \text{N.A.}}$ mm ($\frac{1}{90000\ \text{N.A.}}$ in.) will be resolved. For an objective of 0.95 N.A., this is equal to 0.00029 mm (0.000012″).

The numerical aperture is also indicative of the depth of focus of the objective; the greater the N.A., the smaller the depth of focus. The image formed by the objective is not that of a mathematical plane located at the specimen surface, but rather that of a thin layer which extends above and below the ideal specimen plane, all points located in this thin layer being in sharp focus. The extent of this layer varies from ±0.055 mm for the 5×, 0.10 N.A. objective to ±0.0003 mm for the 77×, 1.40 N.A. apochromatic objective. Thus it will be noticed that specimen flatness is very critical, particularly for the higher N.A. objectives.

As the numerical aperture increases, the greater are the demands placed upon the objective to form a more perfect image so that full use may be

made of the increased resolving power. It is for this reason that there are three types of objective construction: achromatic, fluorite, and apochromatic, which, in the order given, have increasing complexity of construction and produce increasingly good quality of image.

Achromatic Objectives

The achromatic objective, in which chromatic aberration is corrected for two wavelengths and the spherical aberration is corrected for one wavelength, is generally useful for most purposes up to a numerical aperture of 0.85 for dry objectives.

Fluorite Objectives

The fluorite objectives, which use the mineral fluorite as one of the refracting elements, produce an image superior to that of the achromatic objectives, primarily because of the reduction of the secondary spectrum or spread between the foci of the chromatically and spherically corrected wavelengths.

Apochromatic Objectives

Apochromatic objectives represent the closest approach to the ideal objective as yet attained. Chromatic aberration is corrected for three colors and spherical aberration for two. Secondary spectrum is virtually eliminated. These objectives should be used when the utmost in resolving power is desired.

The decision as to which objective to use in any particular case will depend on the requirements as to magnification, resolving power, and flatness of field. One rule to follow in regard to the relationship between magnification and numerical aperture is that the total magnification should not exceed approximately 1000 times the numerical aperture of the objective. The "1000 times" rule insures that the magnification is more than sufficient to reveal all of the detail which the objective is capable of resolving.

If the magnification is greater, no new detail will be revealed; therefore, it is termed "empty magnification." Exceptions to this rule may be made providing that great care is taken. Experience has shown that satisfactory photomicrographs may be made at 2000× and even higher with an objective of 1.40 N.A.

All Bausch & Lomb objectives for metallurgical microscopes are now anti-reflection coated to increase image contrast. This is of importance when employing vertical illumination, in order to eliminate light which would otherwise be reflected by the lens components and thereby reduce image contrast.

This coating is a layer of magnesium fluoride which is one-quarter of a wavelength of green light (0.000005″) thick, and its action is to cause the ordinarily reflected light to interfere destructively; the transmitted light is reenforced to give closer to the ideal 100% transmittance.

Eyepieces

The eyepiece magnifies the image produced by the objective much as a magnifying glass permits one to observe an object held close to the eye. The type of eyepiece used has no effect upon the resolution obtained in the image but its type of aberration correction does affect the general image quality, particularly with respect to the aberration known as chromatic difference of magnification.

The Huygenian eyepiece is best suited for use with the lower power achromatic objectives. It consists of two plano-convex lenses, one at each end of the eyepiece tube, with a field diaphragm between them.

The hyperplane eyepiece features a flatter image plane than the Huygenian type and is recommended for use with the medium and higher power achromatic and fluorite objectives.

The compensating eyepiece is intended primarily for use with apochromatic objectives, being corrected to compensate for the considerable chromatic difference of magnification which is typical of apochromats.

The negative amplifier is meant to be used for photomicrographic purposes only, and is recommended for use at photographic magnifications of 500× and higher. It was previously pointed out that the eyepiece adapter must be reversed when using the negative amplifier.

