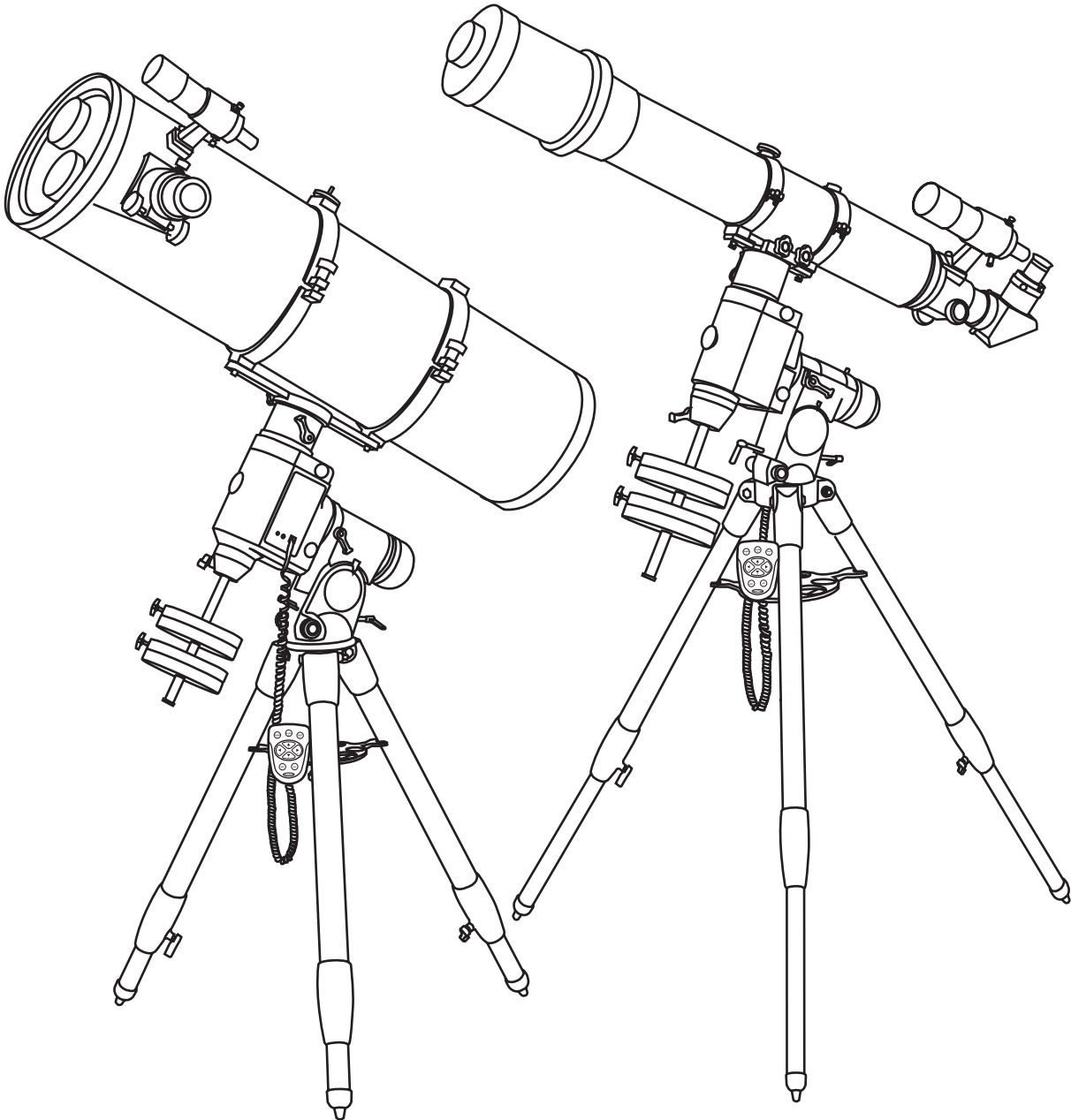


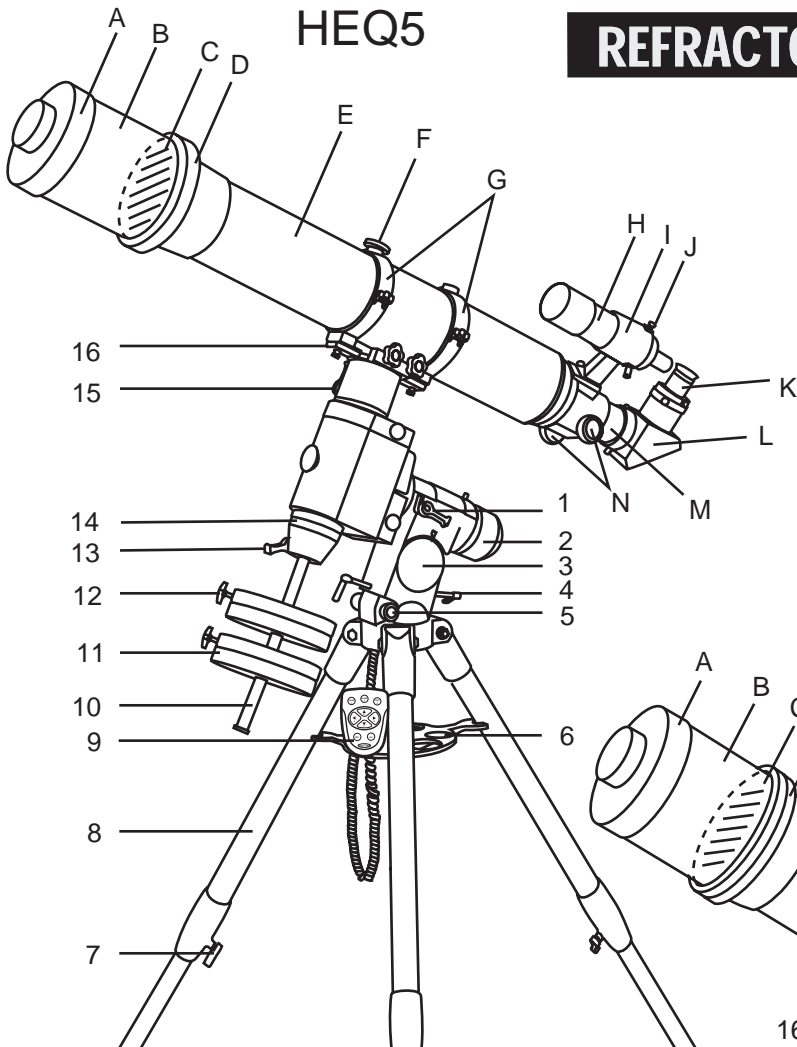
# INSTRUCTION MANUAL

## HEQ5/EQ6 MOUNT

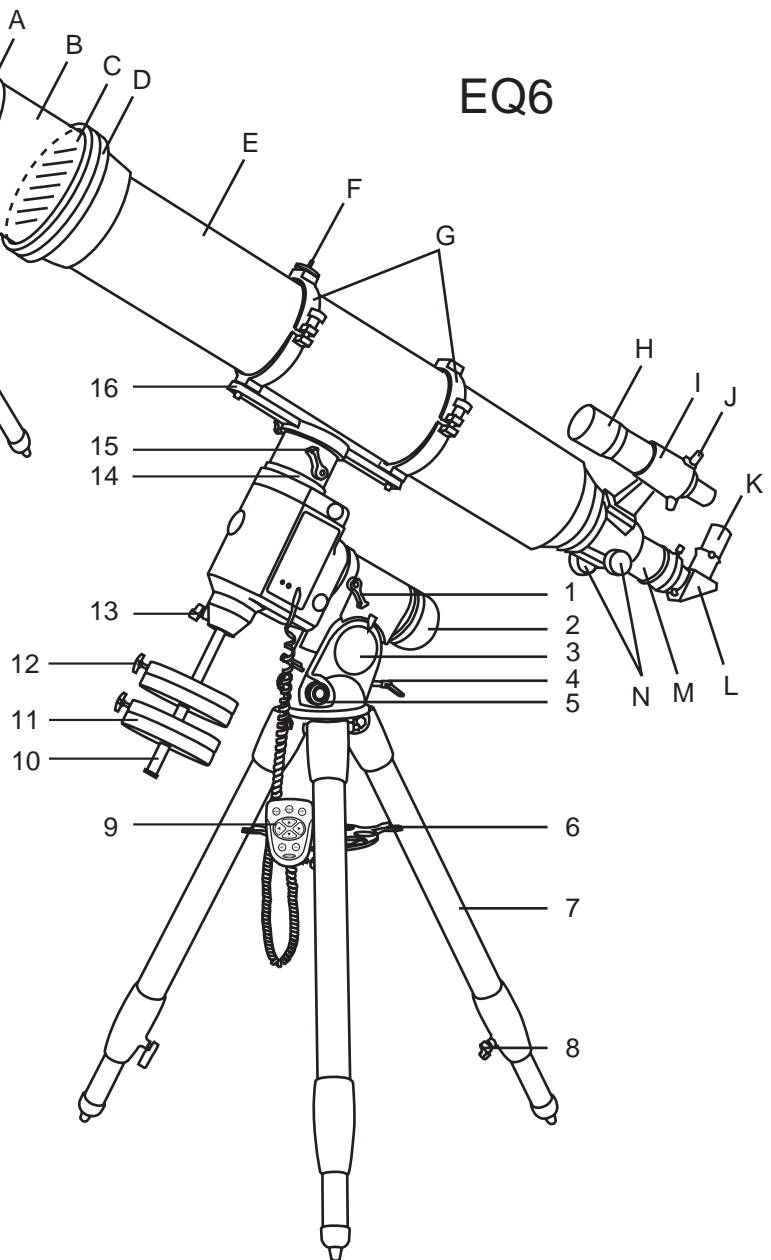


# HEQ5

# REFRACTOR



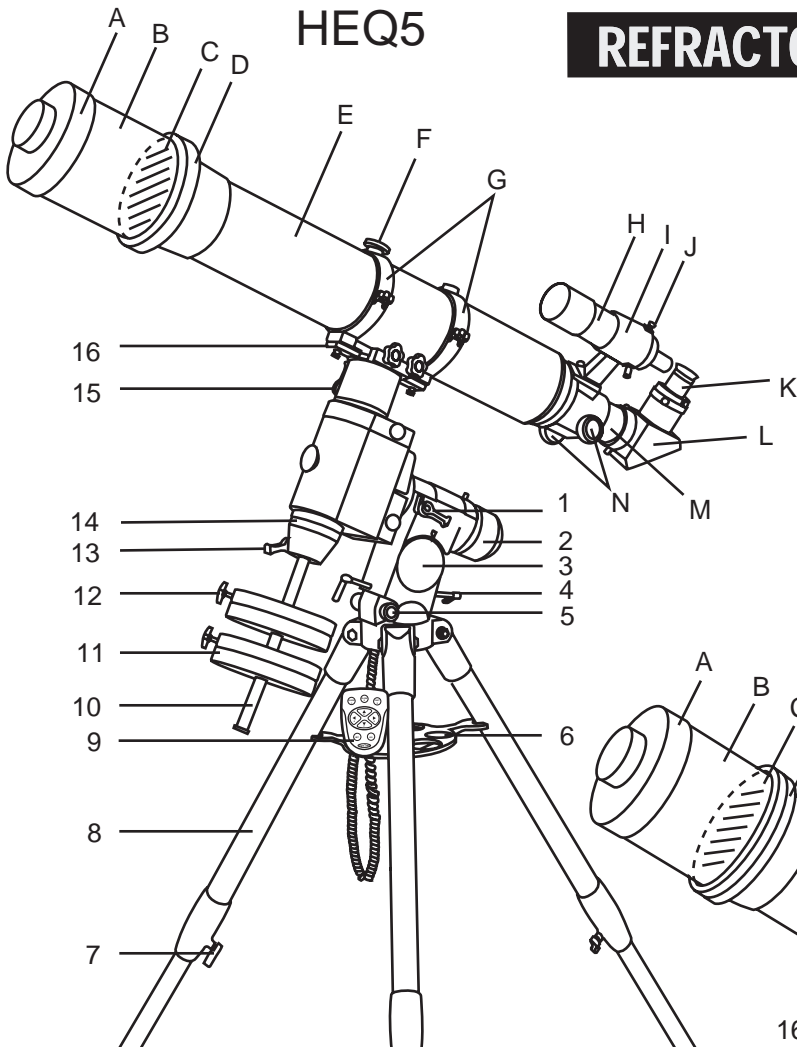
# EQ6



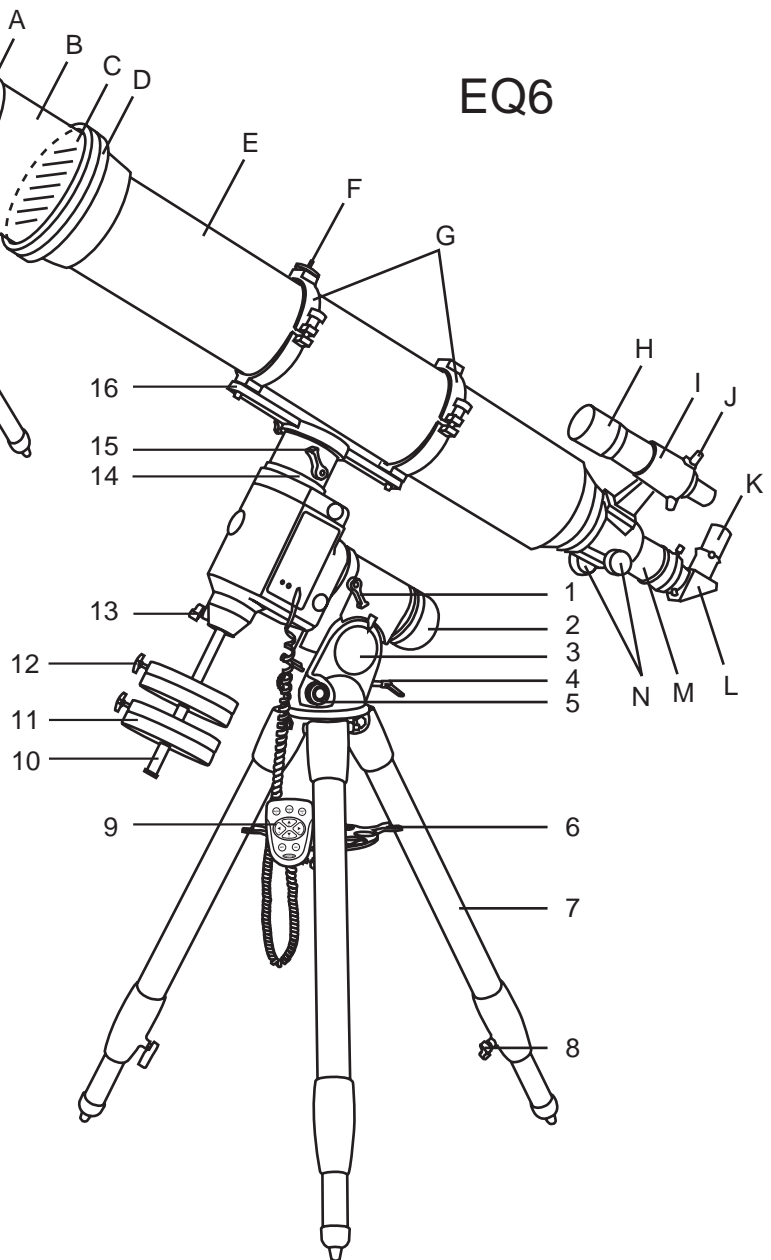
HEQ5	EQ6
A. Dust Cap/Mask (Remove before Viewing)	A. Dust Cap/Mask (Remove before Viewing)
B. Sun Shade/Dew Cap	B. Sun Shade/Dew Cap
C. Objective Lens Location	C. Objective Lens Location
D. Adjustable Lens Cell	D. Adjustable Lens Cell
E. Telescope Main Body	E. Telescope Main Body
F. Piggyback Bracket	F. Piggyback Bracket
G. Tube Ring	G. Tube Ring
H. Finderscope	H. Finderscope
I. Finderscope Bracket	I. Finderscope Bracket
J. Alignment Screw	J. Alignment Screw
K. Eyepiece	K. Eyepiece
L. Diagonal	L. Diagonal
M. Focus Tube	M. Focus Tube
N. Focus Knob	N. Focus Knob
1. R.A. Lock Lever	1. R.A. Lock Lever
2. Polarscope Holder (not shown)	2. Polarscope Holder (not shown)
3. Latitude Scale	3. Latitude Scale
4. Altitude Adjustment T-bolts	4. Altitude Adjustment T-bolts
5. Azimuth Adjustment Knob	5. Azimuth Adjustment Knob
6. Accessory Tray	6. Accessory Tray
7. Height Adjustment Clamp	7. Tripod Leg
8. Tripod Leg	8. Height Adjustment Clamp
9. Hand Control	9. Hand Control
10. Counterweight Rod	10. Counterweight Rod
11. Counterweight	11. Counterweight
12. Counterweight Thumb Screw	12. Counterweight Thumb Screw
13. Counterweight Rod Lock Knob	13. Counterweight Rod Lock Knob
14. Dec Setting Circle	14. Dec Setting Circle
15. Dec Lock Lever	15. Dec Lock Lever
16. Mounting Plate	16. Mounting Plate

# HEQ5

# REFRACTOR

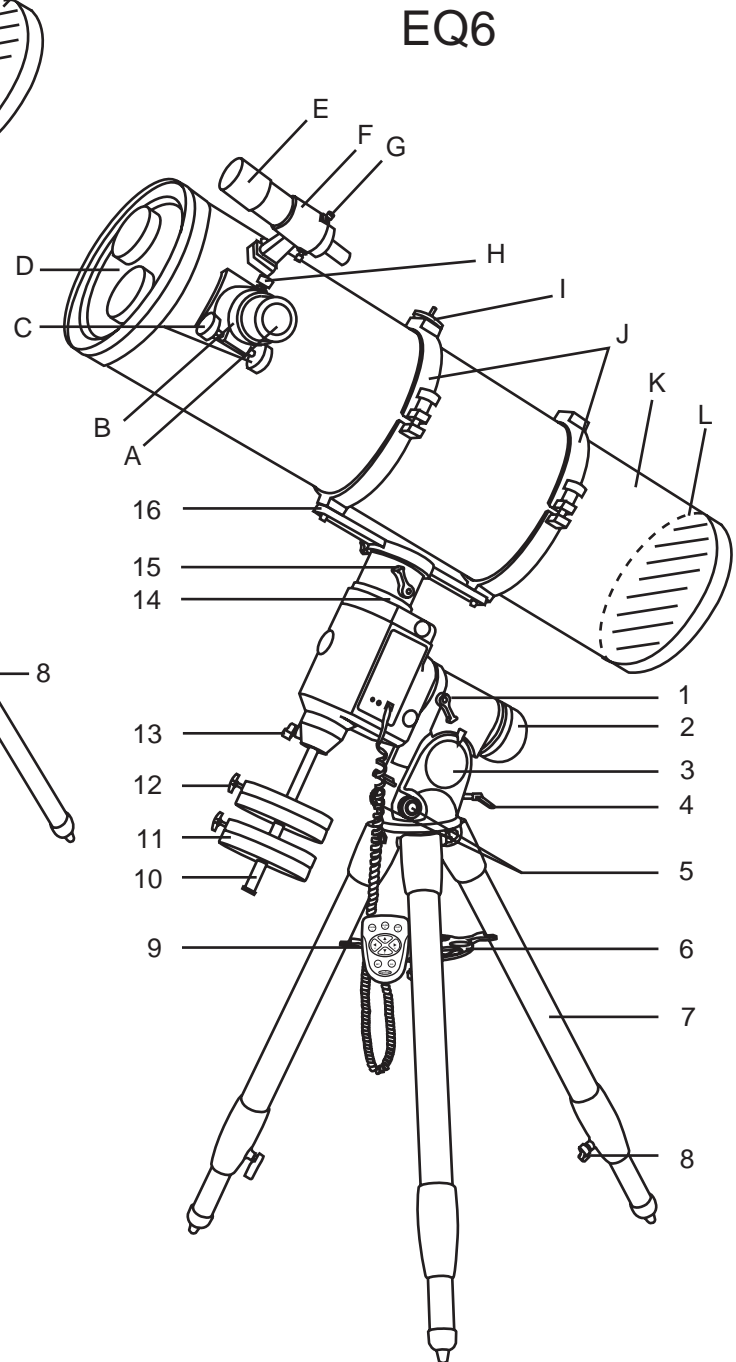
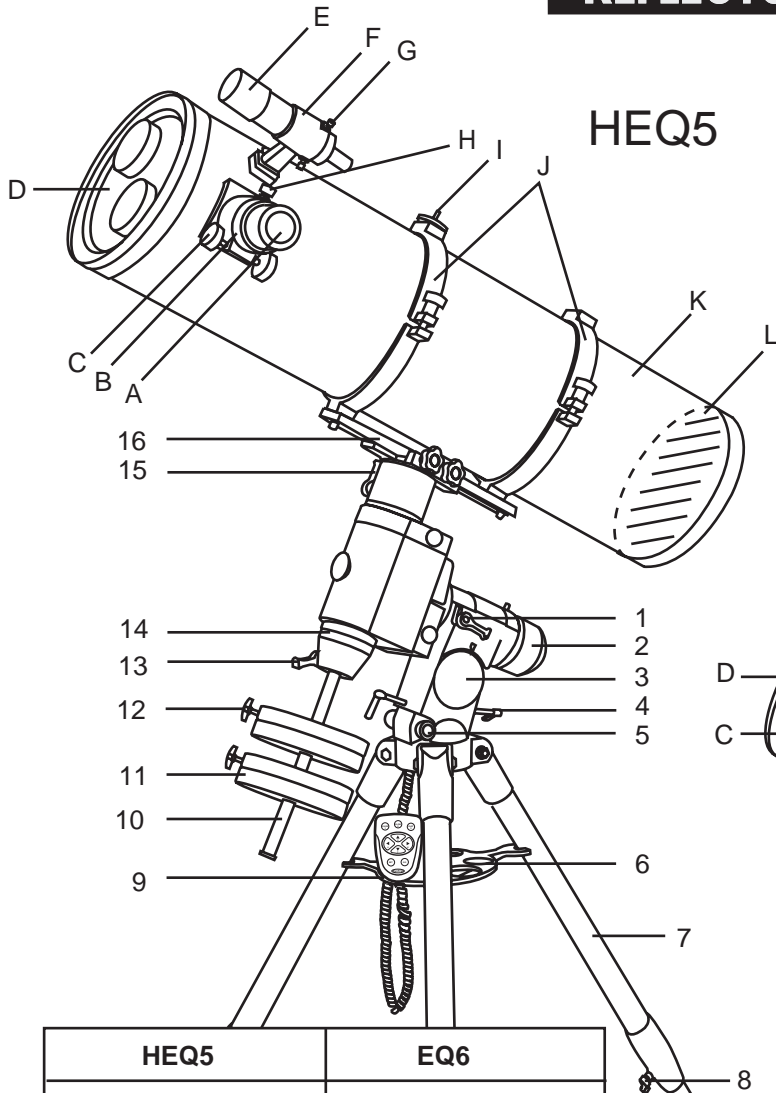


# EQ6



HEQ5	EQ6
A. Dust Cap/Mask (Remove before Viewing)	A. Dust Cap/Mask (Remove before Viewing)
B. Sun Shade/Dew Cap	B. Sun Shade/Dew Cap
C. Objective Lens Location	C. Objective Lens Location
D. Adjustable Lens Cell	D. Adjustable Lens Cell
E. Telescope Main Body	E. Telescope Main Body
F. Piggyback Bracket	F. Piggyback Bracket
G. Tube Ring	G. Tube Ring
H. Finderscope	H. Finderscope
I. Finderscope Bracket	I. Finderscope Bracket
J. Alignment Screw	J. Alignment Screw
K. Eyepiece	K. Eyepiece
L. Diagonal	L. Diagonal
M. Focus Tube	M. Focus Tube
N. Focus Knob	N. Focus Knob
1. R.A. Lock Lever	1. R.A. Lock Lever
2. Polarscope Holder (not shown)	2. Polarscope Holder (not shown)
3. Latitude Scale	3. Latitude Scale
4. Altitude Adjustment T-bolts	4. Altitude Adjustment T-bolts
5. Azimuth Adjustment Knob	5. Azimuth Adjustment Knob
6. Accessory Tray	6. Accessory Tray
7. Height Adjustment Clamp	7. Tripod Leg
8. Tripod Leg	8. Height Adjustment Clamp
9. Hand Control	9. Hand Control
10. Counterweight Rod	10. Counterweight Rod
11. Counterweight	11. Counterweight
12. Counterweight Thumb Screw	12. Counterweight Thumb Screw
13. Counterweight Rod Lock Knob	13. Counterweight Rod Lock Knob
14. Dec Setting Circle	14. Dec Setting Circle
