

A Telescope Operating Manual

for Celestron 8-inch Schmidt Cassegran Telescopes

1. Introduction

This booklet is a handbook for the use of the lab telescopes. In it you should find all the information necessary to become an expert in operating the lab telescopes.

Read it more than once and review it each week before lab. Bring copies of any useful pages to lab until you are comfortable working without them. Remember as you read this document, the telescope you will be using is delicate and can become severely damaged unless the proper rules of operation are followed. **These rules are in bold faced type throughout this handbook and collected together on page 9.** Please memorize these rules and follow them as you use the telescope. Also please report any telescope problems or difficulties to your lab instructor or lab assistant.

Even though these are very good telescopes, some first-time observers are disappointed with the view. The images are small and the observations are difficult to make and require practice and effort. Perhaps we have all been spoiled by television images from space telescopes or the wonderful color pictures on the web that are the result of hours-long time exposures with the largest and best telescopes in the world.

Still there is a real thrill in following in the footsteps of the early astronomers, in seeing what they saw, and in discovering for oneself what they discovered. In this way beginning astronomers become one with the ancients and relive one of the greatest adventures of discovery that the human race has experienced. Here is to many hours of happy observing!

2. The Celestron Telescope

There are two models of Celestron telescopes in service in astronomy labs—the older telescopes, which have orange tubes and newer models with black tubes. Both types are functionally equivalent and with slight differences between them. Learning on one will teach you to operate the other.

Figure 1 is a photograph of a Celestron assembled and ready for use. The photograph names of most of the parts used in operating the telescope. Figure 2 shows the tailpiece of an assembled telescope. Study these photographs and familiarize yourself with the part names before you first work with the telescope. In addition it is useful to know a little about the purpose of each part and the special cautions to be observed when using the telescope.

On the following pages is a glossary of Celestron telescope part names with a description and a few important facts about each. **It is helpful for the student to memorize the important cau-**

tions that are shown in boldface type. They should be followed or serious telescope damage will certainly result.

Glossary of Celestron parts:

base—the part of the telescope that attaches to the wedge and contains the clock drive.

clock drive—the motor in the base of the telescope that allows a telescope to follow the stars. In order for this function to operate properly, the telescope must be mounted on an equatorial wedge that is correctly aligned with the Earth's axis of rotation.

corrector plate—a thin lens of low refractive power that is the front optical element of a Schmidt-Cassegrain telescope. **Never touch this glass or try to clean or wipe any condensation off this corrector plate.**