Aperture Diaphragm

The aperture diaphragm has as its primary purpose the control of the illuminating beam so that only that bundle of light which is sufficient to fill the aperture of the objective is passed through the system. It is also used to increase the flatness of field, depth of focus, and contrast in the image. It must be realized that these advantages are gained only at the expense of loss of resolving power. As soon as the diaphragm is stopped down beyond the point at which the back aperture of the objective is just filled with light, the effective numerical aperture and, therefore, the resolving power are reduced.

It cannot be too emphatically stated that the aperture diaphragm should never be used merely to reduce the intensity of the illumination. Neutral density filters are available for this purpose and their use involves no loss of resolving power.

The proper setting of the aperture diaphragm can best be determined by slowly closing it while watching the image. At some certain setting an ideal compromise between image contrast and resolution will be found. Closing the diaphragm beyond this point will bring about a thickening of the image structure due to diffraction effects; opening it wider will cause the image to lose contrast.

The optimum setting of the aperture diaphragm is generally found to be that for which the objective aperture is approximately 2/3 filled with light.

The opening of the aperture diaphragm relative to the objective aperture may best be observed by using the pinhole cap in the observation eyepiece tube instead of an eyepiece.

Field Diaphragm

The field diaphragm serves to control the illuminating beam so that only that portion of the specimen which is under examination is illuminated, thus eliminating stray light which might cast a haze over the image. It is usual to close the field diaphragm until its image lies just outside of the field of view of the eyepiece.

Filters

Filters are normally used for metallographic photomicrography and are generally used to control resolving power and image contrast, rather than to reproduce tone values in the photographic image.

In the section on numerical aperture it was pointed out that the resolving power depends on the wavelength of the light employed as well as on the numerical aperture of the objective. Therefore, it might be assumed that a blue filter should be used at all times to obtain the maximum resolving power. This is true when one uses apochromatic objectives with their superior color and spherical aberration correction. How-

ever, when using the achromatic objectives, it is best to employ a green filter as these objectives are spherically corrected for this region of the spectrum. A blue filter would give greater resolving power for the achromatic objectives, but the resolving power thus gained would be more than offset by the fuzzier image obtained.

Neutral density filters should be used when it is desired to reduce the intensity of the illumination without changing its spectral characteristics. The Bausch & Lomb evaporated inconel neutral density filters closely approximate an ideal neutral filter which has a constant transmission over the range of the visible spectrum.

PHASE CONTRAST ACCESSORIES

In the following section, instructions are given for the use of the Bausch & Lomb Phase Contrast Accessories for Metallography (Cat. No. 42-32-51-54) in conjunction with the Balphot Metallograph.

The Bausch & Lomb Phase Contrast Accessories for Metallography make possible the application of the principles of phase contrast microscopy to metallographic microscopes. No special phase objectives are needed with this equipment, since all of the standard metallographic objectives are usable. The equipment shown in Figure 21 consists of one phase contrast accessory and one annular stop holder. A lined, leatherette-covered case is supplied.

Fitting to the Microscope

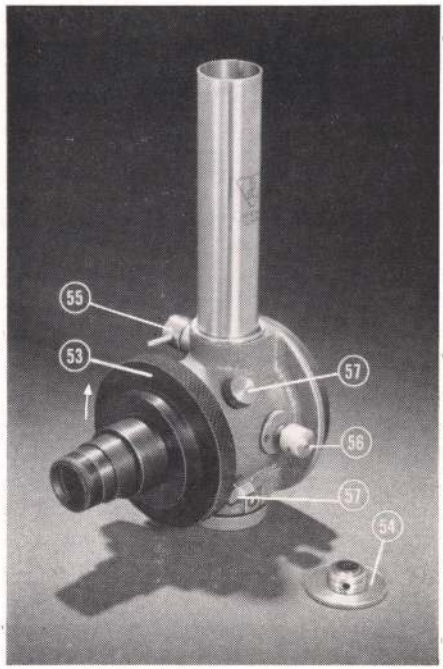
The phase contrast accessory fits directly into the camera eyepiece adapter tube. Figure 24 shows the unit in place and ready for use. To attach the unit, first remove the reversible eyepiece adapter from the camera axis tube and insert the phase contrast accessory in its place. Rotate the unit until the eyepiece tube is at a convenient angle and then turn the large knurled ring (Fig. 21—53) in the direction of the arrow, as shown, clamping the unit securely in position.

