OLYMPUS TRINOCULAR STEREO MICROSCOPE

MODEL X-Tr
REPAIR MANUAL

OLYMPUS

P R E F A C E

The functions of a microscope can be analyzed into the mechanical and optical systems. To those who are engaged in line of microscope repair, it is a self-evident truth that if the optical system is not correctly adjusted, the fundamental function of the microscope may be lost.
Among the various types of microscopes, the stereo microscopes such as the OLYMPUS Stereo Microscopes Models X and X-Tr require most difficult and complicated techniques to repair. Prior to repair of them, read this manual and make yourself familiar with these models so that you can find what parts are defective and degrees of their damages.

In case of the Models X and X-Tr it is necessary, first of all, to find out what lens(es) or/and prism(s) is(are) the cause(s) of the microscope mulfunction. Checks and repairs of these models should be carried out in the following orders:

1. Porro prisms
2. Parfocality of drum lenses
3. Total deviation of drum lenses
4. Optical axes of left and right fields of view

Each of these 4 items can be checked and repaired individually. However, if you observe a double image through the binocular observation tube, for instance, the optical axes of the left and right fields of view are not coincided, simultaneously and totally due to the items 1, 3, and 4 mentioned above. These 3 steps must be repaired in the order 1-3-4.
You cannot change this order, because if you complete steps 3 and 4 prior to step 1, you must repeat checks and repairs steps 3 and 4 after completing step 1.
If you get skilled in repair of the Model X and X-Tr, the optical adjustments of the other OLYMPUS Stereo Microscopes except the Model SZ-III become more easier because they are of the same optical system.
(Your comments are welcome on this manual for improvements of other manuals.)

CONTENTS

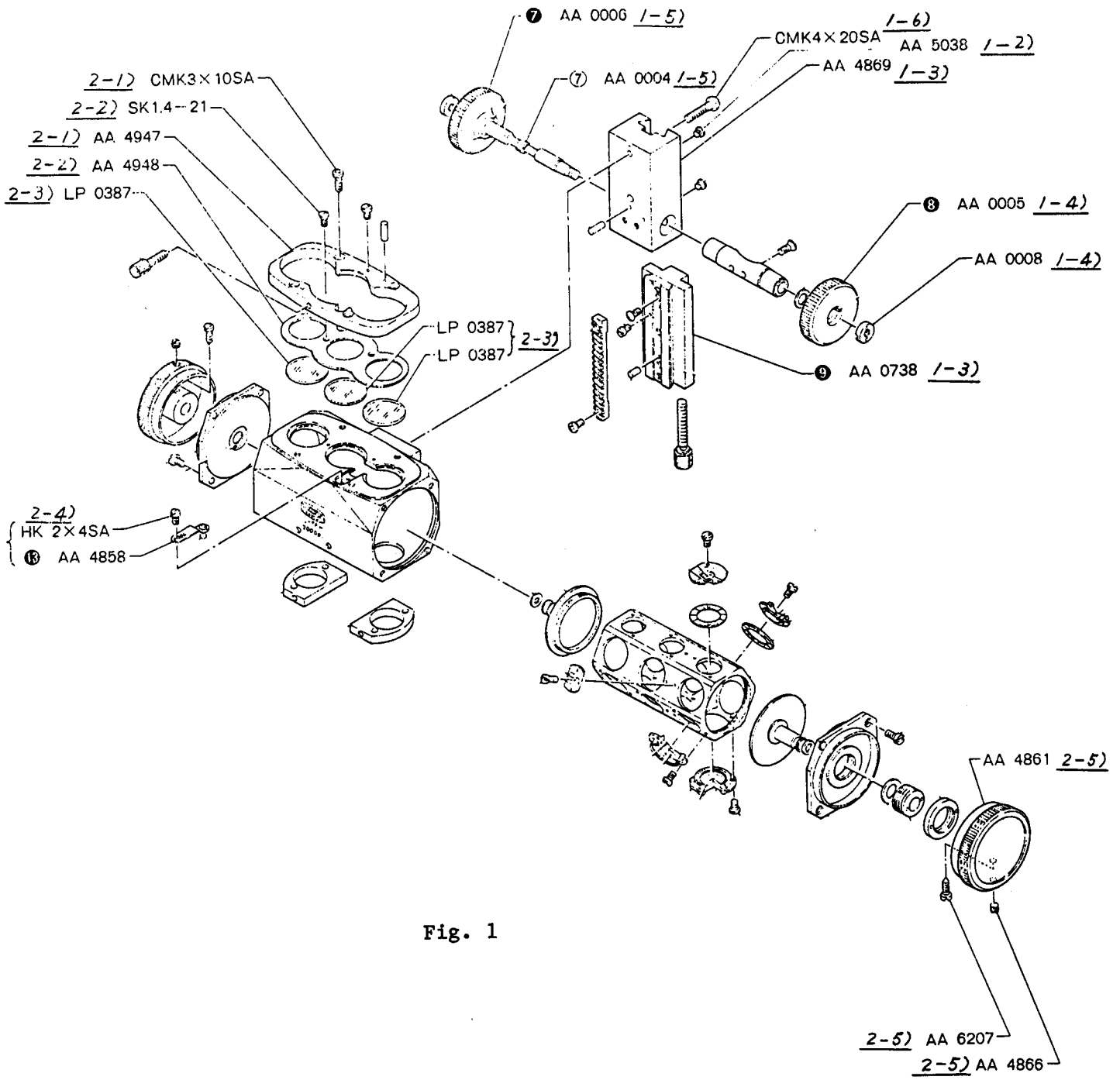

❼ AA 0006 1-5)
CMK4×20SA 1-6)
AA 5038 1-2)
AA 4869 1-3)
⑦ AA 0004 1-5)
2-1) CMK3×10SA
2-2) SK1.4-21
2-1) AA 4947
2-2) AA 4948
2-3) LP 0387
❽ AA 0005 1-4)
AA 0008 1-4)
LP 0387
LP 0387
2-3)
❾ AA 0738 1-3)
2-4)
HK 2×4SA
⑱ AA 4858
AA 4861 2-5)
2-5) AA 6207
2-5) AA 4866

Fig. 1

A. SEQUENTIAL PROCEDURE OF DISASSEMBLY (See Fig. 1)

1. Disassembly of Focusing Mechanism

1-1) Rotate focusing knobs until main body goes up as well as possible.

1-2) Unscrew AA5038 that can be seen in dovetail block AA4869.

1-3) Disengage metal block AA0738 from dovetail AA4869.
Rotate focusing knobs, and lower main body so that rack and pinion are disengaged, and pull out metal block.

1-4) Remove focusing knobs AA0005.
Holding both of focusing knobs in both hands, rotate them in the opposite directions simultaneously so that they are loosened. When they are completely loosened, focusing knob AA0005 and nut AA0008 are disengaged.

1-5) Pull out pinion from bearing.
As you pull out focusing knob AA0006 in the axial direction, pinion can be pulled out.

1-6) Unscrew two CMK4x20SA and pull out block AA4869 from main body.

2. Disassembly of Main Body and Lens Drum

2-1) Unscrew four CMK3x10SA and pull out fixing guide AA4947.

2-2) Unscrew two SK1.4-21, and remove cover plate AA4948.

2-3) Remove three glass discs LP0387.
Prior to removal, immerse three glass discs with a little amount of alcohol for a few minutes, because these discs were shellaced, then stick them to Scotch tape to remove with ease.

2-4) Unscrew two HK2x4SA, and remove click-spring AA4858.

2-5) Unscrew left knob AA4861.
After removal of screw AA4866, insert a small screwdriver through empty hole to loosen setscrew AA6207. Knob can be removed.