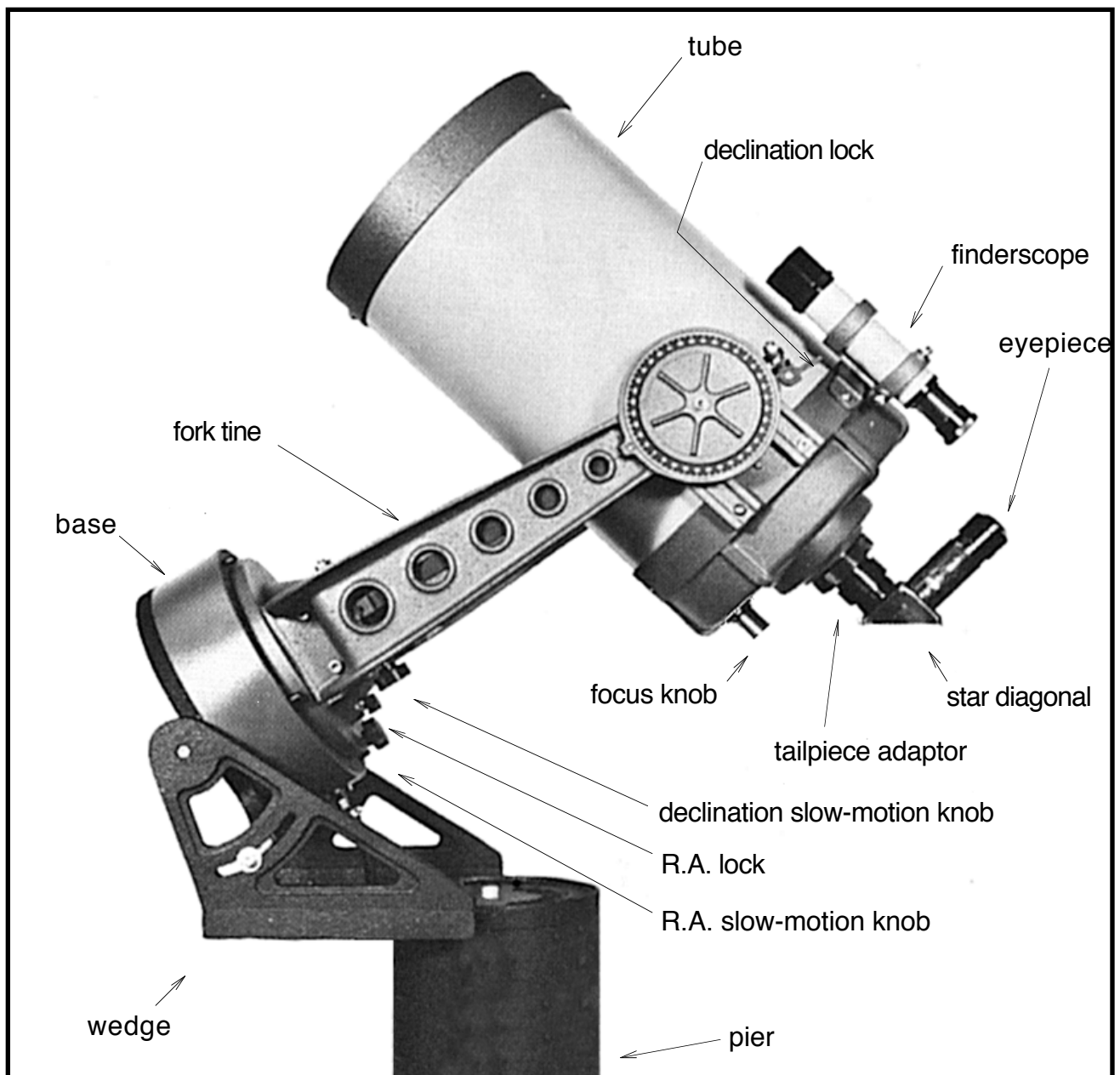


Figure 1 A Celestron 8-inch Schmidt-Cassegrain telescope assembled on a pier.

declination lock—the lock on the declination axis of the telescope located at the top of one of the fork tines. See Figure 3. **This lock must be loosened before slewing the telescope in the direction of changing declination or the mount will be damaged.** This lock is operated by turning the lock knob to the left to unlock and to the right to lock the declination axis. It is important to hold the telescope while unlocking the declination axis and usually on turn or less will loosen the lock enough. When locking the axis, turn the knob only enough to keep the telescope from moving. It is unnecessary and damaging to the mechanism if one overtightens this

knob.

declination setting circle—the scale on the end of the fork tines, which shows the declination angle of the telescope. See Figure 4. This angle tells how far north or south of the celestial equator the telescope is pointed.

declination slow-motion drive arm—the drive arm located inside one of the fork tines and which drives the telescope in the direction of changing declination. See Figure 5. **It is important to center this arm at the beginning of an observing session. Stop immediately and check this arm if the declination slow-motion knob shows**