15. Dec Lock Lever	15. Dec Lock Lever
16. Mounting Plate	16. Mounting Plate

# REFLECTOR



HEQ5	EQ6
A. Eyepiece	A. Eyepiece
B. Focus Tube	B. Focus Tube
C. Focus Knob	C. Focus Knob
D. Dust Cap/Mask (Remove before viewing)	D. Dust Cap/Mask (Remove before viewing)
E. Finderscope	E. Finderscope
F. Finderscope Bracket	F. Finderscope Bracket
G. Alignment Screw	G. Alignment Screw
H. Tension Adjustment Screw	H. Tension Adjustment Screw
I. Piggyback Bracket	I. Piggyback Bracket
J. Tube Rings	J. Tube Rings
K. Telescope Main Body	K. Telescope Main Body
L. Primary Mirror Location	L. Primary Mirror Location
1. R.A. Lock Lever	1. R.A. Lock Lever
2. Polarscope Holder (not shown)	2. Polarscope Holder (not shown)
3. Latitude Scale	3. Latitude Scale
4. Altitude Adjustment T-bolts	4. Altitude Adjustment T-bolts
5. Azimuth Adjustment Knob	5. Azimuth Adjustment Knob
6. Accessory Tray	6. Accessory Tray
7. Tripod Leg	7. Tripod Leg
8. Height Adjustment Clamp	8. Height Adjustment Clamp
9. Hand Control	9. Hand Control
10. Counterweight Rod	10. Counterweight Rod
11. Counterweight	11. Counterweight
12. Counterweight Thumb Screw	12. Counterweight Thumb Screw
13. Counterweight Rod Lock Knob	13. Counterweight Rod Lock Knob
14. Dec Setting Circle	14. Dec Setting Circle
15. Dec Lock Lever	15. Dec Lock Lever
16. Mounting Plate	16. Mounting Plate

# TABLE OF CONTENTS

<b>ASSEMBLING YOUR TELESCOPE</b> .....	<b>5</b>
Tripod Set Up .....	5
Mount Assembly .....	5
Telescope Assembly .....	6
Finderscope Assembly .....	6
Eyepiece Assembly .....	7
Hand Control Holder Installation (For SynScan™ Only) .....	7
<b>OPERATING YOUR TELESCOPE</b> .....	<b>8</b>
Aligning the Finderscope .....	8
Balancing the Telescope .....	8
Operating the Mount Manually .....	9
Using the Optional Barlow Lens .....	10
Focusing .....	10
Polar Alignment .....	10
Pointing Your Telescope .....	14
Choosing the Appropriate Eyepiece .....	17
<b>OBSERVING THE SKY</b> .....	<b>18</b>
<b>PROPER CARE FOR YOUR TELESCOPE</b> .....	<b>19</b>
Collimating a Newtonian Reflector .....	19
Collimating a Refractor with the Adjustable Objective-Lens Cell .....	21
Cleaning Your Telescope .....	21
<b>APPENDIX A - STANDARD TIME ZONES OF THE WORLD</b> .....	<b>I</b>
<b>APPENDIX B - OPTIONAL ACCESSORIES</b> .....	<b>II</b>
<b>APPENDIX C - RECOMMENDED READING</b> .....	<b>IV</b>
<b>APPENDIX D - GLOSSARY</b> .....	<b>V</b>

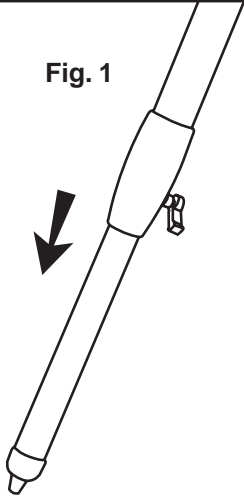


NEVER USE YOUR TELESCOPE TO LOOK DIRECTLY AT THE SUN. PERMANENT EYE DAMAGE WILL RESULT. USE A PROPER SOLAR FILTER FIRMLY MOUNTED ON THE FRONT OF THE TELESCOPE FOR VIEWING THE SUN. WHEN OBSERVING THE SUN, PLACE A DUST CAP OVER YOUR FINDERSCOPE OR REMOVE IT TO PROTECT YOU FROM ACCIDENTAL EXPOSURE. NEVER USE AN EYEPIECE-TYPE SOLAR FILTER AND NEVER USE YOUR TELESCOPE TO PROJECT SUNLIGHT ONTO ANOTHER SURFACE, THE INTERNAL HEAT BUILD-UP WILL DAMAGE THE TELESCOPE OPTICAL ELEMENTS.