Insert the annular stop holder (Fig. 21—54) into the end of the aperture diaphragm assembly. Should the holder fit a little too loosely, bend the lips of the T slot slightly until a snug fit is obtained. With the aperture diaphragm in the centered position, open it all the way.

Image Formation

Figure 22 shows schematically the optical system of the phase contrast

Figure 20— The Phase Contrast Accessories



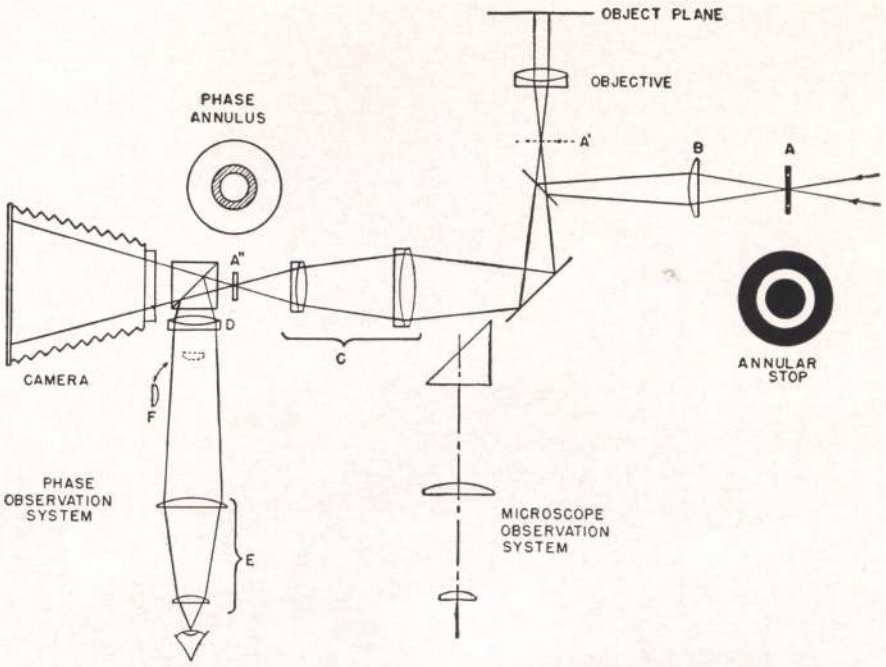
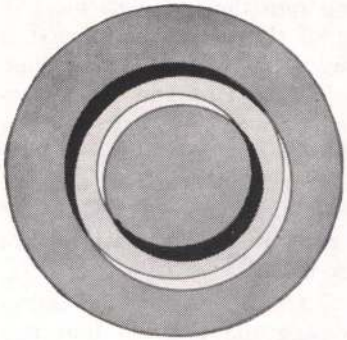


Figure 21—Schematic Diagram of the Optical Path of the Phase Contrast Accessory

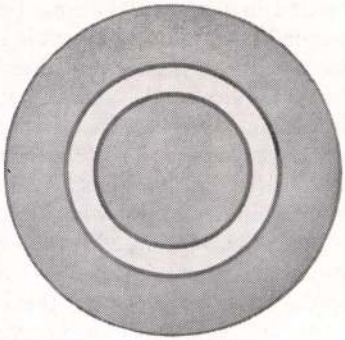
accessory in conjunction with the microscope. The annular stop is placed at A, the plane of the aperture diaphragm. The stop is imaged by the condensing system at A′, in (or close to) the rear focal plane of the objective. The objective images A′ at infinity and, upon reflection from the specimen, it is imaged back upon itself at unit magnification. The projector system relays this image onto the phase retarding annulus at A″, and the re-