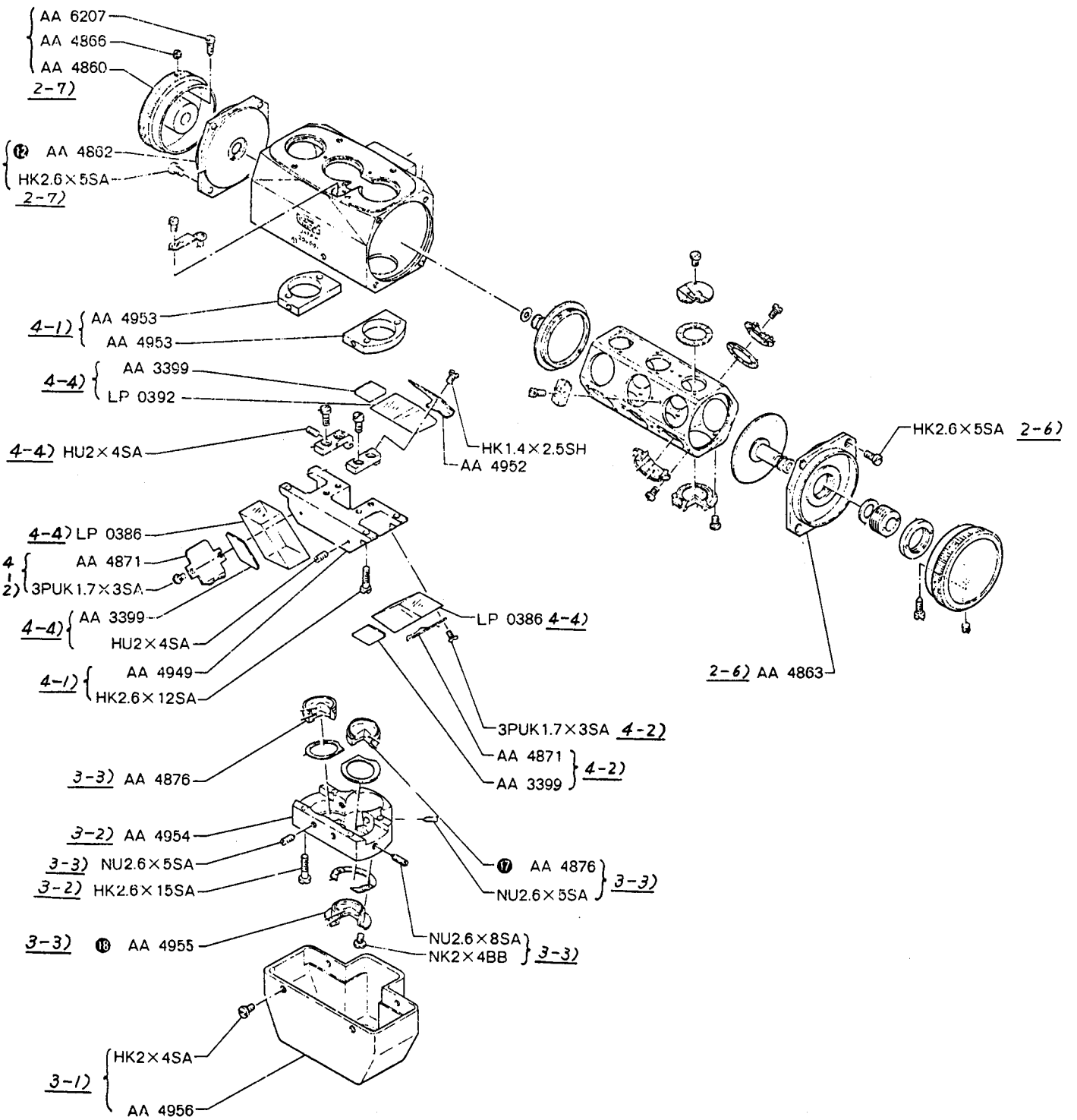

AA 6207
AA 4866
AA 4860
2-7)
⑫ AA 4862
HK2.6×5SA
2-7)
4-1) AA 4953
AA 4953
4-4) AA 3399
LP 0392
4-4) HU2×4SA
HK1.4×2.5SH
AA 4952
HK2.6×5SA 2-6)
4-4) LP 0386
4-2) AA 4871
3PUK1.7×3SA
4-4) AA 3399
HU2×4SA
4-1) AA 4949
HK2.6×12SA
LP 0386 4-4)
2-6) AA 4863
3PUK1.7×3SA 4-2)
AA 4871
AA 3399
4-2)
3-3) AA 4876
3-2) AA 4954
3-3) NU2.6×5SA
3-2) HK2.6×15SA
⑰ AA 4876
NU2.6×5SA
3-3)
3-3) ⑱ AA 4955
NU2.6×8SA
NK2×4BB
3-3)
3-1) HK2×4SA
AA 4956

Fig. 2

(See Fig. 2)

2-6) Unscrew four HK2.6x5SA and remove bearing AA4863.

2-7) Disassemble right knob AA4860 from bearing AA4862 in the same manner as above.

2-8) Pull out lens drum.

3. Disassembly of Objective Mount

3-1) Unscrew four HK2x4SA and remove objective cover AA4956.

3-2) Unscrew four HK2.6x15SA and remove adjusting washer AA4954.

3-3) Unscrew objectives.

Unscrewing NU2.6x5SA and NU2.6x8SA, remove retaining frame AA4876. When this frame was shellaced, immerse it with alcohol for a few minutes prior to removal, then loosen it. Objective frame AA4955 can be removed by removing two screws HK2x4BB.

4. Disassembly of Prism Mount

4-1) Unscrew four HK2.6x12SA, and remove prism mount AA4949 and plate AA4953.

4-2) Unscrew four 3PUK1.7x3SA and remove two P-holders AA4871.

4-3) Unscrew two HK1.4x2.5SH, and remove P-holder AA4952.

4-4) Loosen three HU2x4SA, and then remove two prisms LP0386, prism LP0392 and three side plates AA3399.