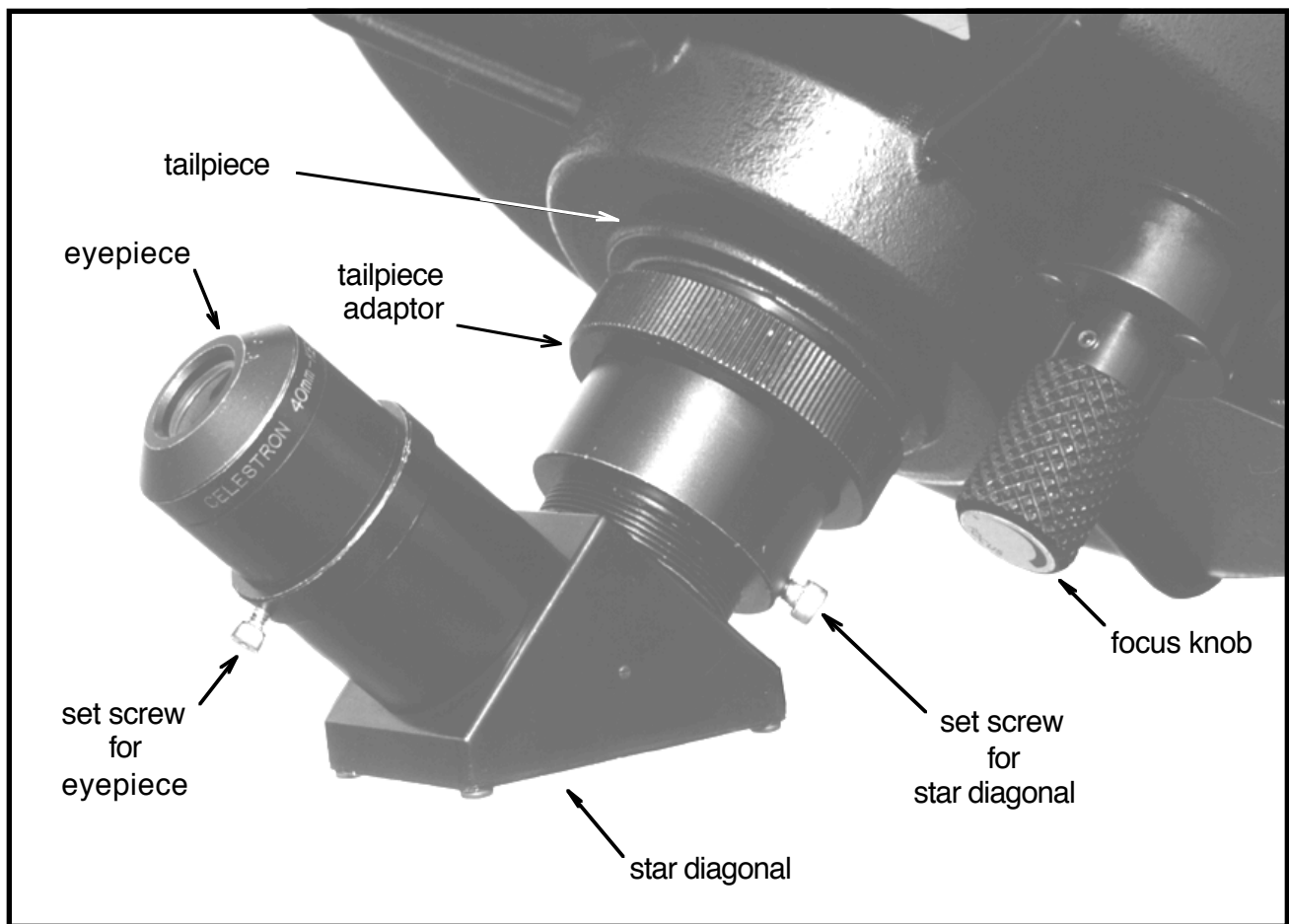


Figure 2 The tailpiece end of the telescope showing the parts used for focusing and viewing. Most of these parts are stored after an observing session and part of telescope assembly is to properly install these parts.

the slightest bit of increased resistance to turning. Not doing so will result in the declination slow-motion drive becoming stripped and unusable.

declination slow-motion knob—the knob at the base of one of the fork tines which is used to makes slight changes in the declination setting of the telescope. **Unlike the R.A. slow-motion knob, the declination slow-motion knob is operated with the declination lock fully locked. However if this knob shows the slightest bit of increased resistance to turning, it is important to stop immediately and check the declination slow-motion drive arm. It may have reached the end of its travel and will need to be reset to the middle of its track. Not doing so will result in the declination slow-motion drive becoming stripped and unusable.**

eyepiece—an optical element consisting of several carefully spaced lenses in a tube. Its purpose is to magnify the image formed by the telescope objec-

tive and make it viewable by the human eye. **Do not to touch the glass parts of the eyepiece.** Different eyepieces produce different magnifications and different size fields of view.

finderscope—a small telescope with a wider field of view than the main telescope. It aides in locating objects for the main telescope.

focus knob—an adjustment knob on the back of the telescope that adjusts the sharpness of the image you see. There is no need to use this knob unless something is visible in the telescope field of view. No amount of turning this knob will make something miraculously appear. One must have an image before that image can be focused.

fork tines—the arms of the telescope mount which support and carry the telescope tube on its declination axis. The declination lock is on one of the fork tines.

lens cap—with the Celestron telescope, the cover for the front element which is the corrector plate.