Figure 22—Centration of Stop Image and Phase Disc

A—Not Centered



B—Centered



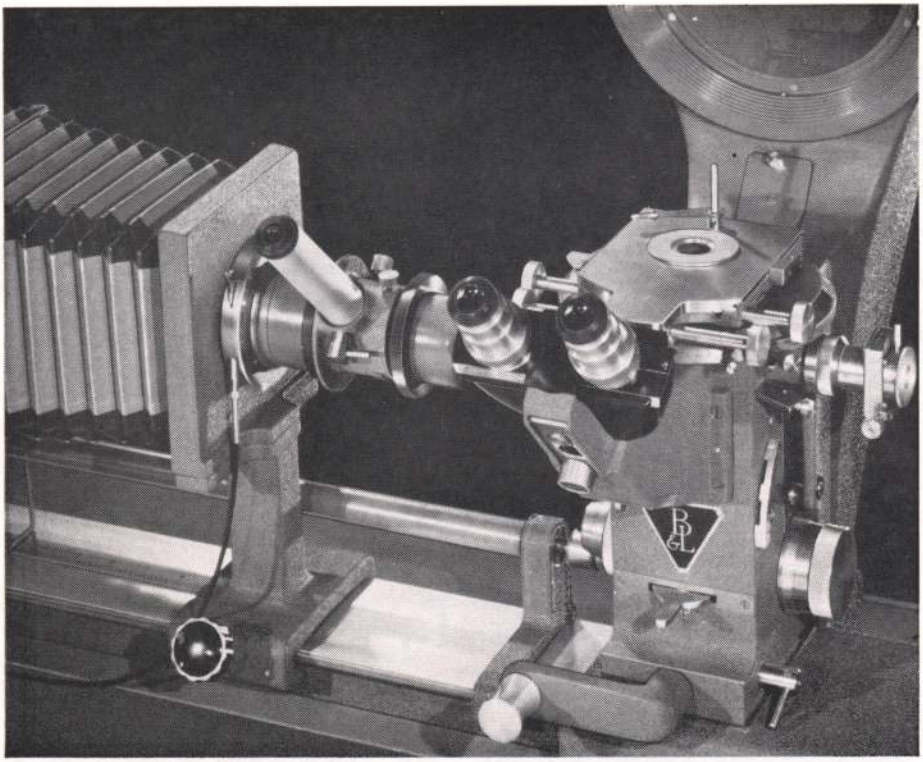


Figure 23—The Balphot with Phase Contrast Accessories

tarding and absorbing action of this annulus converts the light energy into a phase contrast image.

Changes in surface elevation of a specimen result in a "phase image" whose phase pattern is a replica of the surface contour, depressions being retarded in phase, elevations being advanced. This phase pattern is invisible in normal bright field illumination, but can be made visible by superimposing a "coherent background" upon the image. This coherent background is simply a level illumination background of light which has a definite phase relation with respect to the invisible "phase image." Its addition to the phase image causes this image to become visible by interference, in much the same manner that superposition of a test glass on an optical surface causes the otherwise invisible surface contour of the optical surface to become visible.

The coherent background in the case of the test glass comes from the reflection from the test glass face; in the case of the phase microscope it comes from the direct undiffracted light which goes through the phase-retarding annulus. The beam-splitting cube permits approximately 85% of the light to pass on out to the camera, and directs the remaining 15% of the light to the visual observation tube of the phase unit.

Lens D serves as a telescope objective, focusing the light so that any

standard eyepiece (E) may be used for visual observation. The phase visual observation system has a magnification factor of 2.5×; i.e., the total magnification is 2.5 times the product of the eyepiece and objective magnifications.

The auxiliary centering lens (F) may be swung in and out of the optical path as desired. When swung into position, as shown by the dotted lines, and with an eyepiece (E) in place, the system is focused on the phase disc (A″) and centration of the annular stop image may be made. With the lens (F) swung out of the optical path, the system is focused on the specimen under examination. The projection lens system (C) is equivalent to a 5× eyepiece in its photographic magnification. It is corrected to give not only a sharp image of the specimen but a sharp image of the illumination annulus as well.