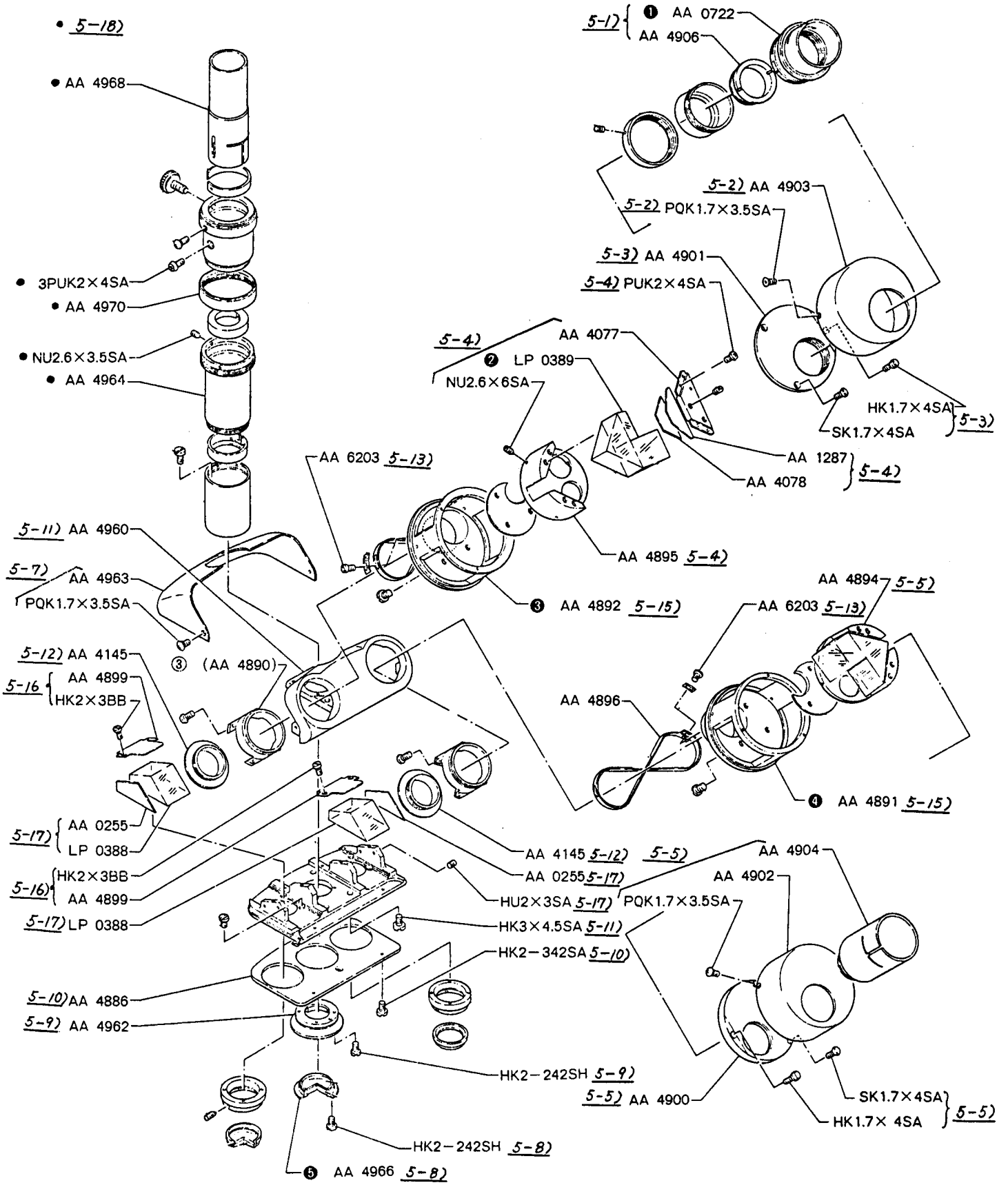

• 5-18)
• AA 4968
• 3PUK2×4SA
• AA 4970
• NU2.6×3.5SA
• AA 4964
5-11) AA 4960
5-7) AA 4963
PQK1.7×3.5SA
5-12) AA 4145
5-16) AA 4899
HK2×3BB
③ (AA 4890)
5-17) AA 0255
LP 0388
5-16) HK2×3BB
AA 4899
5-17) LP 0388
5-10) AA 4886
5-9) AA 4962
HK2−242SH 5-8)
❺ AA 4966 5-8)
5-1) ❶ AA 0722
AA 4906
5-2) AA 4903
5-2) PQK1.7×3.5SA
5-3) AA 4901
5-4) PUK2×4SA
5-4)
AA 4077
❷ LP 0389
NU2.6×6SA
AA 6203 5-13)
AA 4895 5-4)
❸ AA 4892 5-15)
AA 1287
AA 4078
5-4)
HK1.7×4SA
SK1.7×4SA
5-3)
AA 4894 5-5)
AA 6203 5-13)
AA 4896
❹ AA 4891 5-15)
AA 4145 5-12) 5-5)
AA 0255 5-17)
HU2×3SA 5-17)
HK3×4.5SA 5-11)
HK2−342SA 5-10)
AA 4904
AA 4902
PQK1.7×3.5SA
5-5) AA 4900
SK1.7×4SA
HK1.7× 4SA
5-5)

Fig. 3

(See Fig. 3)

5. Disassembly of Trinocular Tube

5-1) Unscrew left eyepiece tube.
Insert flat-tip divider into eyepiece tube, and rotate nut AA4906 counter-clockwise.

5-2) Unscrew three PQK1.7x3.5SA, and cover-L AA4903.

5-3) Unscrew three SK1.7x4SA, and OC-mount-L AA4901.

5-4) Disassemble porro-prism.
Unscrew three NU2.6x6SA and take out prism mount-L AA4895.
Unscrew four PUK2x4SA, porro-prism, pressing plate AA4077, plate AA1287 and plate AA4078.

5-5) Disassemble right porro-prism in the same manner as above with the exception that eyepiece tube is unscrewed by rotating it counter-clockwise.

5-6) By rotating counter-clockwise, remove upper part of phototube including inner sleeve AA4964 and above.

5-7) Unscrew two PQK1.7x3.5SA, and remove cover AA4963.

5-8) Unscrew two HK2-242SA, and remove F-frame AA4966.

5-9) Unscrew four HK2-242SA and remove dovetail AA4962.

5-10) Unscrew four HK2-342SA and remove washer AA4886.

5-11) Unscrew four HK3x4.5SA and remove holding block AA4960.

5-12) Unscrew nut AA4145 by rotating it counter-clockwise with round-tip divider.

5-13) Unscrew two HK AA6203 on right and left sides respectively.

5-14) Remove belt AA4896.

5-15) Remove prism housings AA4891 and AA4892, by pulling them from holding block AA4960.

5-16) Unscrew four HK2x3BB, and remove two prism holders AA4899.

5-17) Unscrew four HU2x3SA, and remove two prisms LP0388 and two side frames AA0255.

5-18) Disassemble phototube.

a. Rotate cover AA4970.

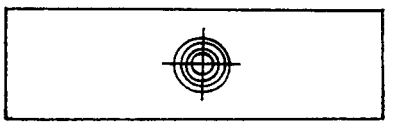
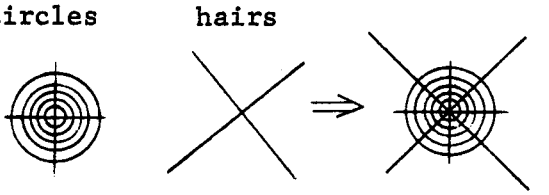
b. Loosening three NU2.6x3.5SA, remove inner sleeve AA4964.

c. Unscrew 3PUK2x4SA, and remove eyepiece tube AA4968.

B. SEQUENTIAL PROCEDURE OF OPTICAL ADJUSTMENTS

1. Tools and Test Plate
   a. Eyepiece with cross hairs G10X
   b. Focusing telescope
   c. Screwdrivers
   d. Dividers, flat and ball tips
   e. Photomicrographic equipment Model PM-6
   f. Shellac (adhesive)
   g. Test plate with 5/100 concentric circles

2. Porro-Prism Centration
   * Porro-prisms should be centered within a range of interpupillary distance.

Working Steps	Remarks
2-1) Remove right and left eyepiece tubes. 2-2) Remove covers AA4902 and AA4903. 2-3) Mount right and left eyepiece tubes. 2-4) Mount main body on stand and place test plate (5/100 concentric circles) on stage. Set test plate in position with stage clips. 2-5) Insert eyepiece with cross hairs G10X into right eyepiece tube. 2-6) Set drum lens 40X into position, and bring concentric circles into focus. Coincide centers of concentric circles and cross hairs of eyepiece.	2-4)  Test Plate (5/100 concentric circles) 2-6) Concentric circles Cross hairs Centered 

2-7) Maximize or minimize interpupillary distance, and if these centers are not concentric, optical axes are eccentric.

2-8) Adjustment of optical axes

Adjust optical axes so that centers of concentric circles and cross hairs do not depart from each other even at maximum or minimum interpupillary distance.

a. After coinciding centers of cross hairs and concentric circles, rotate prism housings.

b. If center of concentric circles moves, determine center of the movement from the locus of its movement (concentric circles move centering around this center).

c. Coincide locus center and center of concentric circles. (Move test plate)

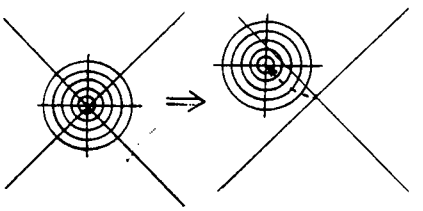
d. After determination of locus center, rotate three screws NU2.6x6SA to move prism and prism mount AA4894 together until centers of cross hairs and concentric circles are coincided.

e. Repeat steps above until centration is complete. Then clamp screws. Allowance of centeringdeviation:

0.2 on image plane

f. Follow steps above with left porro-prism.