# ASSEMBLING YOUR TELESCOPE

## TRIPOD SET UP

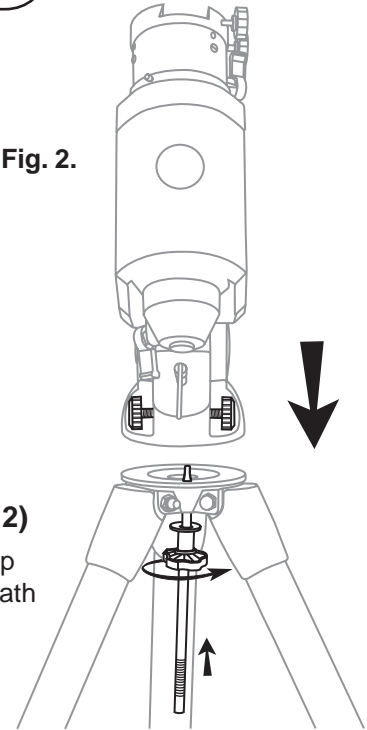
Fig. 1



### ASSEMBLING THE TRIPOD LEGS (Fig.1)

- 1) Slowly loosen the height adjustment clamp and gently pull out the lower section of each tripod leg. Tighten the clamps to hold the legs in place.
- 2) Spread the tripod legs apart to stand the tripod upright.
- 3) Place a carpenter's level or bubble level on the top of the tripod legs. Adjust the height of each tripod leg until the tripod head is properly leveled. Note that the tripod legs may not be at same length when the equatorial mount is level.

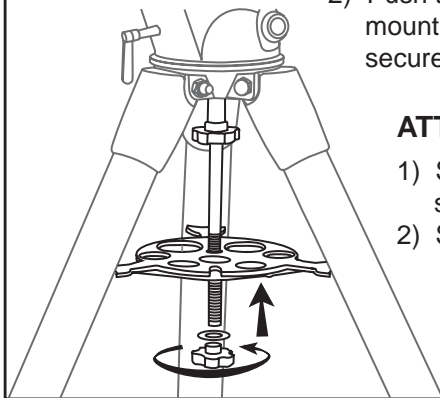
Fig. 2.



### ATTACHING MOUNT TO TRIPOD LEGS (Fig. 2)

- 1) Align metal dowel on the tripod head with the gap between the azimuth adjustment knobs underneath the mount.
- 2) Push the primary locking shaft up against the mount and turn the knurled knob underneath to secure mount to tripod.

Fig. 3



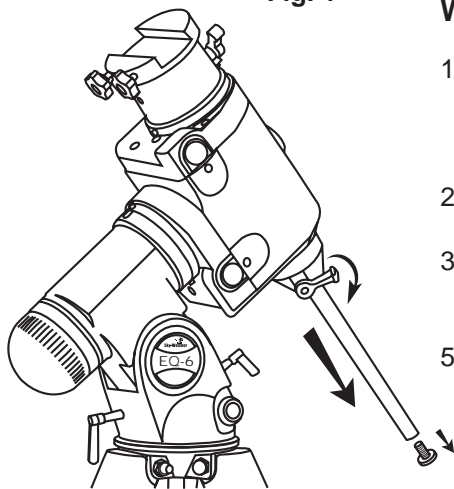
### ATTACHING THE ACCESSORY TRAY (Fig. 3)

- 1) Slide the accessory tray along the primary locking shaft until it pushes against the tripod legs.
- 2) Secure with the washer and locking knob.

Note: Loosen the azimuth adjustment knobs if mount does not fit into tripod head completely. Retighten knobs to secure.

## MOUNT ASSEMBLY

Fig. 4

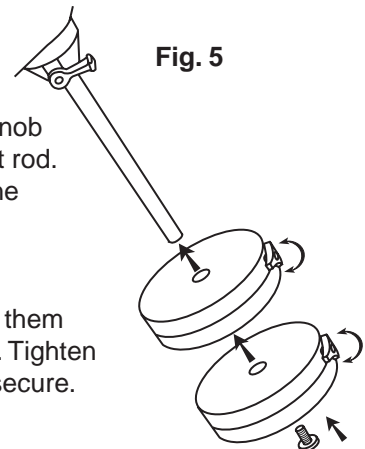


### INSTALLING THE COUNTERWEIGHTS (Fig. 4, 5)

- 1) Loosen the counterweight rod lock knob and gently pull out the counterweight rod. Re-tighten the lock knob to secure the counterweight rod in place.
- 2) Unscrew the threaded cap from the end of the counterweight rod.
- 3) Locate the counterweights and slide them halfway along the counterweight rod. Tighten the counterweight thumb screws to secure.
- 5) Replace the cap on the end of the counterweight rod.

(diagram applicable to both mounts)

Fig. 5





## TELESCOPE ASSEMBLY

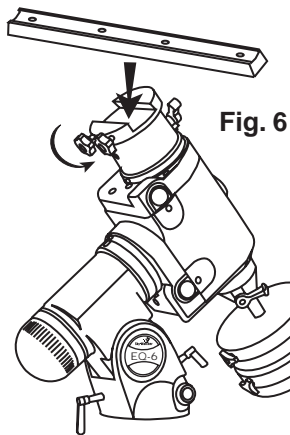


Fig. 6

### ATTACHING THE MOUNTING PLATE (Fig.6)

- 1) Position the mounting plate on the mounting bracket.
- 2) Secure by tightening the two locking screws.

### ATTACHING THE TUBE RINGS (Fig.7)

- 1) Remove the telescope tube assembly from its plastic packaging.
- 2) Remove the tube rings from the telescope by releasing their thumb nuts and opening their hinges.
- 3) Using the bolts provided, fasten the tube rings to the mount with the 10mm wrench provided.

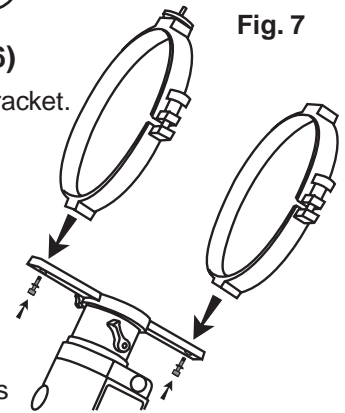


Fig. 7

(diagram applicable to both mounts)

## TELESCOPE ASSEMBLY

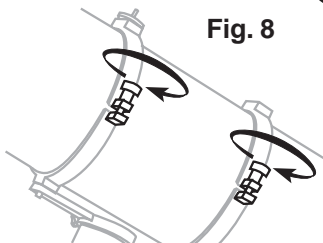


Fig. 8

### ATTACHING THE TELESCOPE MAIN TUBE TO THE TUBE RINGS (Fig.8)

- 1) Remove the telescope tube from the paper covering.
- 2) Find the center of balance of the telescope tube. Place this in between the two tube rings. Close the hinges around the telescope and fasten securely by tightening the thumb nuts.

## FINDERSCOPE ASSEMBLY (for reflectors)

Fig.9

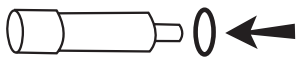
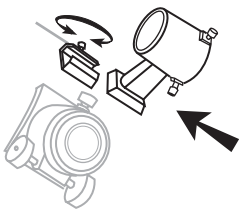


Fig.10



### ATTACHING THE FINDERSCOPE BRACKET (Fig. 9,10,11)

- 1) Locate the finderscope bracket. Carefully remove the rubber-o-ring from the finderscope bracket.
- 2) Position the o-ring into the groove located approximately half-way along the finderscope tube.
- 3) Locate the finderscope optical assembly.
- 4) Slide the finderscope bracket into the rectangular slot and tighten the screw to hold the mount in place.
- 5) Position the finderscope into its bracket by sliding it backwards until the rubber o-ring seats in the finderscope mount.

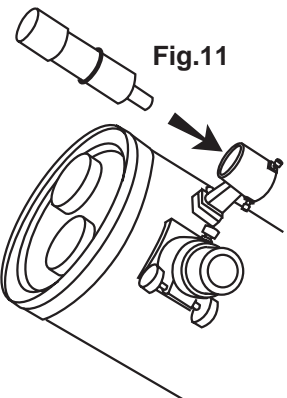


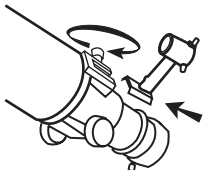
Fig.11

## FINDERSCOPE ASSEMBLY (for refractors)

Fig.12



Fig.13



### ATTACHING THE FINDERSCOPE (Fig.12,13,14)

- 1) Locate the finderscope bracket. Carefully remove the rubber-o-ring from the finderscope bracket.
- 2) Position the o-ring into the groove located approximately half-way along the finderscope tube.
- 3) Locate the finderscope optical assembly.
- 4) Slide the finderscope bracket into the rectangular slot and tighten the screw to hold the mount in place.
- 5) Position the finderscope into its mount by sliding it backwards until the rubber o-ring seats in the finderscope mount.

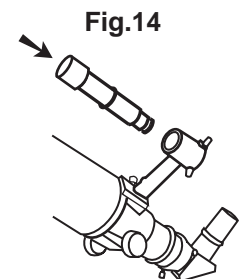


Fig.14

## EYEPIECE ASSEMBLY (for reflectors)

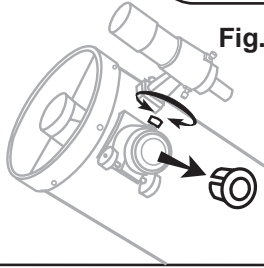


Fig.15

### INSERTING THE EYEPIECE (Fig.15, 16)

- 1) Unscrew the thumbscrews on the end of the focus tube to remove the black plastic end-cap.
- 2) Insert the desired eyepiece and secure it by retightening the thumbscrews.

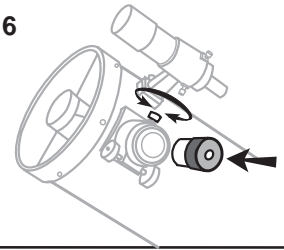


Fig.16

## EYEPIECE ASSEMBLY (for refractors)

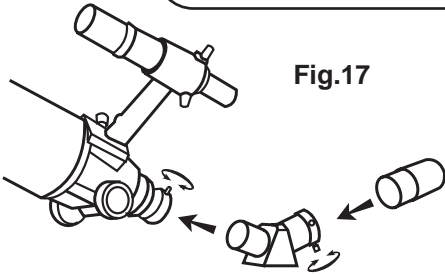


Fig.17

### INSERTING THE EYEPIECE (Fig.17)

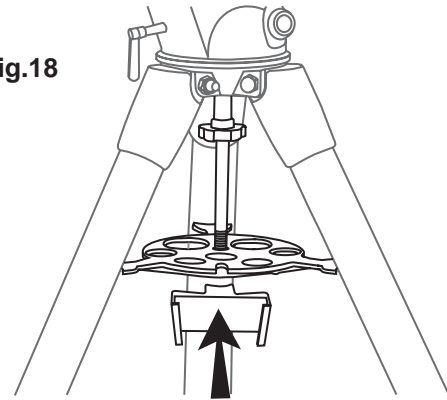
- 1) Loosen the thumbscrew on the end of the focus tube.
- 2) Insert the diagonal into the focus tube and re-tighten the thumbscrew to hold the diagonal in place.
- 3) Loosen the thumbscrews on the diagonal.
- 4) Insert the desired eyepiece into diagonal and secure by re-tightening the thumbscrews.

## HAND CONTROL HOLDER INSTALLATION

### INSTALLING THE HAND CONTROL HOLDER (Fig.18) (for SynScan™ only)

Locate the hand control holder. Slide the holder onto the accessory tray as shown in Fig.6.

Fig.18

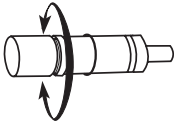




# OPERATING YOUR TELESCOPE

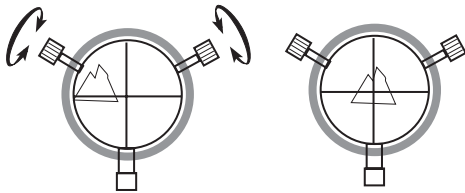
## Aligning the finderscope

Fig.a



These fixed magnification scopes mounted on the optical tube are very useful accessories. When they are correctly aligned with the telescope, objects can be quickly located and brought to the centre of the field. Alignment is best done outdoors in day light when it's easier to locate objects. If it is necessary to refocus your finderscope, sight on an object that is at least 500 yards (metres) away. Loosen the locking ring by unscrewing it back towards the bracket. The front lens holder can now be turned in and out to focus. When focus is reached, lock it in position with the locking ring (Fig.a).

Fig.a-1



- 1) Choose a distant object that is at least 500 yards away and point the main telescope at the object. Adjust the telescope so that the object is in the centre of the view in your eyepiece.
- 2) Check the finderscope to see if the object centred in the main telescope view is centred on the crosshairs.
- 3) Adjust the two small screws to centre the finderscope crosshairs on the object (Fig.a-1).

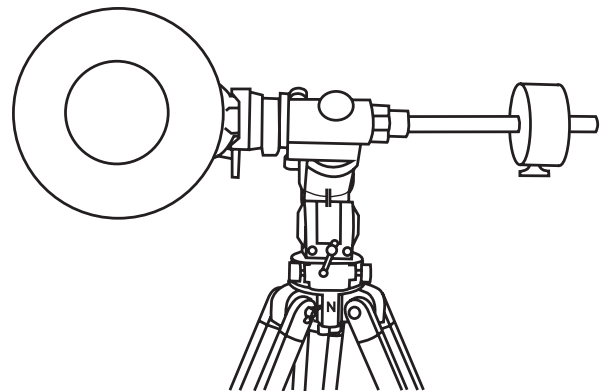
## Balancing the telescope

A Telescope should be balanced before each observing session. Balancing reduces stress on the telescope mount and allows for precise control of micro-adjustment. A balanced telescope is specially critical when using the optional clock drive for astrophotography. The telescope should be balanced after all accessories (eyepiece, camera, etc.) have been attached. Before balancing your telescope, make sure that your tripod is balanced and on a stable surface. For photography, point the telescope in the direction you will be taking photos before performing the balancing steps.