Adjustment and Alignment

Attach the desired objective to the microscope and insert the desired eyepiece in the phase visual observation tube. Make sure that the aperture diaphragm assembly is centered, and that the auxiliary-centering, lens-actuating handle (Fig. 21—55) is turned so that it is parallel with the camera axis. With the light directed into the microscope camera axis (and thus into the phase contrast unit), focus the microscope in the usual manner. Rotate the handle (55) 90° counterclockwise. This will swing the auxiliary centering lens into position and bring the phase-altering annulus (dark ring) into focus.

By turning the focusing knob (56), bring the image of the annular stop (bright ring) into focus in the plane of the phase disc. With the phase disc centering screws (57) center the dark annulus to the bright annulus. The bright annulus must be concentric with, and completely covered by, the dark annulus to insure correct performance. Figure 23A shows the appearance of the two overlapping annular patterns when the stop image (bright) is properly focused but not properly centered to the phase-altering annulus (dark). The regions of complete overlap appear gray.

Figure 23B shows the optimum condition for the concentric overlap of the two annular patterns. Rotate the auxiliary centering lens handle 90° clockwise and the image of the specimen will be seen. It may be necessary to refocus the microscope slightly. The unit is now in adjustment and the specimen may be studied under the conditions of phase contrast. This alignment procedure must be rechecked upon changing objectives or specimen.

Phase Photography

To take a phase contrast picture after the above alignment is completed, it is only necessary to bring the light-tight connector of the camera up to the light-tight adapter of the phase contrast unit and focus the image on the ground glass in the usual manner.

Comparison of Phase and Bright Field

With the phase unit attached to the microscope and in adjustment, it is possible to view the image under bright field conical illumination simply by switching to the visual observation tube of the microscope. While the bright field image under conical illumination will appear somewhat different from the image as seen under the more conventional central axial illumination, it will serve as an adequate guide as to what characteristics of the

specimen the phase contrast is revealing which would be unnoticed otherwise. To obtain central axial bright field illumination it is necessary to remove the annular stop from the illuminating beam. If this is done and then one wishes to return to phase contrast conditions, simply replace the annular stop, open the aperture diaphragm, and check the focus and centration of the phase disc and the annular stop image.

Filters

For optimum photographic results the green filter should be used, but visual observation may conveniently be carried out without the use of filters.

Type of Contrast

The phase-altering annulus supplied with the unit is designed to give positive, or dark, contrast. That is, in the resulting phase image, regions of greater optical path will appear darker than those of less optical path. This means that areas which are depressed with respect to the general surface level of the specimen will appear dark, and elevated areas will appear bright. Thus the surface contour of the specimen may be interpreted from the gradations of tones in the phase image.

Care of the Instrument

As with any optical instrument, one should take precautionary measures to prevent the accumulation of dust on the optical elements. When it is not in use, keep the unit in its case. When the unit is attached to the microscope, always keep an eyepiece in the visual observation tube. Should dust accumulate, brush it off gently with a camels hair brush or blow it off with a gentle blast of air. If necessary, the exposed lens surfaces may be wiped with a piece of lens tissue or a soft lintless cloth moistened with Xylol.

UNPACKING AND ASSEMBLY

The Balphot Metallograph is shipped disassembled, packed in several boxes and crates to provide protection during transportation. The number of boxes used will depend, of course, on the particular equipment ordered. No detailed instructions are necessary as to the unpacking of these boxes as all screws, etc., will be evident upon inspection. Needless to say, rough treatment and handling are to be avoided. Remove all bracing blocks which hinder easy removal of the equipment from its crate.

Certain portions of the equipment will be wrapped and tied both to prevent dirt and dust from getting into the mechanisms and to prevent movement during shipment. Dust the equipment off before removing these wrappings.