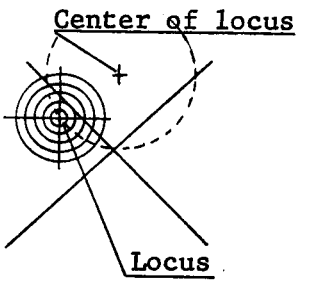
2-7)



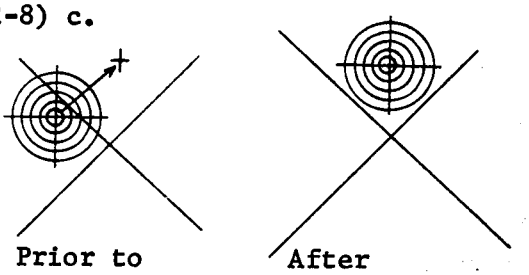
Before rotation

Decentration after rotation

2-8) b.



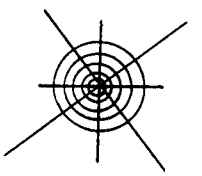
2-8) c.

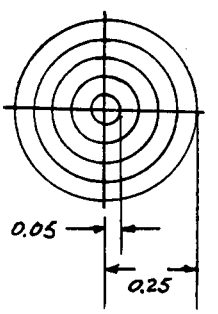


Prior to centiation

After coincidence

2-8) d.





2-8) e

0.2 (on image plane) = Obj. magnification (on zoom scale) x Distance (on specimen surface)

Ex. Zoom scale = 4

$0.2 = 4 \times X$

$X = \frac{0.2}{4} = 0.05$

The allowance 0.05 at zoom scale 4 equals one graduation of the concentric circle from the center.

2-9) Remove right and left eyepiece tubes.

2-10) Place right and left covers AA4902 & AA4903.

2-11) Mount right and left eyepiece tubes.

2-12) Again confirm centration of optical axes.

2-8) e.

Take care that when eyepiece tubes are mounted, left eyepiece tube is apt to deviate from center, which requires re-centration.

2-12)

Even though prism housing is rotated, center of cross hairs should not depart from center of concentric circles.

3. Adjustment of Click Spring

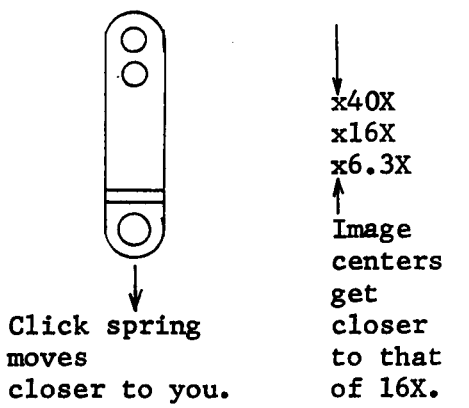
3-1) Set drum lens 16X into position, insert eyepiece with cross hairs G10X into right eyepiece tube, and coincide centers of concentric circles and cross hairs.

3-2) By changing drum lens magnification to 40X and then to 6.3X, check movement of image in north-south direction.

a. In case that image moves upward (north direction) at 40X, and downward (south direction) at 6.3X in conjuction with 16X drum lens, loosen screw that affixes click spring, and move click spring closer to you slightly, until images at 40X and 6.3X are almost equidistant from center (16X).

b. In case that 40X image is downward, and 6.3X upward, reverse click spring until these images are almost equidistant from center (16X).

3-2) a.



3-3) Ascertain that 25X and 10X images are coincided to 16X image by steps above.

4. Focusing of Drum Lenses in the Right Field of View

4-1) Rotate drum to position 16X, insert eyepiece G10X into right eyepiece tube, and focus with focusing telescope.

4-2) Check deviation direction of focus at 40X and 6.3X in comparison with 16X.

a. In case focus is "below" at 6.3X in comparison with 16X, move prism P2 forward until focuses of 40X and 6.3X are in the same direction and equidistant.

b. In case focus is "below" with drum lens 6.3X, move prism P2 forward until focuses of 40X and 6.3X are in the same direction and equidistant.

4-3) Coincide focus of 40X and 6.3X to that of 16X.

a. If focus of 6.3X is above that of 16X, lift 40X drum lens (LA4174), by rotating two setscrews counterclockwise equally.

b. If focus of 40X is below that of 16X, lower 40X drum lens by rotating two setscrews clockwise equally.

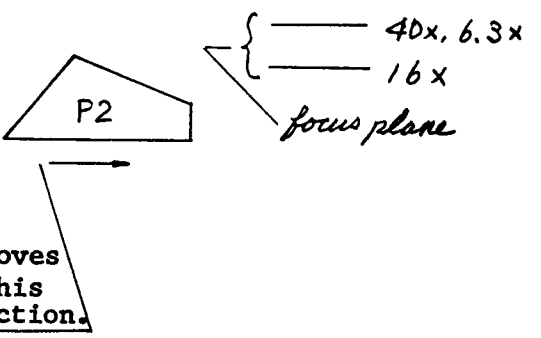
4-4) Coincide focus of 25X and 10X to that of 16X.

4-1)

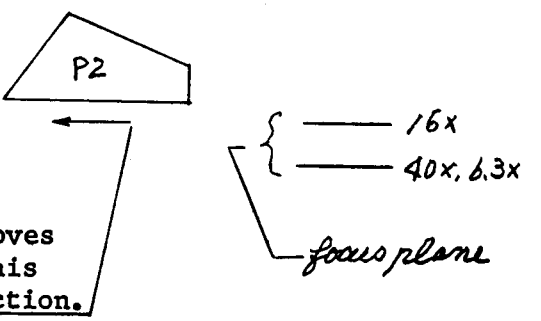
Use eyepiece G10X (f=250mm) and focusing telescope should be matched for focusing with this eyepiece.

If microscope main body has to be moved upward with focusing knobs to obtain correct focus, this state is called "focus is above"; on the contrary, if main body has to be lowered, it is called "focus is below".

4-2) a.



4-2) b.



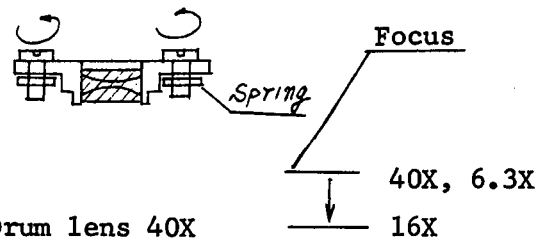
a. If focus of 25X is above that of 16X, lift 25X drum lens (LA4212) by rotating two setscrews counter-clockwise equally.

b. If focus of 25X is below that of 16X , lower 25X drum lens by rotating two setscrews clockwise equally.

4-3)

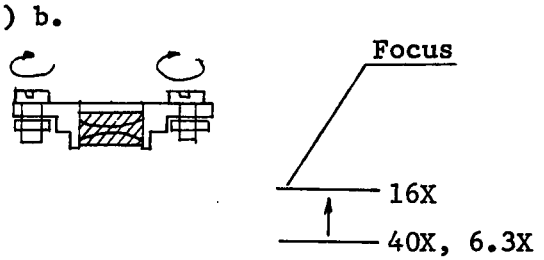
Drum lens 40X can be moved up and down by aid of spring located beneath drum lens, for focus adjustment.

4-3) a.



Drum lens 40X

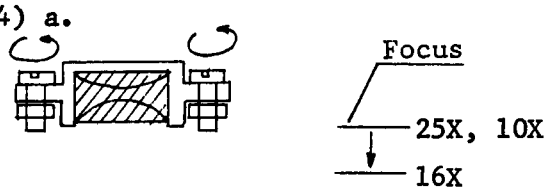
4-3) b.