### R.A. Balancing

- 1) Slowly unlock the R.A. and Dec. lock knobs. Rotate the telescope until both the optical tube and the counterweight rod are horizontal to the ground, and the telescope tube is to the side of the mount (Fig.b).
- 2) Tighten the Dec. lock knob.
- 3) Move the counterweights along the counterweight rod until the telescope is balanced and remains stationary when released.
- 4) Tighten the counterweight thumb screws to hold the counterweights in their new position.

Fig.b



(diagram applicable to both mounts)

### Dec. Balancing

The R.A. balancing should be done before proceeding with Dec. balancing.

- 1) For best results, adjust the altitude of the mount to between  $60^\circ$  and  $75^\circ$  if possible.
- 2) Release the R.A. lock knob and rotate around the R.A. axis so that the counterweight rod is in a horizontal position. Tighten the R.A. lock knob.
- 3) Unlock the Dec. lock knob and rotate the telescope tube until it is parallel to the ground.
- 4) Slowly release the telescope and determine in which direction it rotates. Loosen the telescope tube rings and slide the telescope tube forward or backward in the rings until it is balanced.
- 5) Once the telescope no longer rotates from its parallel starting position, re-tighten the tube rings and the Dec. lock knob. Reset the altitude axis to your local latitude.

## Operating the mount manually

The HEQ5 and EQ6 mount have controls for both conventional altitude (up-down) and azimuthal (left-right) directions of motion. Use the altitude adjustment T-bolts for altitude adjustments. These allow fine-adjustment for setting the mount to your local latitude. The azimuthal axis is changed by the two azimuth adjustment knobs located near the tripod head. These allow fine-adjustment of azimuth for polar aligning (Fig.c).

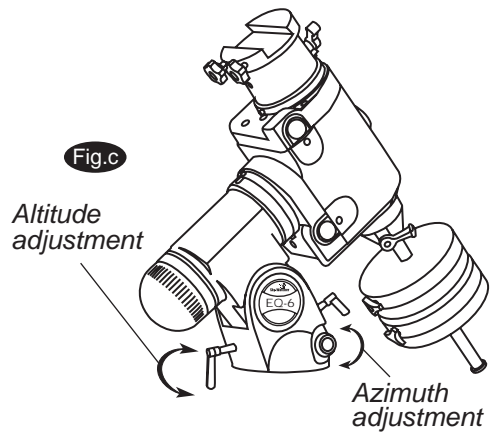


Make sure to loosen one altitude adjustment T-bolt before tightening the other. Over-tightening can cause the bolts to bend or break.

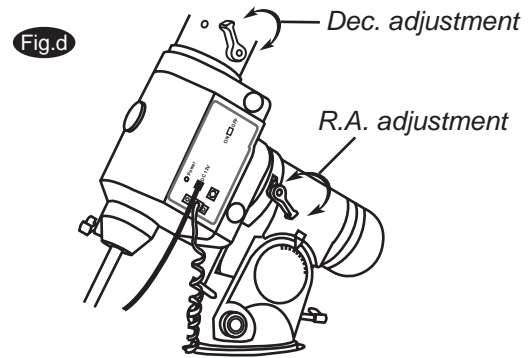
In addition, the HEQ5 and EQ6 mounts have direction controls for polar aligned astronomical observing. These directions use right ascension (east/west) and declination (north/south) axis. There are two options to move the telescope in these directions: For large and quick movement, loosen the R.A. lock level under the R.A. shaft or the Dec. lock level near the top of the mount (Fig.d). For fine adjustments, use the SynTrek™ or SynScan™ hand control.

There are three numerical scales on this mount. The lower scale is used for polar alignment of the telescope to your local latitude. The R.A. (right ascension) scale is measures hour angle and is adjustable to your local meridian. The declination scale is located near the top of the mount (Fig.e).

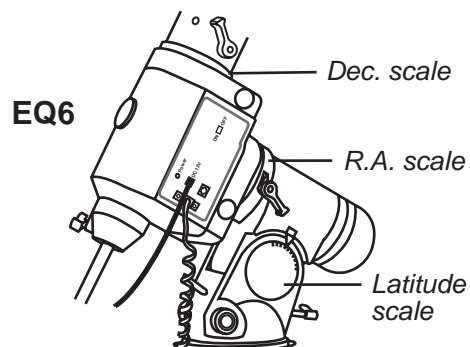
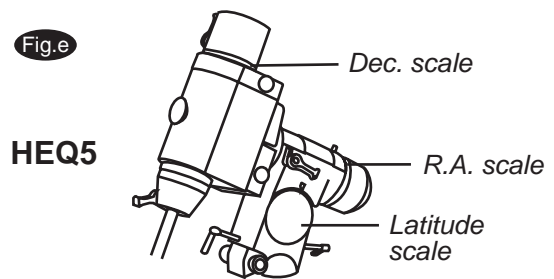
(For SynScan™ Only) Do not adjust the mount manually when under the SynScan™ operation mode. The telescope will have to be returned to the Home Position and initial star alignment will have to be done again.



(Diagram applicable to both mounts)



(Diagram applicable to both mounts)



## Using the optional Barlow lens

A Barlow is a negative lens which increases the magnifying power of an eyepiece, while reducing the field of view. It expands the cone of the focussed light before it reaches the focal point, so that the telescope's focal length appears longer to the eyepiece.

The Barlow is inserted between the focuser and the eyepiece in a reflector, and usually between the diagonal and the eyepiece in a refractor or a maksutov (Fig.f). With some telescopes, it can also be inserted between the focuser and the diagonal, and in this position it gives even greater magnification. For example, a 2X Barlow when inserted after the diagonal can become 3X when placed in front of the diagonal.

In addition to increasing magnification, the benefits of using a Barlow lens include improved eye relief, and reduced spherical aberration in the eyepiece. For this reason, a Barlow plus a lens often outperform a single lens producing the same magnification. However, its greatest value may be that a Barlow can potentially double the number of eyepieces in your collection.

## Focusing

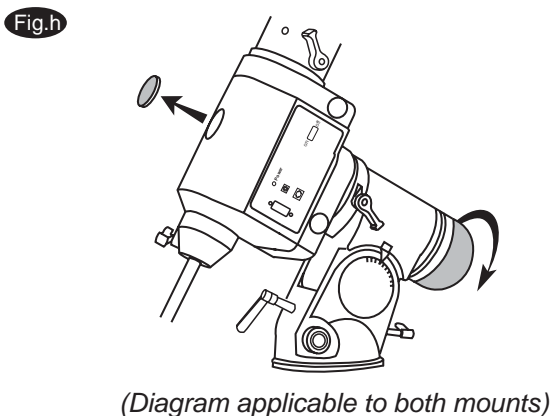
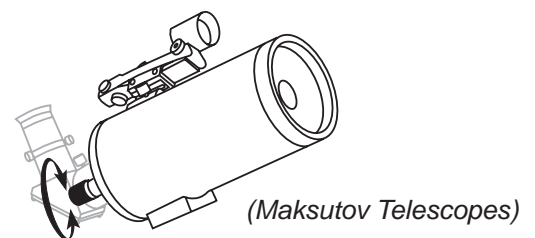
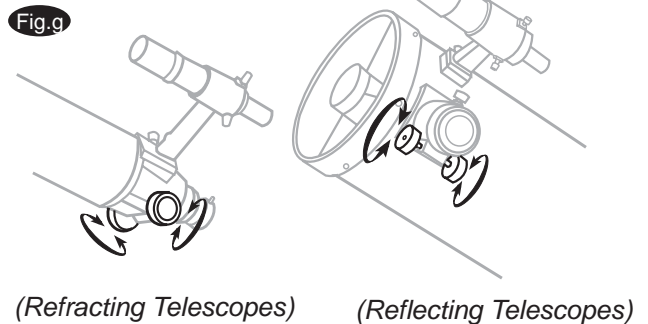
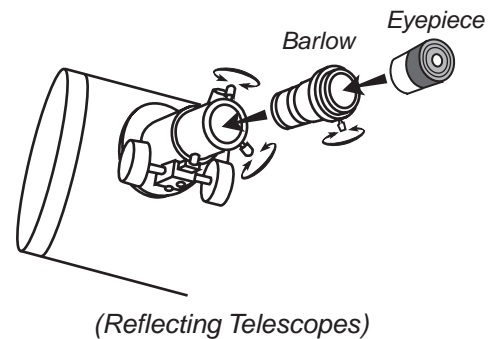
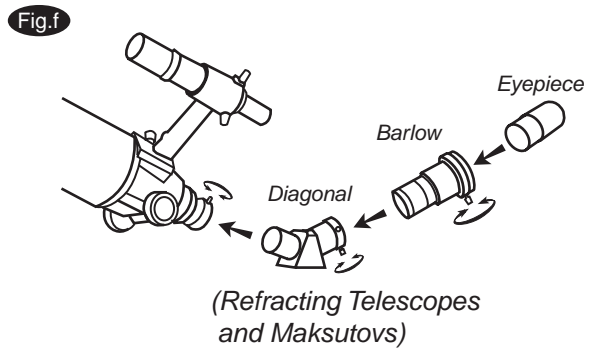
Slowly turn the focus knobs under the focuser, one way or the other, until the image in the eyepiece is sharp (Fig.g). The image usually has to be finely refocused over time, due to small variations caused by temperature changes, flexures, etc. This often happens with short focal ratio telescopes, particularly when they have not yet reached outside temperature. Refocusing is almost always necessary when you change an eyepiece or add or remove a Barlow lens. On some focusers, there is a tension adjustment. Over-tighten this may damage the rack and pinion assembly.

## Polar Alignment

### Preparing the Mount

This section describes how to achieve a precise polar alignment with your HEQ5/EQ6 mount. To achieve a precise polar alignment it is first necessary to prepare the mount. In the Northern Hemisphere, this includes orienting the polar scope reticule and aligning the polar scope reticule. If you are in the Southern Hemisphere, you only need to align the polar scope reticule. These steps, which only need to be done once, are outlined first.

If you have already prepared your mount then you can skip to the final section entitled "Procedure for Precise Polar Alignment of the HEQ5/EQ6 Mount". If not, follow the steps to prepare your mount for precise polar alignment.



First, remove the caps from the upper and lower ends of the RA axis so you can look into the polar scope (Fig.h). Release the counterweight shaft and rotate the mount in declination axis so that the hole in the shaft is in front of the polar scope. This allows you to see all the way through the RA shaft.



## GLOSSARY (Fig.h-1)

### Date Scale Indicator

This indicator is used as a reference point when using the Date Scale.

### Date Scale

The circular scale surrounding the polar scope eyepiece. On the outer part of the scale you will see months from 1 (January) to 12 (December) with divisions in between them. The longer divisions mark 10-day increments and the short ones 2-day increments. The number of the month appears below the 15th day of that month.

### Longitude Scale

The small scale that appears below the Date Scale and is labeled E 20 10 0 10 20 W. Since the Date and Longitude scales are on the same ring, this ring is sometimes referred to as the Date/Longitude scale.

### Longitude Index Marker

A small line on the black plastic ring that is next to the Date/Longitude Ring.

### Index Marker Ring

The small black ring with the Index marker on it.

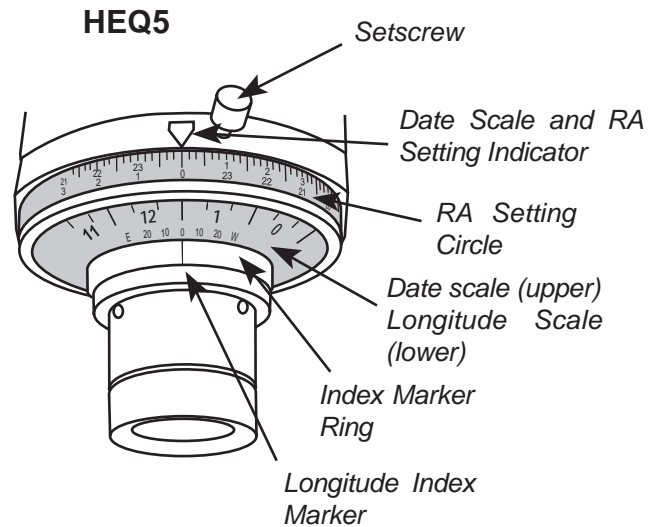
### RA Setting Circle

The scale showing hours from 0 to 23. On the HEQ5 it is directly above the Date/Longitude Scale. On the EQ6 it is opposite the end where the polar scope eyepiece is located. If you live in the Northern Hemisphere you will be using the upper scale on the RA Setting Circle. The lower scale is for use in the Southern Hemisphere.

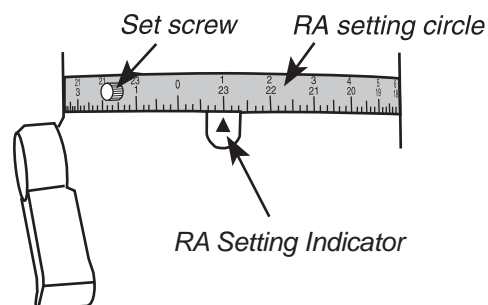
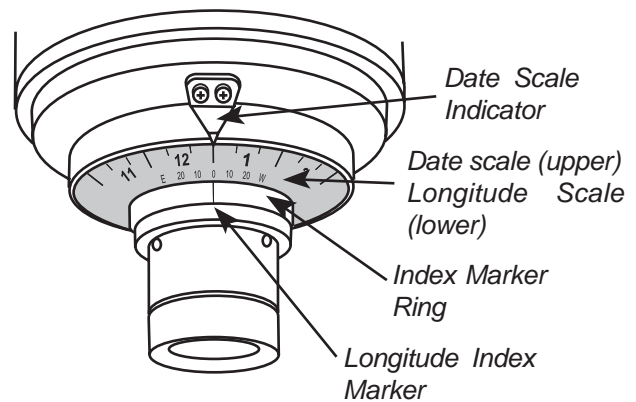
### RA Setting Indicator

On the HEQ5 the Date Scale Indicator also acts as the RA Setting indicator. On the EQ6, it is the small triangular indicator next to the RA setting circle.

Fig.h-1



EQ6

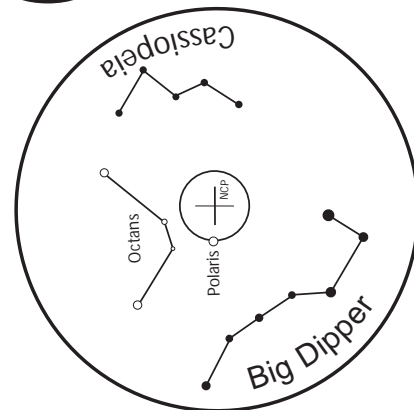


### Step 1: Orienting the Polar Scope Reticule

Follow the steps as outlined below to properly orient the reticule inside the polar scope.