NOTE: Do not use the camera eyepiece tube as a handle when removing the microscope from its case.

A study of Figure 1 will indicate the relative positions of the various components with respect to each other and will serve as a guide to assembly.

The supporting stand and optical bed are shipped as an assembled unit. The shock-absorbing knobs (Fig. 17—39) will be tightened and should be left tightened until all is assembled.

Unscrew the two lock screws in the microscope base (Figs. 9 and 14—58) until they do not protrude through the

inside of the base. Place the microscope on the optical bed. It will be necessary to tilt it backwards somewhat in order that the dovetail surface of the microscope base contacts the rear dovetail surface of the optical bed. A scribe mark, located approximately 10″ from the first engraved line of the camera scale, will indicate the position of the left end, of the microscope base. Make sure that the dovetail surface at the rear of the microscope base is in contact with its mating surface of the optical bed and tighten the screws (58).

Slide the camera supports on the optical bed from the left, making sure that the camera support gibs are in place in their respective supports. Two small headless screws on the front of each of the camera supports control the separation between the gibs and the front dovetail surface of the optical bed. To adjust these properly, with the camera in place on the optical bed, tighten the screws completely and then back them off about one half a turn. If the gibs are too loose, there will be chatter as the supports are moved.

The remote-control fine focusing rod is held in place by two screws, one in each of the supporting pieces. Scribe lines on the optical bed will indicate the correct positioning of supports.

The stage will not be on the microscope when it is received. Unscrew the centering screws (Fig. 2—3) until they do not protrude through the stage support. On the under side of the rotating stage there will be seen a notch and two plane beveled surfaces. The centering pin engages the notch and the centering screws contact the plane surfaces when properly positioned. Hold the stage, right side up, allowing it to tip slightly toward the rear. Engage the centering pin in its notch on the lower side of the stage, push forward against the spring, and allow the stage to settle gently into position. Screw in the centering screws until they contact their bearing surfaces. Instructions for centering the stage are given on page 25.

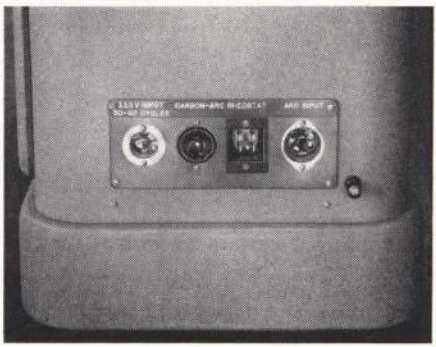
A hexagonal head bolt will be seen in the bottom of the left hand accessory cabinet. This bolt is provided to permit the leveling of the supporting stand with respect to the floor on which it rests. A socket wrench is provided with the equipment for adjusting this bolt.

Before attaching the Magna-Viewer to the microscope see page 15.

Electrical Connections

Three loose wiring cables, two long and one short, are supplied with the supporting stand in order that proper connections can be made between the integral wiring system of the metallograph and the sources of electrical supply. In addition, there are three other cables, one emerging from the rear of the condenser support and two emerging from the carbon arc rheostat. These will have to be connected, for proper operation, in the manner described below. The lengths of the wires, and the sizes and shapes of their plugs

Figure 24



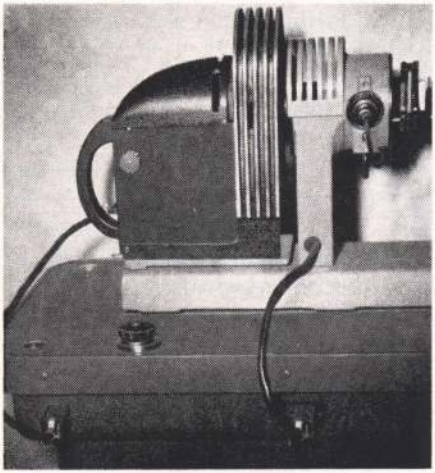


Figure 25

and receptacles, are such that it will be difficult to make a wrong connection.