4-4)

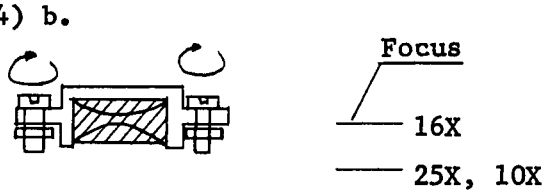
Drum lens 25X can be moved up and down by aid of spring beneath drum lens for focus adjustment.

4-4) a.



Drum lens 25X

4-4) b.



5. Centration of Drum Lenses in the Right Field of View

5-1) Set drum lens 16X into position, insert eyepiece with cross hairs G10X into right eyepiece tube, and coincide the

centers of concentric circles and cross hairs.

5-2) Coincide image of 40X and 6.3X to that of 16X.

a. If image moves over a long distance at different magnifications (distance more than 0.8mm in image plane), swing prism P2 to the right or left, until images of 40X and 6.3X are coincided on vertical center line of 16X.

a-1. In case image of 40X moves to the right, and image of 6.3X to the left.

a-2. In case image of 40X moves to the left, and image of 6.3X to the right.

b. Adjustment of vertical and horizontal image positions at 40X and 6.3X. Coincide optical axes of 40X and 6.3X to that of 16X by movement of 40X drum lens and B lens.

* Image movement by adjustment of drum lens:

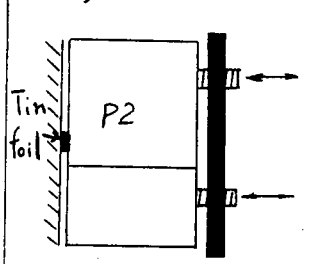
b-1. Image movement by adjustment of drum lens 40X.

Move lens frame of 40X drum lens by prying it with screwdriver tip in a range as screw clearance allows.

b-2. North-south movement of optical axis.

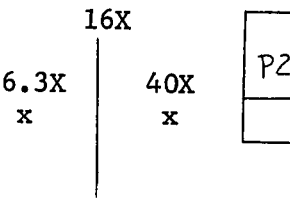
b-3. East-west movement of optical axis.

5-2) a.



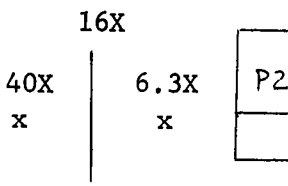
Put tin foils at the side of prism P2 and rotate two screws alternately to swing prism to the right or left as desired.

a-1.



Swing prism P2 in arrows' directions.

a-2.

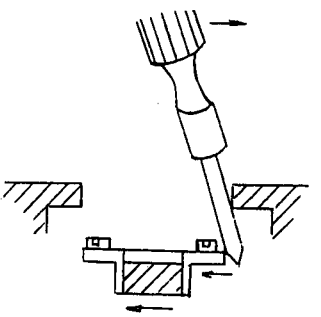


Swing prism P2 in arrows' directions.

5-2) b.

B lens AA4889 is positioned beneath inclined prism.

b-1.

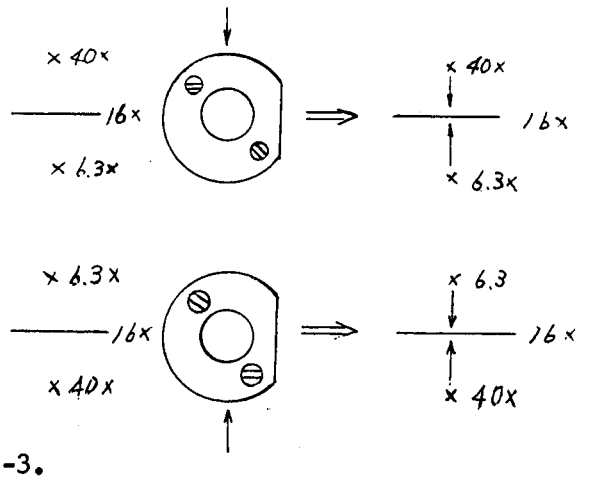


b-4. Image movement by adjustment of B lens AA4889. B lens can be moved by rotation of three setscrews.

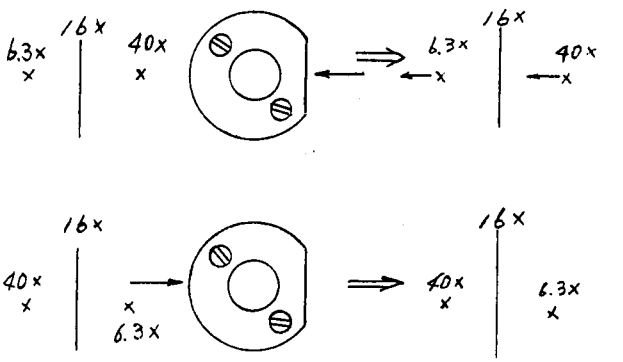
b-5. North-south movement of optical axis.

b-6. East-west movement of optical axis.

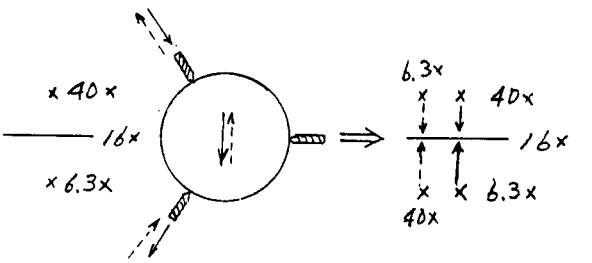
b-2.



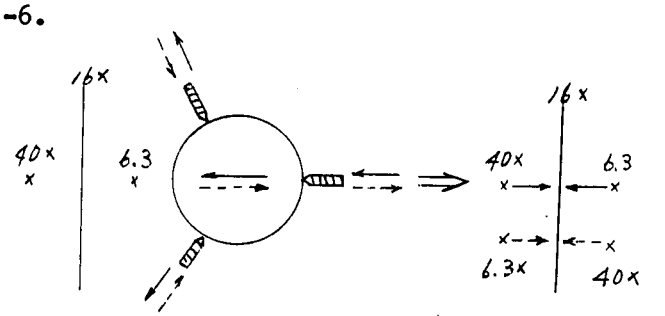
b-3.



b-5.



b-6.



c. Examples:

c-1. 40X image moves to the left, and 6.3X image to the right.

c-2. Lower 40X drum lens until 40X image is aligned with horizontal center line of 16X.

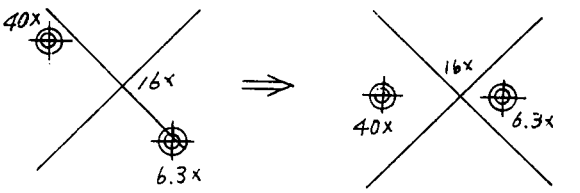
c-3. Move 40X drum lens to the right until 40X image is at equidistant from north-south optical axis of 16X.

c-4. Move B lens to the right until image of 40X and 6.3X are coincided with image of 16X.

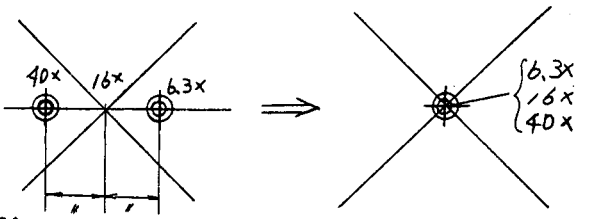
5-3) Adjustment of image movement of 25X and 10X in north-south and east-west directions. Coincide optical axes of 25X and 10X to that of 16X by movement of 25X drum lens.

5-4) Steps 5-2) and -3) sometimes require repetition until adjustment is complete. Ascertain coincidence of optical axes of 40X, 25X, 16X, 10X and 6.3X.

c-1. c-2.



c-3. c-4.



5-3)

There is correspondence between the image movements of 25X and 40X; 10X and 6.3X, respectively. This adjustment does not require movement of B lens.