1. Unlock the RA axis and rotate it until the reticule pattern shows the Polaris Location Indicator at the very bottom (i.e., the 6 o'clock position - See Figure h-2). Re-lock the RA axis.
2. Loosen the RA setting circle by loosening the setscrews, then turn the setting circle so that its indicator is pointing to zero. Do not rotate the mount in RA, just loosen and move the RA Setting Circle. When done, tighten the setscrews.
3. Now unlock the RA axis and rotate the mount so the Setting Circle indicator points to 1 h 0 m. Use the top scale if you are in the northern hemisphere and the bottom scale if you are in the southern hemisphere. Lock the RA axis.
4. Rotate your Date/Longitude scale so that October 10 lines up with the Date Scale Indicator (i.e., 10th day of month 10).
5. Unlock the RA axis and rotate it back so the RA Setting Indicator points to zero again on the RA Setting Circle scale.
6. Use small flat head screw driver to loosen the setscrew on the Index Marker Ring. Rotate the ring so that the marker is aligned with October 10 on the datescale. Tighten the setscrew to lock the ring in place.

Fig.h-2



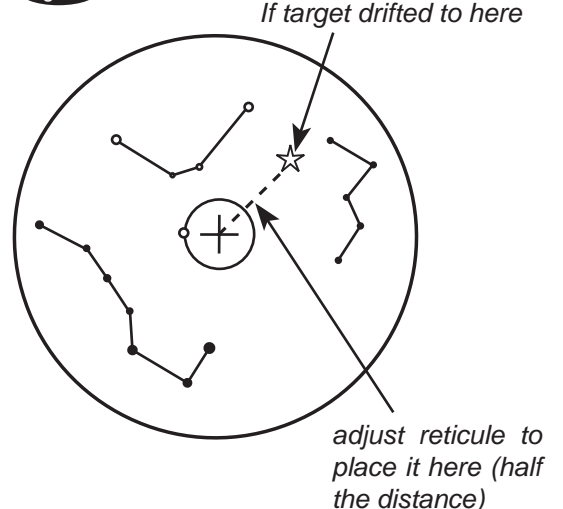
After completing these steps you will have the reticule in the proper orientation.

### Step 2: Aligning the Polar Scope Reticule

The polar scope needs to be aligned with the polar axis of your mount. The steps below tell you how to perform this alignment. Note, you can do this procedure at night while pointing at Polaris. However, it is probably easier to do it in the daytime using a distant point as your target (e.g, a street light a couple of hundred yards away). If doing the procedure during the day, you might find it convenient to set your altitude to near parallel with the ground to put the eyepiece of the polar scope into a comfortable position. Just be sure to leave room to make vertical adjustments in both directions. Also, do this procedure without an OTA or counterweights. It will make turning the mount a lot simpler.

1. Locate a distant object and place it under the cross at the centre of the polarscope reticule.
2. Rotate the mount in RA 180 degrees (i.e., 12 hours on the RA setting circle).
3. Note the displacement of your target from the centre of the crosshairs. If it is not displaced at all, it means your polar scope reticule is already properly aligned and you don't need to do any more. If it is displaced, continue with the next step of the alignment procedure.

Fig.h-3



4. Use the three adjustment screws on the polar scope to move the reticule so that exactly one-half of the displacement is corrected for. For example, if the displacement were about half an inch in the direction of 1 o'clock, then you would adjust the cross at the centre of the reticule to go half the distance in that direction (See Figure h-3).
5. Now continue to move the cross using the altitude and azimuth adjusters on the mount. When the target is back under the cross, go back to step 2, but this time rotate the mount 180 degrees in the opposite direction. If you still get displacement of the target, repeat steps 3-5.



## Procedure for Precise Polar Alignment of the HEQ5/EQ6 Mount.

Preliminary Step: Determining the Zero Point on the Longitude Scale

The alignment procedure requires that you set the Longitude scale to "Zero". Depending on where you live, "Zero" can be anywhere between the E and the W on longitude scale, so first you need to determine where zero is for your location. Your Zero point is equal to the difference between your actual longitude and the longitude of the central meridian of your time zone. To calculate the longitude of your central meridian, multiply your time zone offset from Greenwich Mean Time (GMT) by 15.

For example, in Waterloo, Ontario, Canada (Eastern Time) the time zone offset is -5 hours. Ignore the sign and simply multiply  $5 \times 15 = 75$ . The longitude of the central meridian for the Eastern Time Zone is 75 degrees west. The actual longitude at the viewing location in Waterloo is 80 degrees 30 minutes West. Ignore the 30 minutes and just use 80 in the equation. Now it's simple,  $80 - 75 = 5$ . Since 80 is greater than 75 the result is positive 5. That means Waterloo, Ontario is west of its Central Meridian. In this case, the zero point is at the "5" mark on the W side of the scale. If the location was east of its central meridian the equation would yield a negative value. In that case the E side of the scale should be used.

Precise Polar Alignment for the **Northern Hemisphere:**

1. Rotate the RA axis so the Longitude Index Marker (See Figure h-4) lines up with your Date Scale Indicator. Lock the RA axis.
2. Turn the Date/Longitude scale so that your calculated "Zero" point lines up with the Longitude Index Marker.
3. Unlock the RA axis and rotate the mount so the Date Scale Indicator is pointing at the current date. Lock the RA axis.
4. Loosen and move the RA Setting Circle to show the current time. Use the upper portion of the scale for the Northern Hemisphere and the bottom for the Southern hemisphere. Tighten the Setting Circle.
5. Unlock the RA axis and rotate the mount until RA setting circle indicator points at Zero. The reticule is now in the proper orientation.
6. Use the altitude and azimuth adjusters to place Polaris into the small circle on the perimeter of the bigger circle in the polar scope reticule.

The polar alignment is complete. This procedure should get you within a couple of minutes of true north.

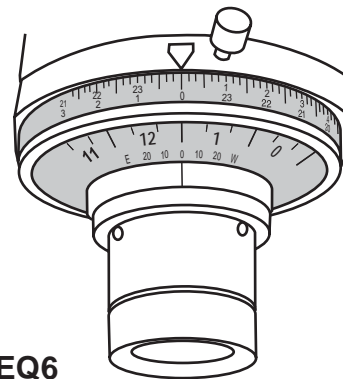
Precise Polar Alignment for the **Southern Hemisphere:**

There is a 4-star pattern in the polar scope, which resembles the bucket of the big Dipper. In the Southern Hemisphere, there is an Asterism in Octans which can be used for Polar Alignment. This procedure can be somewhat difficult in the city because all four of the stars in the Asterism are fainter than Magnitude 5.

Rotate the telescope in RA axis and/or use the altitude and azimuth adjusters to place the four stars in the Asterism in the four circles (Fig. h-5).

Fig.h-4

HEQ5



EQ6

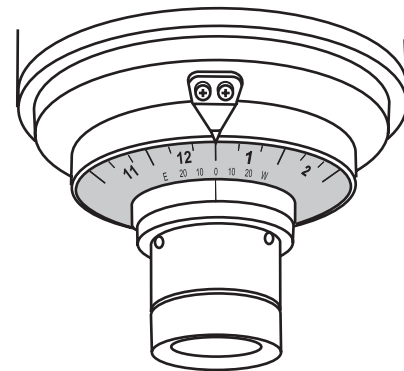
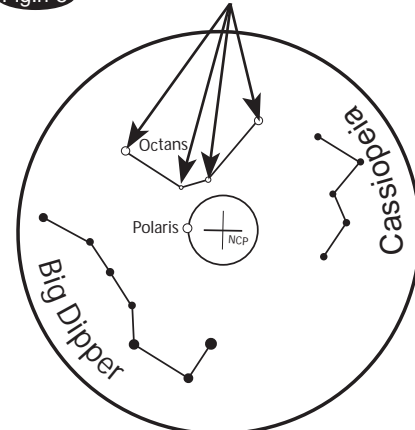


Fig.h-5

Place the four stars in the Asterism here

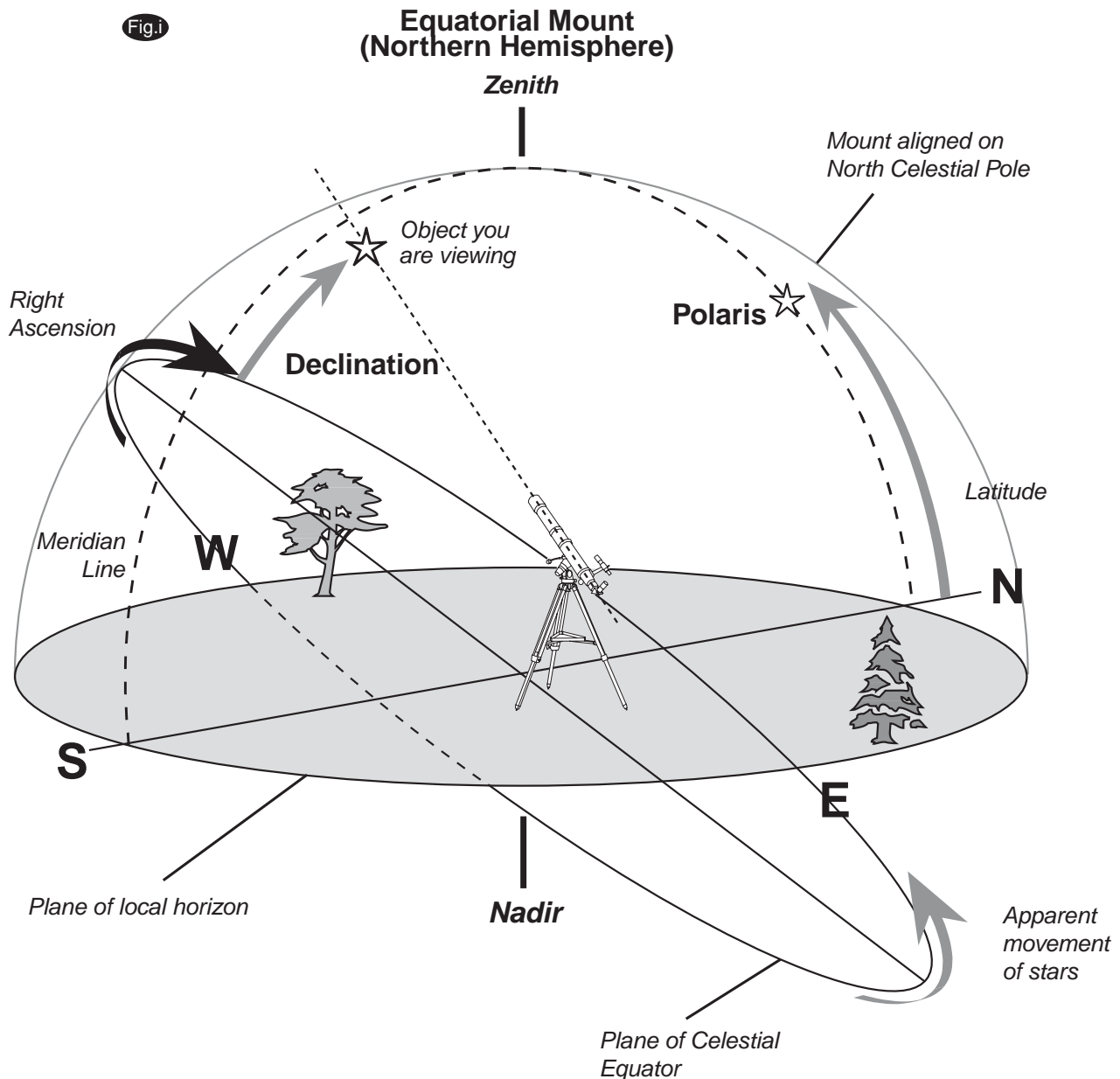


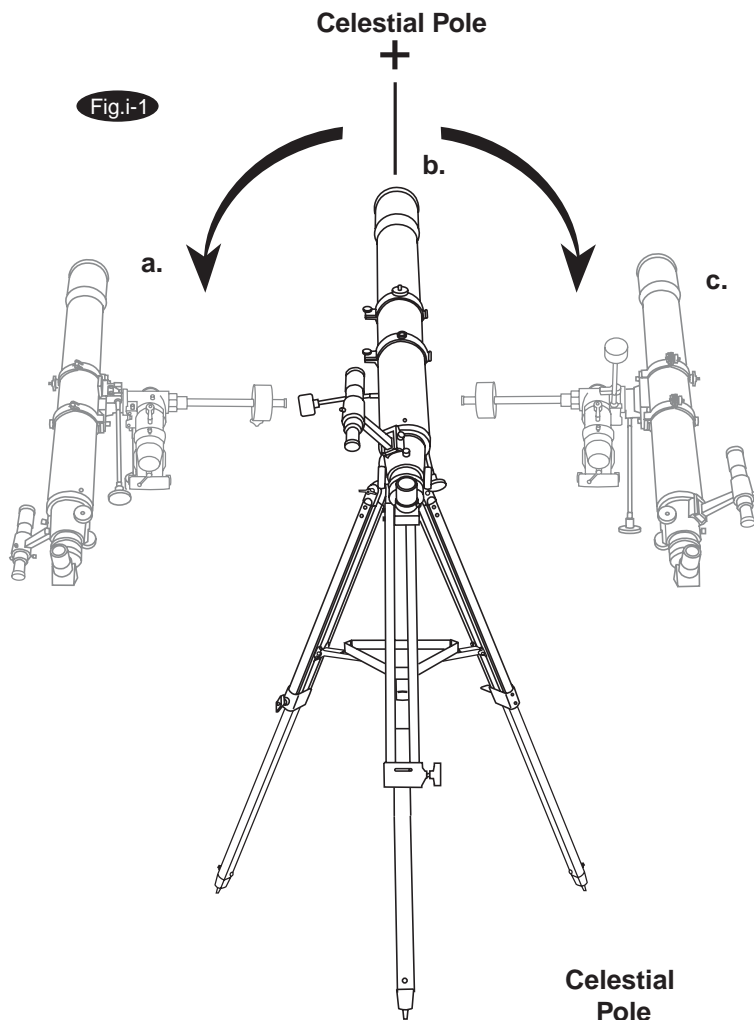


# Pointing your telescope

A German Equatorial mount has an adjustment, sometimes called a wedge, which tilts the mount's polar axis so that it points at the appropriate Celestial Pole (NCP or SCP). Once the mount has been polar aligned, it needs to be rotated around only the polar axis to keep an object centred. Do not reposition the mount base or change the latitude setting. The mount has already been correctly aligned for your geographical location (ie. Latitude), and all remaining telescope pointing is done by rotating the optical tube around the polar (R.A.) and declination axes.