Figure 24 shows the wiring panel which is located on the lower right side of the right column of the supporting stand. Connections to this panel are as follows: The female plugs of the two long loose cables are to be connected to the matching male plugs of the panel, one is marked "115V Input, 50-60 Cycles" and the other "Arc Input." The male plugs of these two cables are to be connected to the proper sources of electrical supply; the former to a 110-120v A.C. line and the latter to a line suitable for the characteristics of the carbon arc lamp purchased. Both of the cables which are integral with the carbon arc rheostat are to be connected to the two remaining receptacles of the wiring panel, the ones marked "Carbon Arc Rheostat." Note: The power switch of the rheostat (Fig. 18—44) may be put in the "On" position after all connections have been made and left on. Use the "Arc" switch (Fig. 14—60) as the control switch.

The short loose cable is to be connected between the receptacle in the rear of the arc lamp housing and the receptacle in the upper right rear of the supporting stand. See Figure 25.

Connect the cable which emerges from the rear of the condenser support to the receptacle which is immediately beneath the condenser support in the supporting stand. Refer to Figure 25.

As a final precaution, a grounding wire should be connected between the "terminal G," adjacent to the wiring panel (Fig. 24), and a radiator, water pipe, or other grounding medium. Use a wire no smaller than No. 14 AWG.

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

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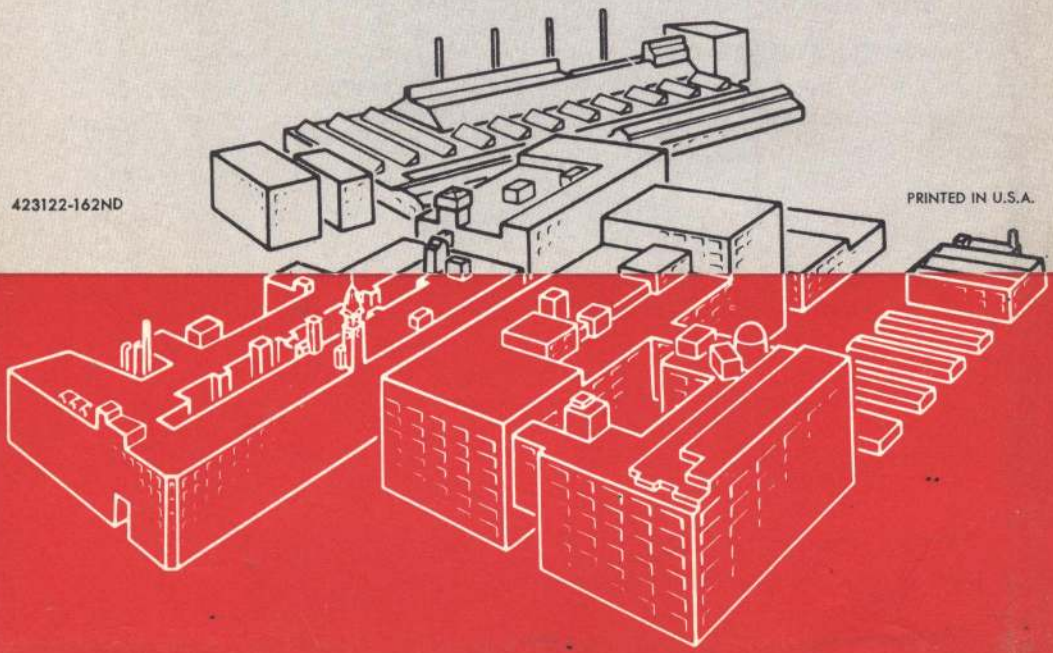

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Typical Photomicrograph taken on the Bausch & Lomb Balphot Metallograph