6. Adjustment of Left Diopter

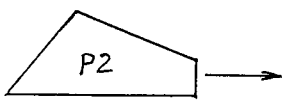
6-1) Insert eyepiece G10X into right eyepiece tube, bring drum lens 16X into path, and focus on specimen by use of focusing telescope.

6-2) Coincide focus of left drum lens 16X to that of right 16X.

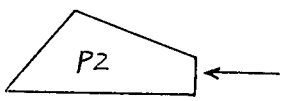
a. When focus is deviated to the "+" side (or eyepiece tube is lengthened), move prism P2 backward until focus is obtained by aligning helicoid ring to position "0".

6-1) Make it sure that when helicoid ring on left eyepiece tube is positioned to "0", left drum lens 16X must be brought into focus.

a.



b.



b. If focus is deviated to the "-" side (or eyepiece tube is shortened), move prism P2 forward until focus is obtained by aligning helicoid ring to position "0".	

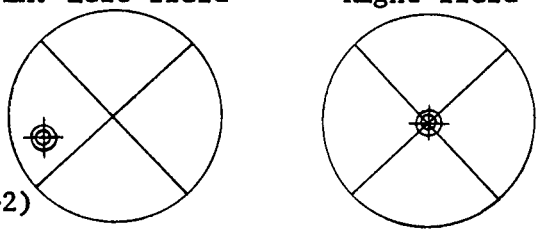
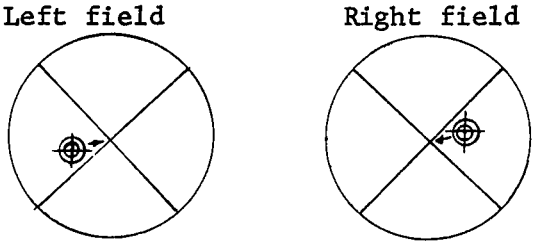
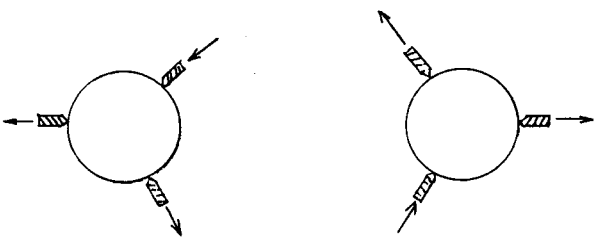
7. Centration and Focusing of Drum Lenses in the Left Field of View.

7-1) Bring drum lens 16X into light path, insert eyepiece G10X into left eyepiece tube, and focus on specimen with focusing telescope.	
7-2) Coincide focus of drum lenses 40X and 6.3X to that of drum lens 16X.	7-2) Move drum lens 40X up and down by aid of spring located beneath drum lens, until focus is adjusted, in a same manner as in 4-3).
7-3) Coincide focus of drum lens 25X and 10X to that of drum lens 16X.	7-3) Move drum lens 25X up and down by aid of spring located beneath drum lens, until focus is adjusted in a same manner as in 4-4).
7-4) Bring drum lens 16X to light path, insert eyepiece with cross hairs G10X into left eyepiece tube and coincide centers of concentric circles and cross hairs.	
7-5) Coincide image of specimen at 40X and 6.3X to image at 16X	7-5) Follow step 5-2).
7-6) Coincide images at 25X and 10X to that at 16X.	7-6) Follow step 5-3).
7-7) Repeat steps 7-3), 7-5) and 7-6) until adjustment is complete.	

8. Attachment of Dust Glasses

8-1) Place dust glasses in position on both sides, and shellac them at three spots respectively. 8-2) Sometimes image moves at magnification change after dust glasses are attached. This can be corrected by adjustment of B lens.	8-2) See 5-2).

9. Coincidence of Reight and Left Optical Axes

9-1) Check difference between right and left optical axes in both fields of view in conjunction with drum lens 40X and eye-piece with cross hairs G10X in position. 9-2) Eliminate this difference by equally moving right and left objectives. * Difference allowance: 0.2 on image plane	9-1) Ex. Left field Right field  9-2) Left field Right field  Left obj. Right obj. 

10. Mounting of PM-6

10-1) Lift sliding sleeve as well as possible along phototube, and clamp. 10-2) Insert eyepiece P10X into PM-6, and attach it on sliding sleeve. 10-3) Apply focusing telescope to viewer of PM-6 and looking through viewer, bring image into focus on focusing screen.	

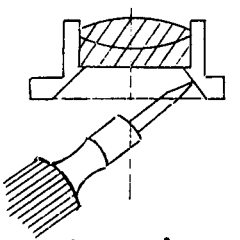
11. Focusing of Phototube Objectives

11-1) Bring drum lens 16X into light path, and looking through binocular observation tube, focus on specimen. 11-2) Looking through viewer of PM-6, lower sliding sleeve along phototube until concentric circles are focused. 11-3) Check distance from focus of 40X and 6.3X to that of 16X, and adjust phototube objective into position for correct focusing. 11-4) Move drum lens 40X up and down until focus of 40X and 6.3X is coincided with that of 16X. 11-5) Move drum lens 25X up and down until focus of 25X and 10X is coincided with that of 16X. 11-6) Repeat steps 11-3), 4) and 5) until adjustment is complete.	11-3) Move phototube objective up and down so that focus of 40X and 6.3X is in the same direction and equidistant. In case focus of 40X is in the opposite direction to that of 6.3X, lift phototube objective. 11-4) See steps 4-1) through 4-4).

12. Centration of Drum Lenses and Phototube

12-1) Bring drum lens 16X into light path, and coincide centers of concentric circles and focusing screen of viewer of PM-6. 12-2) Eliminate difference from image of 40X and 6.3X to 16X. 12-3) Adjust differences between images of 25X and 10X from 16X. 12-4) Repeat steps 12-2) and 3) until differences between respective images are eliminated. Make sure of correct centration of optical axes of 40X, 25X, 16X, 10X and 6.3X collectively.	12-2) Move lens frame of drum lens 40X by prying it with screwdriver's tip in a range its thread clearance allows, until it is coincided with 16X. In case this adjustment is not enough, move B lens AA4966 and phototube AA4967 in addition. 12-3) Move lens frame of drum lens 25X by prying lens frame with screwdriver's tip in the same manner as above.

13. Coincidence of Optical Axes through Phototube and Observation Tube

13-1) Bring drum lens 40X into light path, insert eyepiece with cross hairs G10X into one of eyepiece tubes, and coincide centers of concentric circles and cross hairs. 13-2) Move phototube objective by prying objective frame with screwdriver's tip in a range its thread clearance allows until centers of concentric circles and cross hairs are coincided. * Allowance for centration of phototube eyepiece: 0.4 on image plane of PM-6 with drum lens 16X.	13-2)  Put screwdriver's tip at objective frame, and hit screwdriver back with another screwdriver slightly so that objective frame may move. If it is hard to bring center of phototube to optical axis of binocular objectives, try to bring optical axis of binocular objectives to center of phototube by moving binocular objectives.

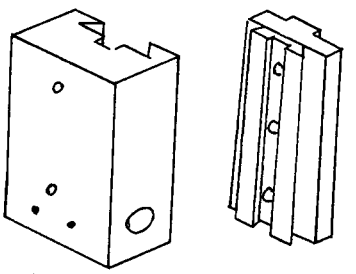
14. Mounting of Dust Glass, Covers, etc.