A problem for many beginners is recognizing that a polar-aligned equatorial mount acts like an alt-azimuth mount which has been aligned to a celestial pole. The wedge tilts the mount to an angle equal to the observer's Latitude, and therefore it swivels around a plane which parallels the celestial (and Earth's) equator (Fig.i). This is now its "horizon"; but remember that part of the new horizon is usually blocked by the Earth. This new "azimuth" motion is called Right Ascension (R.A). In addition, the mount swivels North(+) and South(-) from the Celestial Equator towards the celestial poles. This plus or minus "altitude" from the celestial equator is called Declination (Dec).



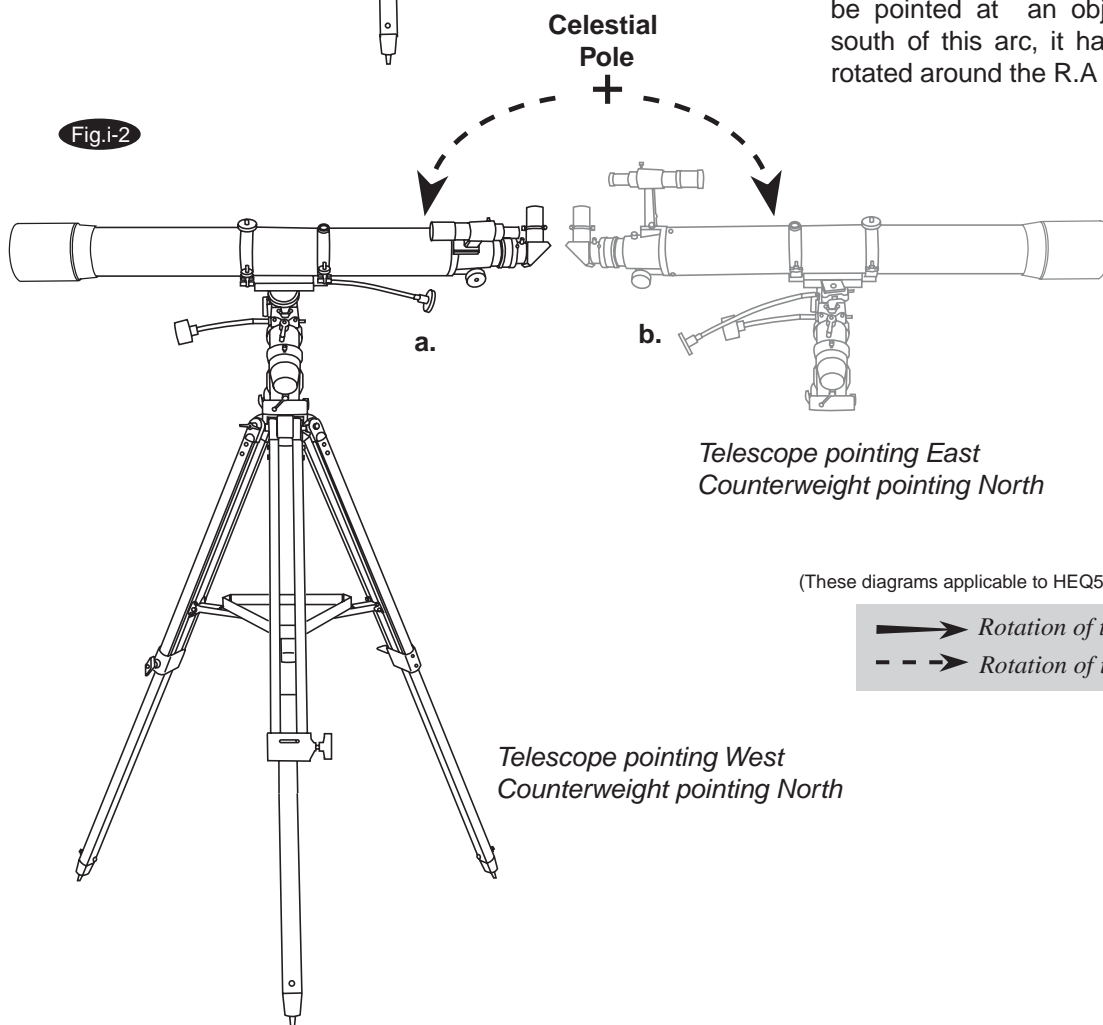


**Pointing to the NCP**

For the following examples, it is assumed that the observing site is in the Northern Hemisphere. In the first case (Fig.i-1b), the optical tube is pointing to the NCP. This is its probable position following the polar-alignment step. Since the telescope is pointing parallel to the polar axis, it still points to the NCP as it is rotated around that axis counter-clockwise, (Fig.i-1a) or clockwise (Fig.i-1c).

**Pointing toward the western or eastern horizon**



Now, consider pointing the telescope to the western (Fig.i-2a) or eastern (Fig.i-2b) horizon. If the counterweight is pointing North, the telescope can be swivelled from one horizon to the other around the Dec axis in an arc that passes through the NCP (any Dec arc will pass through the NCP if the mount is polar-aligned). It can be seen then that if the optical tube needs to be pointed at an object north or south of this arc, it has to be also rotated around the R.A axis.



*Telescope pointing East  
Counterweight pointing North*

*Telescope pointing West  
Counterweight pointing North*

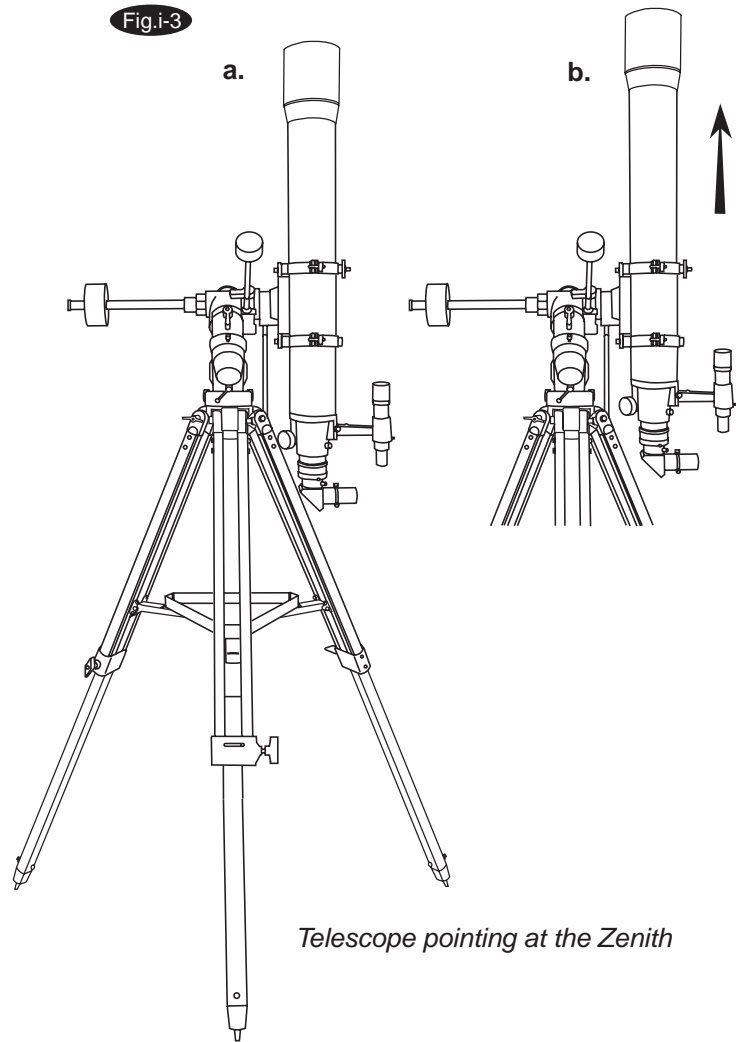
(These diagrams applicable to HEQ5 and EQ6 mounts)

 *Rotation of the R.A. axis*  
 *Rotation of the Dec. axis*

Telescopes with long focal lengths often have a "blind spot" when pointing near the zenith, because the eyepiece-end of the optical tube bumps into the mount's legs (Fig.i-3a). To adapt for this, the optical tube can be very carefully slipped up inside the tube rings (Fig.i-3b). This can be done safely because the tube is pointing almost vertically, and therefore moving it does not cause a Dec-balance problem. It is very important to move the tube back to the Dec-balanced position before observing other sky areas.

Something which can be a problem is that the optical tube often rotates so that the eyepiece, finderscope and the focussing knobs are in less convenient positions. The diagonal can be rotated to adjust the eyepiece. However, to adjust the positions of the finderscope and focussing knobs, loosen the tube rings holding the optical tube and gently rotate it. Do this when you are going to view an area for while, but it is inconvenient to do every time you briefly go to a new area.

Finally, there are a few things to consider to ensure that you are comfortable during the viewing session. First is setting the height of the mount above the ground by adjusting the tripod legs. You must consider the height that you want your eyepiece to be, and if possible plan on sitting on a comfortable chair or stool. Very long optical tubes need to be mounted higher or you will end up crouching or lying on the ground when looking at objects near the zenith. On the other hand, a short optical tube can be mounted lower so that there is less movement due to vibration sources, such as wind. This is something that should be decided before going through the effort of polar aligning the mount.



# Choosing the appropriate eyepiece

## Calculating the magnification (power)

The magnification produced by a telescope is determined by the focal length of the eyepiece that is used with it. To determine a magnification for your telescope, divide its focal length by the focal length of the eyepieces you are going to use. For example, a 10mm focal length eyepiece will give 80X magnification with an 800mm focal length telescope.

$$\text{magnification} = \frac{\text{Focal length of the telescope}}{\text{Focal length of the eyepiece}} = \frac{800\text{mm}}{10\text{mm}} = 80\text{X}$$

When you are looking at astronomical objects, you are looking through a column of air that reaches to the edge of space and that column seldom stays still. Similarly, when viewing over land you are often looking through heat waves radiating from the ground, house, buildings, etc. Your telescope may be able to give very high magnification but what you end up magnifying is all the turbulence between the telescope and the subject. A good rule of thumb is that the usable magnification of a telescope is about 2X per mm of aperture under good conditions.

## Calculating the field of view

The size of the view that you see through your telescope is called the true (or actual) field of view and it is determined by the design of the eyepiece. Every eyepiece has a value, called the apparent field of view, which is supplied by the manufacturer. Field of view is usually measured in degrees and/or arc-minutes (there are 60 arc-minutes in a degree). The true field of view produced by your telescope is calculated by dividing the eyepiece's apparent field of view by the magnification that you previously calculated for the combination. Using the figures in the previous magnification example, if your 10mm eyepiece has an apparent field of view of 52 degrees, then the true field of view is 0.65 degrees or 39 arc-minutes.

$$\text{True Field of View} = \frac{\text{Apparent Field of View}}{\text{Magnification}} = \frac{52^\circ}{80\text{X}} = 0.65^\circ$$

To put this in perspective, the moon is about 0.5° or 30 arc-minutes in diameter, so this combination would be fine for viewing the whole moon with a little room to spare. Remember, too much magnification and too small a field of view can make it very hard to find things. It is usually best to start at a lower magnification with its wider field and then increase the magnification when you have found what you are looking for. First find the moon then look at the shadows in the craters!

## Calculating the exit pupil

The Exit Pupil is the diameter (in mm) of the narrowest point of the cone of light leaving your telescope. Knowing this value for a telescope-eyepiece combination tells you whether your eye is receiving all of the light that your primary lens or mirror is providing. The average person has a fully dilated pupil diameter of about 7mm. This value, varies a bit from person to person, is less until your eyes become fully dark adapted and decreases as you get older. To determine an exit pupil, you divide the diameter of the primary of your telescope (in mm) by the magnification.

$$\text{Exit Pupil} = \frac{\text{Diameter of Primary mirror in mm}}{\text{Magnification}}$$

For example, a 200mm f/5 telescope with a 40mm eyepiece produces a magnification of 25x and an exit pupil of 8mm. This combination can probably be used by a young person but would not be of much value to a senior. The same telescope used with a 32mm eyepiece gives a magnification of about 31x and an exit pupil of 6.4mm which should be fine for most dark adapted eyes. In contrast, a 200mm f/10 telescope with the 40mm eyepiece gives a magnification of 50x and an exit pupil of 4mm, which is fine for everyone.

# OBSERVING THE SKY

## Sky conditions

Sky conditions are usually defined by two atmospheric characteristics, seeing, or the steadiness of the air, and transparency, light scattering due to the amount of water vapour and particulate material in the air. When you observe the Moon and the planets, and they appear as though water is running over them, you probably have bad "seeing" because you are observing through turbulent air. In conditions of good "seeing", the stars appear steady, without twinkling, when you look at them with unassisted eyes (without a telescope). Ideal "transparency" is when the sky is inky black and the air is unpolluted.

## Selecting an observing site

Travel to the best site that is reasonably accessible. It should be away from city lights, and upwind from any source of air pollution. Always choose as high an elevation as possible; this will get you above some of the lights and pollution and will ensure that you aren't in any ground fog. Sometimes low fog banks help to block light pollution if you get above them. Try to have a dark, unobstructed view of the horizon, especially the southern horizon if you are in the Northern Hemisphere and vice versa. However, remember that the darkest sky is usually at the "Zenith", directly above your head. It is the shortest path through the atmosphere. Do not try to observe any object when the light path passes near any protrusion on the ground. Even extremely light winds can cause major air turbulence as they flow over the top of a building or wall.

Observing through a window is not recommended because the window glass will distort images considerably. And an open window can be even worse, because warmer indoor air will escape out the window, causing turbulence which also affects images. Astronomy is an outdoor activity.

## Choosing the best time to observe

The best conditions will have still air, and obviously, a clear view of the sky. It is not necessary that the sky be cloud-free. Often broken cloud conditions provide excellent seeing. Do not view immediately after sunset. After the sun goes down, the Earth is still cooling, causing air turbulence. As the night goes on, not only will seeing improve, but air pollution and ground lights will often diminish. Some of the best observing time is often in the early morning hours. Objects are best observed as they cross the meridian, which is an imaginary line that runs through the Zenith, due North-South. This is the point at which objects reach their highest points in the sky. Observing at this time reduces bad atmospheric effects. When observing near the horizon, you look through lots of atmosphere, complete with turbulence, dust particles and increased light pollution.

## Cooling the telescope

Telescopes require time to cool down to outside air temperature. This may take longer if there is a big difference between the temperature of the telescope and the outside air. This minimizes heat wave distortion inside telescope tube (tube currents). A rule of thumb is to allow 5 minutes per inch of aperture. For example, a 4 inch refractor would require at least 20 minutes, but an 8" reflector would require at least 40 minutes to cool off to outside conditions. Tip: use this time for polar alignment.