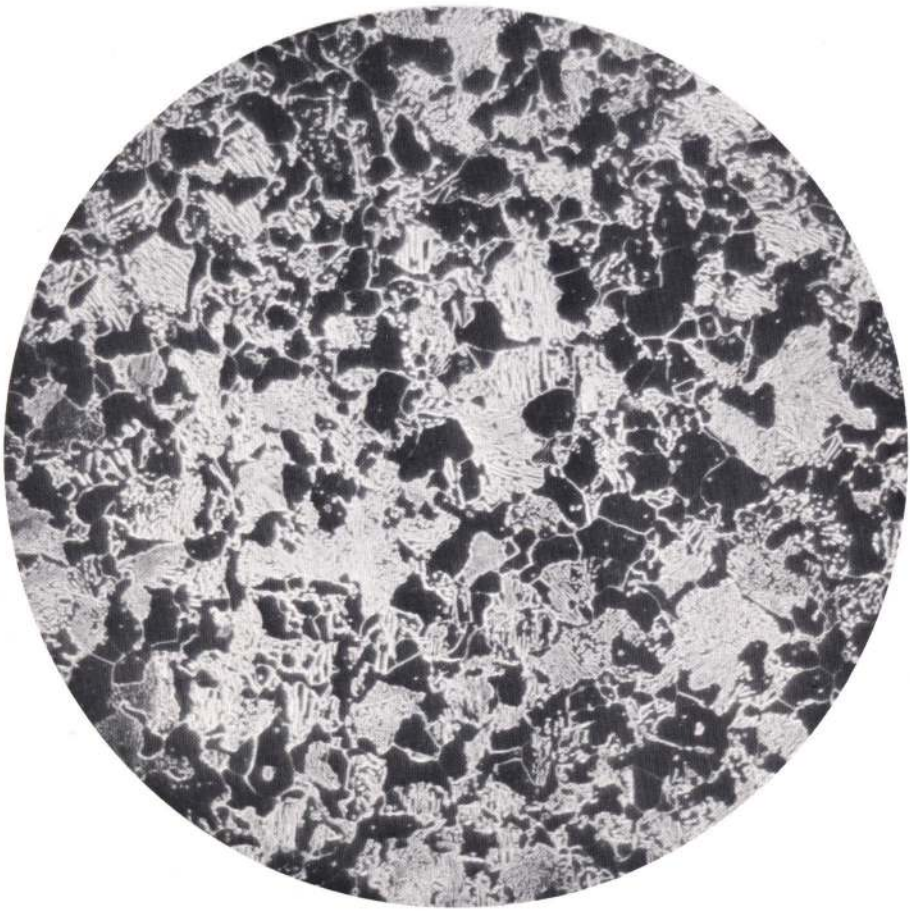
(Reproduction)

Specimen: Manganese Bronze
Magnification: 100×
Illumination: Brightfield
Objective: 8×, 0.20 N. A.
Eyepiece: 5× Huygens

LITHO IN U. S. A.

Typical Photomicrograph taken on the Bausch & Lomb Balphot Metallograph

(Reproduction)



Specimen: Pearlite
Magnification: 500×
Illumination: Darkfield
Objective: 40×, 0.65 N. A.
Eyepiece: 10× Negative Amplifier

LITHO IN U. S. A.

Typical Photomicrograph taken on the Bausch & Lomb Balphot Metallograph

(Reproduction)

Specimen: High Speed Steel
Magnification: 750×
Illumination: Brightfield
Objective: 50×, 0.85 N. A.
Eyepiece: 10× Negative Amplifier

LITHO IN U. S. A.

Typical Photomicrograph taken on the Bausch & Lomb Balphot Metallograph

(Reproduction)

Specimen: Martensite
Magnification: 500×
Illumination: Polarized Light
Objective: 40×, 0.65 N. A.
Eyepiece: 10× Negative Amplifier

LITHO IN U. S. A.

Typical Photomicrograph taken on the Bausch & Lomb Balphot Metallograph

(Reproduction)

Specimen: Pearlite
Magnification: 1500×
Illumination: Brightfield
Objective: 75×, 1.40 N. A. Apochromat
Eyepiece: 10× Negative Amplifier

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