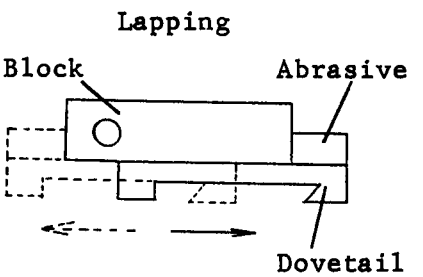
14-1) Attach dust glass into phototube, and shellac it at three spots. 14-2) Attach cover plate AA4948. 14-3) Attach cover AA4963 and Ob-cover AA4956	

C. TROUBLESHOOTING

1. Gnawing in Abrasive Surfaces of Focusing Mechanism

Causes	Procedure
Dust or dirt caught between abrasive surfaces stops movement of focusing mechanism.	1) Disengage block and dovetail of focusing mechanism. When they cannot be disengaged by rotation of focusing knobs, tap dovetail head with wooden hammer to gradually separate them. 2) Disconnect rack and pinion. 3) Clean abrasive surfaces of block and dovetail. 4) Scrape defective surfaces with scraper to eliminate burrs or unevenness of surfaces. 5) To test surface evenness, slowly insert dovetail into block. If you feel unevenness, apply a small amount of abrasive for lapping. 6) Wipe lapped surface clean, apply EP grease and assemble block and dovetail. Repeat sliding of dovetail in block several times until grease is spread all over the surfaces. 7) After setting up rack and pinion, make sure of its smooth movements.

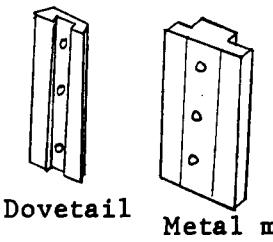


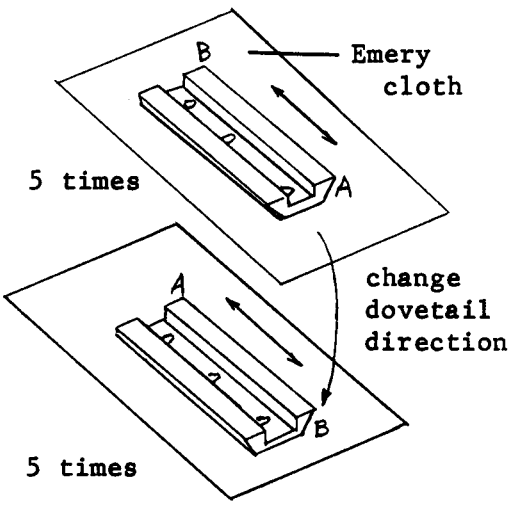


2. Chatter on Abrasive Surfaces of Focusing Mechanism

Worn-out Surfaces after prolonged use

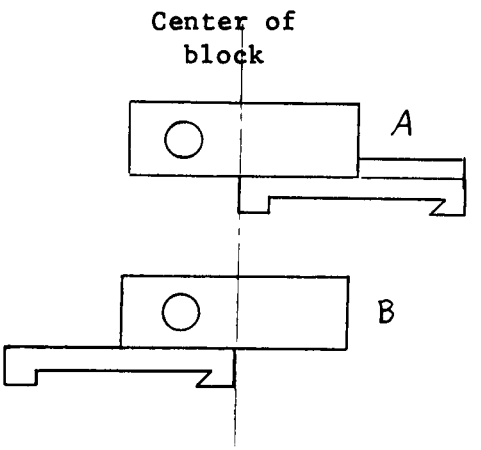
1) Disengage block and dovetail.
2) Disengage rack and pinion.
3) Detach dovetail from metal mount.
4) File the back of dovetail with emery cloth that is flatened on plain surface. To file evenly, slide dovetail in one direction several times on emery cloth, and then reverse sliding direction with even force with which you depress dovetail on emery cloth, in order to avoid tapering of surfaces.
5) Keep lapping of dovetail to such a degree that dovetail and block should be a little tight when assembled.





* If dovetail is filed excessively, slightly loosen screws that fasten dovetail to metal mount, and lap dovetail while fastening screws gradually.

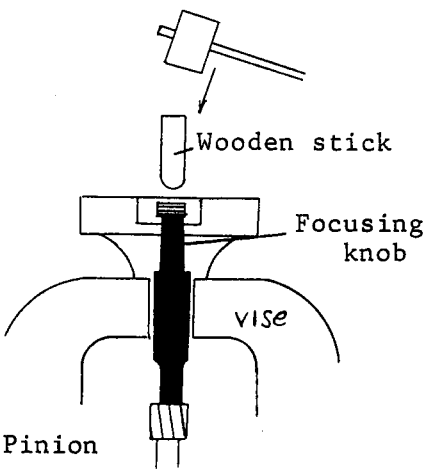
6) When entire surfaces are lapped correctly which means that its movement is not too heavy, nor too light, you have to stop lapping, and clean off abrasive, and check chatter, if any. Holding block firmly in your hand, swing it to the right and left alternately as shown by arrows in figure, right, with dovetail in position "A" and then position "B". If you feel a very faint chatter between dovetail and block as you swing it, it is all right.



	7) Grease abrasive surface and slide it repeatedly until grease is spread. In case you do not feel any chatter as you swing dovetail in position "A" and "B" in conjunction with block after greasing them, dovetail is lapped correctly. If not, scrape dovetail again for re-lapping. 8) Assemble rack and pinion.

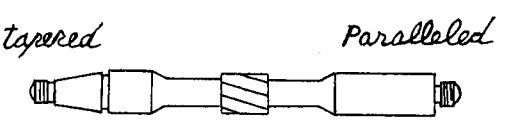
3. Defective Rack and Pinion of Focusing Mechanism

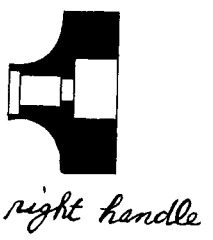
Teeth of rack or pinion are damaged by insertion of foreign matter between them or teeth are broken by forcible rotation of focusing knobs	1) Disengage block and dovetail. 2) Disengage rack and dovetail. 3) Unscrew left focusing knob, and pull out pinion from metal part. 4) Disengage right focusing knob and pinion. a. Rotate nut counter-clockwise with pin-face screwdriver. b. Pull out pinion from focusing knob. Pinion should be driven out by hitting it with hammer, at which it is necessary to apply a wooden stick between hammer and pinion as shown in figure.



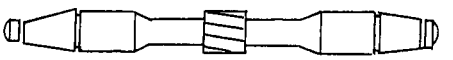
5) Insert replacement pinion into right focusing knob.
Knobs and pinions are available in two types ---new and old--- each of which has its own mounting manner.

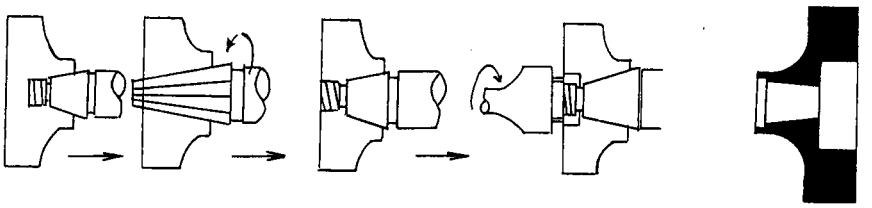
a. New type knob has a parallel hole in its center and right stem of pinion is equally paralleled.
Apply a small amount of instantaneous adhesive to parallel hole of knob into which, pinion is inserted until it stops, then clamp with nut.





b. Old type knob and pinion:
Right knob has a tapered hole, and right stem of pinion is tapered.



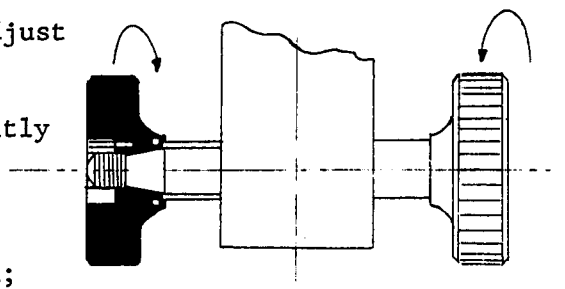


Left Knob

Check pinion inserted into knob:
In case pinion head does not come out of knob, ream knob with taper reamer slightly, so that pinion head flushes knob surface, then clamp it with nut.