## Adapting your eyes

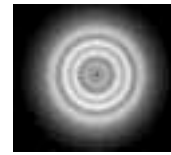
Do not expose your eyes to anything except red light for 30 minutes prior to observing. This allows your pupils to expand to their maximum diameter and build up the levels of optical pigments, which are rapidly lost if exposed to bright light. It is important to observe with both eyes open. This avoids fatigue at the eyepiece. If you find this too distracting, cover the non-used eye with your hand or an eye patch. Use averted vision on faint objects: The center of your eye is the least sensitive to low light levels. When viewing a faint object, don't look directly at it. Instead, look slightly to the side, and the object will appear brighter.

# PROPER CARE FOR YOUR TELESCOPE

## Collimating a Newtonian reflector

Collimation is the process of aligning the mirrors of your telescope so that they work in concert with each other to deliver properly focused light to your eyepiece. By observing out-of-focus star images, you can test whether your telescope's optics are aligned. Place a star in the centre of the field of view and move the focuser so that the image is slightly out of focus. If the seeing conditions are good, you will see a central circle of light (the Airy disc) surrounded by a number of diffraction rings. If the rings are symmetrical about the Airy disc, the telescope's optics are correctly collimated (Fig.j).

Fig.j



Correctly aligned



Needs collimation

Fig.j-1

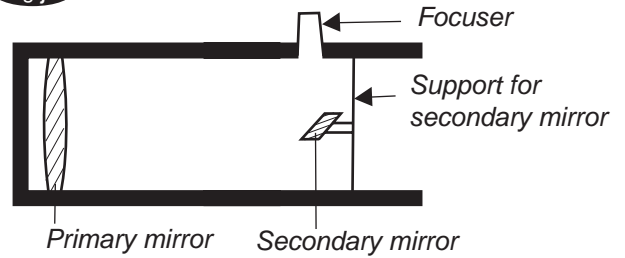


Fig.j-2

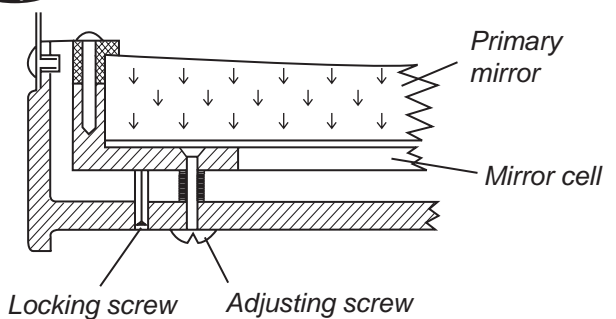


Fig.j-3

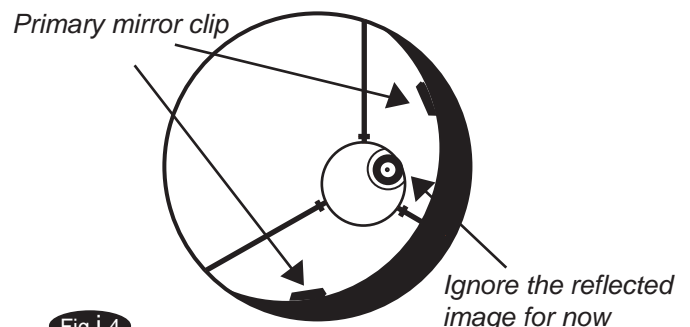
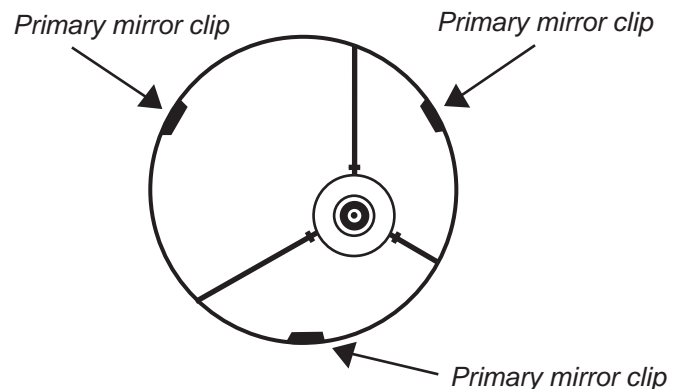


Fig.j-4



If you do not have a collimating tool, we suggest that you make a "collimating cap" out of a plastic 35mm film canister (black with gray lid). Drill or punch a small pinhole in the exact center of the lid and cut off the bottom of the canister. This device will keep your eye centered of the focuser tube. Insert the collimating cap into the focuser in place of a regular eyepiece.

Collimation is a painless process and works like this:

Pull off the lens cap which covers the front of the telescope and look down the optical tube. At the bottom you will see the primary mirror held in place by three clips 120° apart, and at the top the small oval secondary mirror held in a support and tilted 45° toward the focuser outside the tube wall (Fig.j-1).

The secondary mirror is aligned by adjusting the three smaller screws surrounding the central bolt. The primary mirror is adjusted by the three adjusting screws at the back of your scope. The three locking screws beside them serve to hold the mirror in place after collimation. (Fig.j-2)

### Aligning the Secondary Mirror

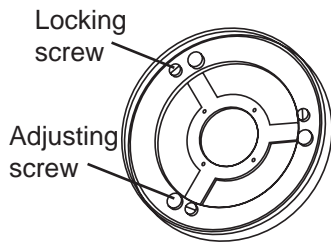
Point the telescope at a lit wall and insert the collimating cap into the focuser in place of a regular eyepiece. Look into the focuser through your collimating cap. You may have to twist the focus knob a few turns until the reflected image of the focuser is out of your view. Note: keep your eye against the back of the focus tube if collimating without a collimating cap. Ignore the reflected image of the collimating cap or your eye for now, instead look for the three clips holding the primary mirror in place. If you can't see them (Fig.j-3), it means that you will have to adjust the three bolts on the top of the secondary mirror holder, with possibly an Allen wrench or Phillip's screwdriver. You will have to



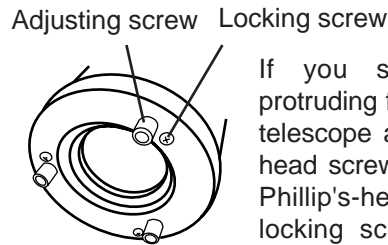
alternately loosen one and then compensate for the slack by tightening the other two. Stop when you see all three mirror clips (Fig.j-4). Make sure that all three small alignment screws are tightened to secure the secondary mirror in place.

### Aligning the Primary Mirror

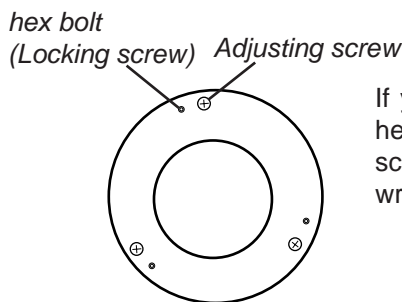
Find the three locking screws at the back of your telescope and loosen them by a few turns.



If you see 3 flat headed screws and 3 thumbscrews, the flat headed screws are the adjusting screws and the thumbscrews are the locking screws.



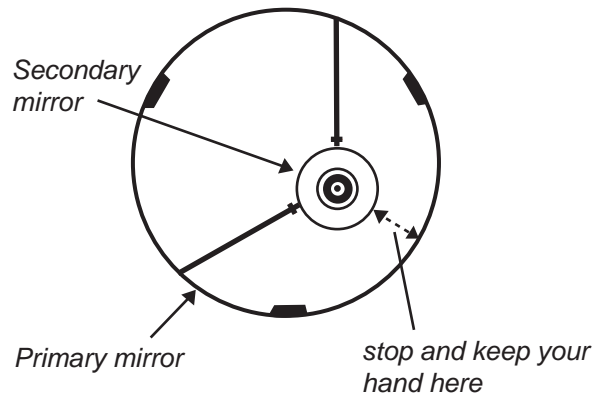
If you see 3 large nuts protruding from the back of your telescope and 3 small Phillip's-head screws besides them, the Phillip's-head screws are the locking screws and the large nuts are the adjusting screws.



If you see 3 hex bolts and 3 Phillip's head screws, the hex bolts are the locking screws and the Phillip's-head screws are the adjusting screws. You will need an Allen wrench to adjust the locking screws.

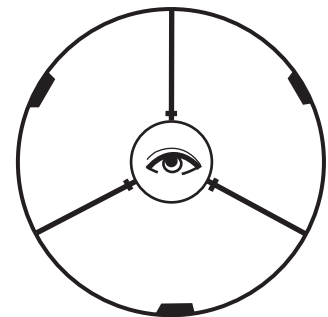
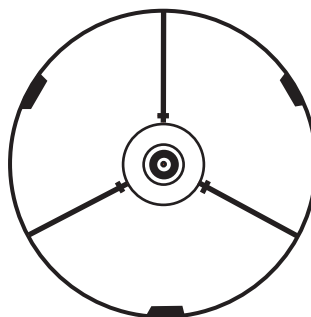
Fig.j-5

Now run your hand around the front of your telescope keeping your eye to the focuser, you will see the reflected image of your hand. The idea here is to see which way the primary mirror is defocused; you do this by stopping at the point where the reflected image of the secondary mirror is closest to the primary mirrors' edge (Fig.j-5).



When you get to that point, stop and keep your hand there while looking at the back end of your telescope, is there an adjusting screw there? If there is you will want to loosen it (turn the screw to the left) to bring the mirror away from that point. If there isn't an adjusting screw there, then go across to the other side and tighten the adjusting screw on the other side. This will gradually bring the mirror into line until it looks like Fig.j-6. (It helps to have a friend to help for primary mirror collimation. Have your partner adjust the adjusting screws according to your directions while you look in the focuser.)

Fig.j-6



After dark go out and point your telescope at Polaris, the North Star. With an eyepiece in the focuser, take the image out of focus. You will see the same image only now, it will be illuminated by starlight. If necessary, repeat the collimating process only keep the star centered while tweaking the mirror.

## Collimating a refractor with the adjustable objective-lens cell

Collimation is the process of aligning the lenses of your telescope so that the light they collect will focus at the right spot at the back of your telescope for your eyepieces to work.

Collimation is a simple process and works like this:

Pull off the dew cap at the front of your telescope and look into the scope. The pair of lenses are held in a cell by a threaded ring. This cell is held in place by three pairs of screws spaced 120 degrees apart. The larger Phillip's head screws actually hold the cell on, while the smaller, buried Allen screws push against a ledge at the front of the tube and allow the cell to tilt slightly, by tension against the Phillips screws (Fig.k). The idea is to alternately loosen and tighten each against the other until you have a round star image.

There are a number of devices available for collimation. One of the best is your eyepiece and Polaris. For this purpose it is best that your telescope not be polar aligned, in fact point the mount head due east or west.

Use your lowest power (largest number) eyepiece to acquire Polaris, place it in the center of the eyepiece view. Now switch to your next higher power eyepiece, while keeping the image centered. The in-focus star image will have a bright innermost point, a slightly fainter inner ring and a fainter still outer ring that is hard to see (Fig.k-1). If it doesn't look like this, or you can't reach focus then start with: take out your star diagonal and look at the image slightly out of focus, this will allow you to gauge the deflection. A typical off-collimation image will have a bright spot off to one side when you bring the focus out (Fig.k-2).

The actual process is to slightly loosen the pair on the side the deflection is, slacken the Allen head screws then tighten the Phillip's head screws against them again. Check the star image again after moving it into the centre of the eyepiece. If you find your image getting worse, then go the other way, or slacken the other two Allen screws a little. Once you have a round star image you are set.

Fig.k

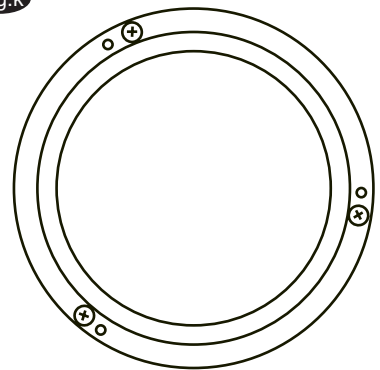
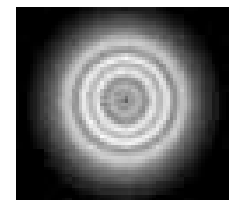
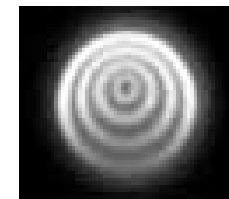


Fig.k-1



*Correctly aligned*

Fig.k-2



*Needs collimation*

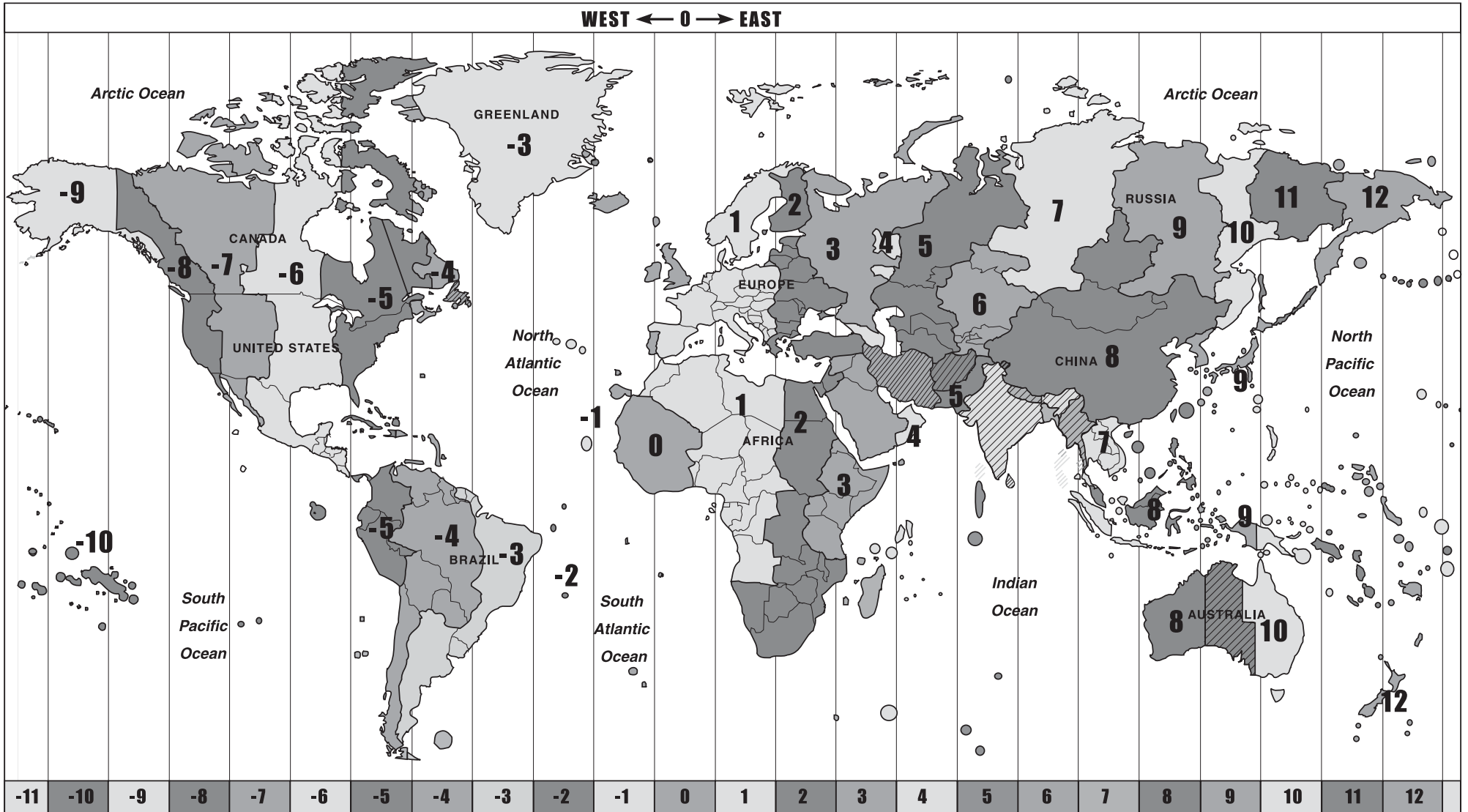


It helps to have a friend to help with the collimation. Have your partner adjust the screws according to your directions while you look in the eyepiece.