6) Insert pinion into metal part, and screw it into knob and then adjust knobs as follows:

a. Although left knob is tightly clamped, focusing knobs rotate lightly, or they chatter in axial direction; this is because that taper is too sharp.



Left Right

b. Slightly ream left knob with reamer until knobs can be properly clamped.
To clamp knobs properly:

a) Hold both knobs in your hands, and when they are slightly clamped, knobs have no chatter in axial direction, but rotate smoothly. This is because left knob is effectively tapered, and,

b) Hold both knobs in your hands, and when they are forcibly clamped, they rotate heavily.

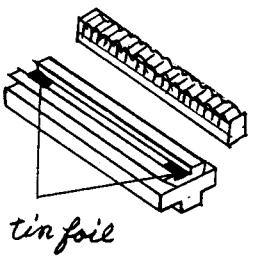
c) In short, knobs should be clamped, heavily or lightly as desired.

c. When left knob is clamped, it becomes too tight abruptly. And when knob is rotated, it will soon become loosened. This is called "dull taper".
To solve "dull taper", take the following steps:
Slightly ream bush of left knob, until proper heaviness is obtained.

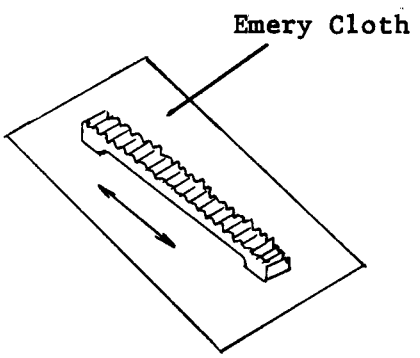
7) Attach rack to dovetail.

8) Attach block to dovetail, and adjust heaviness in their movement.

a. When their engagement is loose and chatter:
In accordance with their chattering degree, insert tin foils in a range of thickness from 0.01mm to 0.05mm between rack and dovetail until they stop chattering.



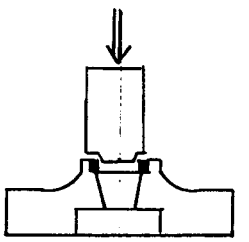
b. When their engagement is too tight:
Slightly lap back surface of rack with emery cloth to abate tightness of their engagement but not to allow any chatter.
* Emery cloth should be placed on a flat surface upon which you supress rack with even force.



c. How to check chatter:
Holding block and dovetail firmly in your hand, swing them; you can feel a chatter, if any.

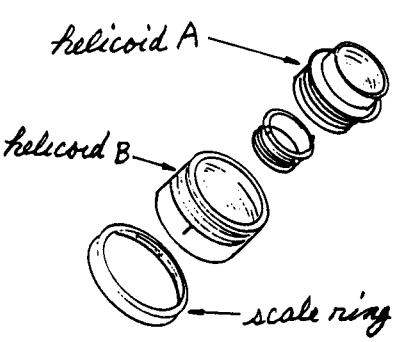
4. Heavy Rotation of Focusing Knob

Unadjustable heaviness caused by worn-out bush in knob	1) Disengage block and dovetail. 2) Remove left knob. 3) Remove worn-out bush. 4) Put replacement bush in position. Apply a small amount of instantaneous adhesive into recess of knob, place new bush, on which a drive stick is placed (see figure, right). Hammer it to drive bush into position. 5) Screw left knob onto pinion shaft and check heaviness in its rotation.

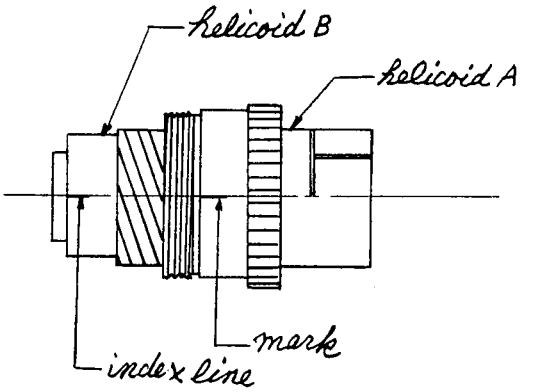


5. Heavy Rotation of Helicoid Ring

Grease coagulated on helicoid ring	1) Remove helicoid unit from porro-prism housing. 2) Remove setscrews from scale ring. 3) Unscrew scale ring from helicoid ring A.

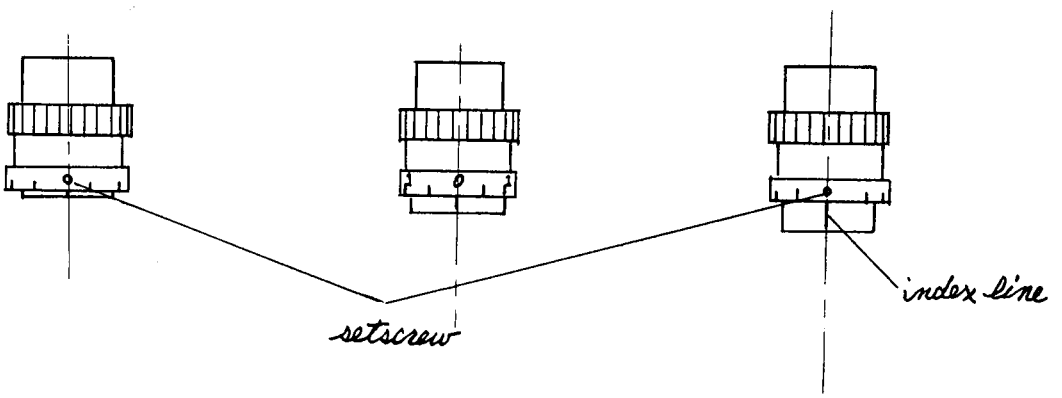


4) Disassemble helicoid unit.
Unscrew helicoid ring A from B.
Make it practice to put a mark on ring A in corresponding position to index line on ring B, immediately before ring A departs from ring B.
Use this mark to identify connecting position of ring A to ring B.

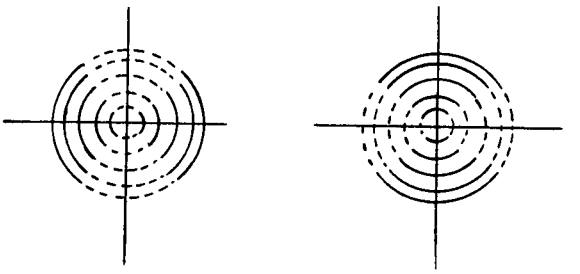


5) Clean off grease deposited on rings.
6) Apply new grease (EP grease) to threads.
7) Aligning positioning marks on rings A and B, screw them, and rotate them repeatedly until grease is spread all over the threads.
8) Attach scale ring.
9) Attach setscrews.
10) Confirm position of helicoid ring.

Minimum eyepiece tube length (Setscrew is aligned to index line.)	Middle length ("0" is aligned to index line.)	Maximum length (Setscrew is aligned to index line.)



6. Defective Binocular Vision

Image distortion caused by change of optical materials with the passage of time	1) Image is not equally focused in north-south and east-west directions as shown in diagrams of 5/100 concentric circles, right.  2) Check up which optical element causes image distortion as diagramed above. 3) Check image distortion at each magnification of drum lenses. a. When image is distorted at all magnifications: Distortion is caused by right or left prism, B lens, objectives or dust glasses. b. When image is distorted only at 40X and 6.3X magnifications: One of 40X and 6.3X drum lens is defective. c. When image is distorted only at 25X and 10X magnifications: One of 25X and 10X drum lens is defective. 4) In case of "b" or "c": Replace lenses one by one until defective one is found. 5) In case of "a": Until defective lens(es) is(are) found, replace all the elements concerned one by one in the order as follows: Dust glasses - objectives - B lens - prisms - porro-prisms. 6) After replacement of defective element(s), follow steps for optical adjustments.