## Cleaning your telescope

Replace the dust cap over the end of the telescope whenever it is not in use. This prevents dust from settling on the mirror or lens surfaces. Do not clean the mirror or lens unless you are familiar with optical surfaces. Clean the finderscope and eyepieces with special lens paper only. Eyepieces should be handled with care, avoid touching optical surfaces.

# APPENDIX A - STANDARD TIME ZONES OF THE WORLD



# APPENDIX B - OPTIONAL ACCESSORIES

## LONG EYE-RELIEF EYEPIECES

These multi-coated eyepieces provide a generous 20mm eye relief, and all focal lengths including the 2mm model feature particularly wide diameter eye lenses for maximum viewing comfort. These eyepieces are especially valuable for spectacle wearers, as the long eye relief allows the entire field to be viewed whilst spectacles are being worn. Soft rubber eyecups are provided for added comfort and to keep out extraneous light.

Available in: 25mm (50° apparent field), 20mm (50° apparent field), 15mm (50° apparent field), 10mm (50° apparent field), 9mm (50° apparent field), 5mm (45° apparent field), 2mm (45° apparent field).



## WIDE-ANGLE EYEPIECES

These ultra-wide angle, multi-Coated eyepieces offer a generous 66° apparent field of view, allowing more sky objects to be viewed at one time. They provide sharp images right across the field. Rubber eyepieces are included for viewing comfort and to exclude extraneous light.

Available in: 20mm (18mm Eye Relief), 15mm (13mm Eye Relief), 9mm (15mm Eye Relief), 6mm (14.8mm Eye Relief).



## 2" EYEPIECES

These 2"/50.8mm fully multi-coated eyepieces offer exceptional value for the money. They feature long eye relief, a wide field of view and soft rubber eyecups. The multi-coatings ensure maximum light transmission and enhance image contrast.

Available in: 42mm (50° apparent field), 35mm (56° apparent field), 28mm (56° apparent field).

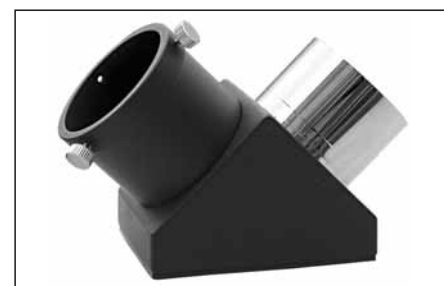


*\*To be used with telescopes with a 2" focuser.*

## 2" 90° STAR DIAGONAL

Made to yield maximum astronomical viewing performance, the 2"/90° star diagonal is perfect with telescopes with a 2" focuser and 2" eyepieces. It comes with a 1.25" adapter to accept standard 1.25" eyepieces.

*\*To be used with telescopes with a 2" focuser.*



### 8-24 ZOOM EYEPIECE

This 6-element 1.25" zoom eyepiece for astronomical telescope provides the benefits of a continuous adjustable focal length for an affordable price. It allows you to find an object at low power, then zoom in until you reach the desired magnification. The fold-down rubber eyecup provides comfortable viewing for eyeglass wearers.

Focal length: 8mm-24mm.

Apparent field: 40° - 60°.

Eye relief: 18mm-15mm.



### DUAL LED FLASHLIGHT

This dual purpose flashlight includes two pairs of LED's for instant switch between night vision protecting red light for telescope operation and white light for non-astronomical use. The brightness wheel provides quick and easy intensity adjustment. Battery included.



### EQ6 MOUNT EXTENSION

The EQ6 extension tube extends the height of the EQ6 mount so it is easier for observer to look into a long refractor. Installed between the tripod and the mount head, this heavy-duty metal tube gives about 8" in height to the assembly while maintaining the stability of the mount.



## APPENDIX C - RECOMMENDED READING

### **A**mateur Astronomy

Beginner's Guide to Amateur Astronomy: An Owner's Manual for the Night Sky by David J. Eicher and, Michael Emmerich (Kalmbach Publishing Co., Books Division, Waukesha, WI, 1993).

NightWatch: A Practical Guide to Viewing the Universe by Terence Dickinson, (Firefly Books, Willowdale, ON, Canada, 3rd edition, 1999).

Star Testing Astronomical Telescopes by Harold Richard Suiter, (Willmann-Bell, Inc., Richmond, VA, 1994).

Star Ware: The Amateur Astronomer's Ultimate Guide to Choosing, Buying, and Using Telescopes and Accessories by Philip S. Harrington (John Wiley & Sons, New York, 1998 ).

The Backyard Astronomer's Guide by Terence Dickinson and Alan Dyer (Firefly Books Ltd., Willowdale, ON, Canada, revised edition, 1994).

The Beginner's Observing Guide: An Introduction to the Night Sky for the Novice Stargazer by Leo Enright, (The Royal Astronomical Society of Canada, Toronto, ON, Canada, 1999).

The Deep Sky: An Introduction by Philip S. Harrington (Sky Publishing Corporation, Cambridge, MA, Sky & Telescope Observer's Guides Series, ed. Leif J. Robinson, 1997).

The Universe from Your Backyard: A Guide to Deep Sky Objects by David J. Eicher (Kalmbach Publishing Co., Books Division, Waukesha, WI, 1988).

Turn Left at Orion: A Hundred Night Sky Objects to See in a Small Telescope--and how to Find Them by Guy J. Consolmagno and Dan M. Davis, (Cambridge University Press, New York, 3rd edition, 2000)

### **A**stro-photography

The Great Atlas of the Stars by Serge Brunier, Constellation photography by Akira Fujii (Firefly Books; Willowdale, ON, Canada 2001).

A Manual Of Advanced Celestial Photography by Brad D. Wallis and Robert W. Provin (Cambridge University Press; New York; 1984).

Astrophotography An Introduction by H.J.P. Arnold (Sky Publishing Corp., Cambridge, MA, Sky & Telescope Observer's Guides Series, ed. Leif J. Robinson, 1995).

Astrophotography for the Amateur by Michael Covington (Cambridge University Press, Cambridge, UK, 2nd edition, 1999).

Splendors of the Universe: A Practical Guide to Photographing the Night Sky by Terence Dickinson and Jack Newton (Firefly Books, Willowdale, ON, Canada, 1997).

Wide-Field Astrophotography by Robert Reeves (Willmann-Bell, Inc., Richmond, VA,

### **O**bservational References

A Field Guide to the Stars and Planets by Jay M. Pasachoff, (Houghton Mifflin Company, 1999).

Atlas of the Moon by Antonín Růkl (Kalmbach Publishing Co., Books Division, Waukesha, WI, 1993).

Burnham's Celestial Handbook: An Observer's Guide to the Universe Beyond the Solar System by Robert Burnham (Dover Publications, New York; 3- volume set, 1978).

Observer's Handbook by The Royal Astronomical Society of Canada, (University of Toronto Press, Toronto, ON, Canada, published annually).

Sky Atlas 2000.0 by Wil Tirion and Roger W. Sinnott (Sky Publishing Corp., Cambridge, MA, 2nd edition, 1998).



# APPENDIX D - GLOSSARY

## **A**bsolute Magnitude

The apparent brightness a star would have if placed at a distance of 10 parsecs from the earth.

## **A**chromatic Lens

A refractor lens, made of two or sometimes three separate lenses, which has the effect of bringing most of the viewed colours to a sharp focus, thus reducing chromatic aberration.

## **A**lt-azimuth

A simple mount that allows movement in altitude (up and down) and in azimuth (side to side).

## **A**ntireflection Coating

A thin layer of film applied to an optical surface that reduces the loss of transmission of light.

## **A**perture

The diameter of the primary mirror or lens.

## **B**arlow Lens

A "negative" lens which, when placed in front of the eyepiece, increases the focal length and magnification and decreases the field.

## **C**ollimation

The process of aligning all the elements of an optical system. Collimation is routinely needed in reflectors, often in Catadioptric systems but seldom in refractors.

## **D**eclination

Similar to Latitude on the Earth's surface, it is the distance in degrees North or South of the Celestial Equator (the projection of the Earth's Equator onto the Celestial Sphere). The degrees can be subdivided into minutes and seconds.

## **D**ew Cap

A tube extending forward from the front lens of a telescope. It prevents dew from forming on the lens as it cools down, and acts as a sunshade to reduce reflections during the day.

## **D**iagonal

A mirror or prism system which changes the angle and orientation of the light rays coming from the telescope to the eyepiece.

## **E**quatorial Mount

A telescope mount with an axis parallel to the axis of the earth. This provides easy tracking of sky objects and for photography when combined with a clock drive.

## **E**yepiece

Also called an ocular. This is a small tube that contains the lenses needed to bring a telescope's focus to a final image in the eye. Telescopes usually come with at least two eyepieces: one for low power and a second for a higher power view.

## **E**ye Relief

The distance between the eyepiece lens and the position in which the eye must be placed to see through the telescope. Telescope users who wear eyeglasses while observing, appreciate the benefits of longer eye relief.

## **E**xit Pupil

This is the diameter of the beam of light from the eyepiece which reaches the pupil of the eye. It is usually expressed in mm, and determined by dividing the diameter of the primary (in mm) by the Magnification. Knowing this value and the diameter of your dilated pupil allows you to choose the eyepieces which will work best for you with a specific telescope.

## **F**ield of View

The maximum view angle of an optical instrument. The number, in degrees, supplied by the manufacturer is the Apparent Field of View. To find the True Field of View (also known as the Actual Field of View), divide the Apparent Field of View by the Magnification.

## **F**inderscope

A low power telescope attached parallel to the main instrument which provides easy object locating and telescope aiming.

## **F**ocal Length

The distance of the light path from the objective (primary lens or mirror) to the convergence of the beam. The convergent spot is called the Focus or Focal Point.

## **F**ocal Ratio

This is found by dividing an optical system's Focal Length by its Aperture. The resulting value is sometimes called the system's "speed".

## **F**ocuser

A device which brings the light rays in a telescope to a precise focus. Common designs include geared (rack-and-pinion), gearless (Crayford- style) and helical.

## **L**ens

A transparent optical element consisting of one or more pieces of glass. A lens has curved surfaces that bring distant light to a focus.

## **M**agnifying Power

The amount by which a system increases the apparent size of objects. Magnification is determined by dividing the Focal Length of the telescope by the Focal Length of the eyepiece.

### **Mirror**

In a telescope, it is a highly polished surface made to reflect light. Primary mirrors are usually made spherical or paraboloidal (parabolic) to focus the light rays.

## **O**bjective

The primary or largest element in an optical system; sometimes called the "fixed optics."

### **Optical Tube Assembly**

The housing and optical train of a telescope; not including the mount, diagonal, eyepiece or accessories.

## **P**arabolic Mirror

A parabolic or more accurately a "paraboloidal" mirror, is ground to a shape which brings all incoming light rays to a perfect focus, on axis.

### **Polar Axis**

A telescope mount's axis that is parallel with the earth's axis. With a drive motor, the motion of stars due to the earth's movement can be counteracted so that they remain in the field.

### **Power**

See Magnifying Power.

### **Prime Focus**

The focal point of the objective mirror or lens.

## **R**esolution

The ability of an optical system to reveal details.

### **Resolving Power**

The ability of a telescope to separate closely positioned points.

### **Right Ascension**

Similar to but not the same as Latitude on the Earth's surface. It is the position eastwards from the Vernal Equinox, in 24 one-hour units. The hours can be subdivided into minutes and seconds.

## **S**etting Circles

Circular scales attached to the telescope. They are marked off in degrees of Declination and hours of Right Ascension. Together, the circles allow the position of a known object to be found by setting the dials to the equatorial coordinates.

## **T** rue Field of View

How much sky, in angular measure, is available at the eyepiece. It is contrasted with Apparent Field of View, which measures the field of the eyepiece alone.

## **W**ide Angle Eyepiece

An eyepiece with an Apparent field of view of more than 50 degrees.

## **Z**oom Eyepiece

An optical system which provides a variable focal length.



NEVER USE YOUR TELESCOPE TO LOOK DIRECTLY AT THE SUN. PERMANENT EYE DAMAGE WILL RESULT. USE A PROPER SOLAR FILTER FIRMLY MOUNTED ON THE FRONT OF THE TELESCOPE FOR VIEWING THE SUN. WHEN OBSERVING THE SUN, PLACE A DUST CAP OVER YOUR FINDERSCOPE OR REMOVE IT TO PROTECT YOU FROM ACCIDENTAL EXPOSURE. NEVER USE AN EYEPiece-TYPE SOLAR FILTER AND NEVER USE YOUR TELESCOPE TO PROJECT SUNLIGHT ONTO ANOTHER SURFACE, THE INTERNAL HEAT BUILD-UP WILL DAMAGE THE TELESCOPE OPTICAL ELEMENTS.