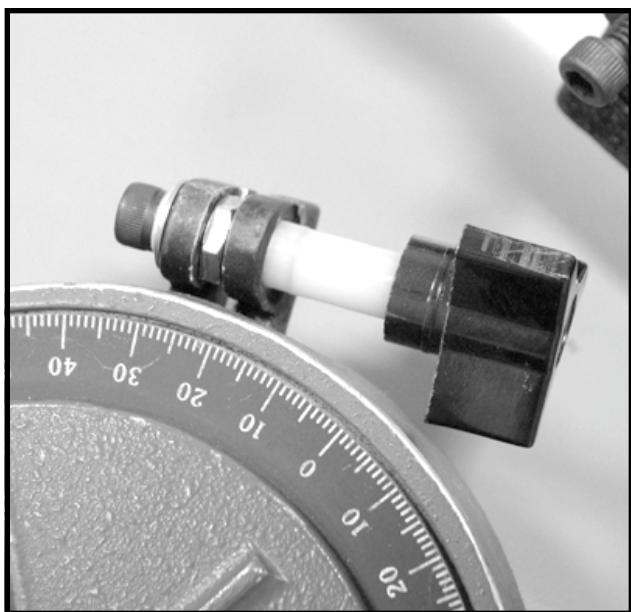


Figure 3 A photograph of the modified declination lock at the top of the fork tube. The lock is operated by turning the knob to the left to unlock the declination and to the right to lock the declination. If it does not operate properly, consult your lab instructor.

pier—a permanent support for a telescope. With the Celestron telescope it is the support structure to which the wedge is attached.

rear cap—the cover of the tailpiece opening. With most telescopes it is a yellow rubber cup.

right ascension (or R.A.) lock—the lock on the telescope base which controls slewing in the direction of right ascension. See Figure 7. **This lock and its associated mechanism is very delicate and damage to it is a perennial problem for beginners. Proper use of this lock is essential to avoid any damage to the R.A. drive mechanism. This lock must be unlocked in order to move the telescope through various angles of right ascension. This lock must be partly loosened before turning the RA slow-motion knob. Not doing so will result in the R.A. slow-motion drive becoming stripped and unusable.**

right ascension (or R.A.) setting circle—the scale on the telescope base which shows the angle of right ascension (and the hour angle) at which the telescope is pointed. See Figure 10. The right ascension angle is measured in hours (1 hour = 15°) eastward along the celestial equator from the vernal equinox.

right ascension (or R.A.) slow-motion knob—the knob which is used to make slight changes in the right ascension setting of the telescope. **It is essential to partially unlock the right ascension lock before using the right ascension slow motion knob. This knob should never be used if any force greater than a light finger touch is needed to operate it. Not following these procedures will always result in the right ascension slow-motion drive becoming stripped and unusable.**

star diagonal—an accessory with a mirror or prism and which directs the light from the telescope through an angle of 90° thus making overhead objects easier to view. Usually our labs use one even when not viewing overhead. One note of caution is in order. This device inverts the image, making it upright from the astronomical telescope's normal upside-down nature, however the image is also reversed from left to right. This feature is inconvenient when using maps.

tailpiece—the part of a telescope where the focused light exits the tube and various accessories (eyepiece holder, star diagonal, camera, etc.) are attached.



Figure 4 A photograph of the declination setting circle. The use of this setting circle is detailed in the section on setting circles.

tailpiece adaptor—the accessory which threads onto the tailpiece and adapts the tailpiece to accept other accessories. The adaptor shown in this handbook is for visual work and holds a star diagonal or an eyepiece.

tube—the telescope itself which contains the main optical components. See figure 8 for a diagram showing the path of light in this tube.

visual back—Celestron's proprietary name for the tailpiece adaptor that holds an eyepiece or star diagonal for visual observation.

wedge—the supporting structure of the telescope which attaches to a tripod or pier and to which the base of the telescope is attached. The wedge is adjustable in order to align the telescope with the polar axis of the earth. For proper alignment the wedge allows the clock drive of the telescope to track the stars and planets.

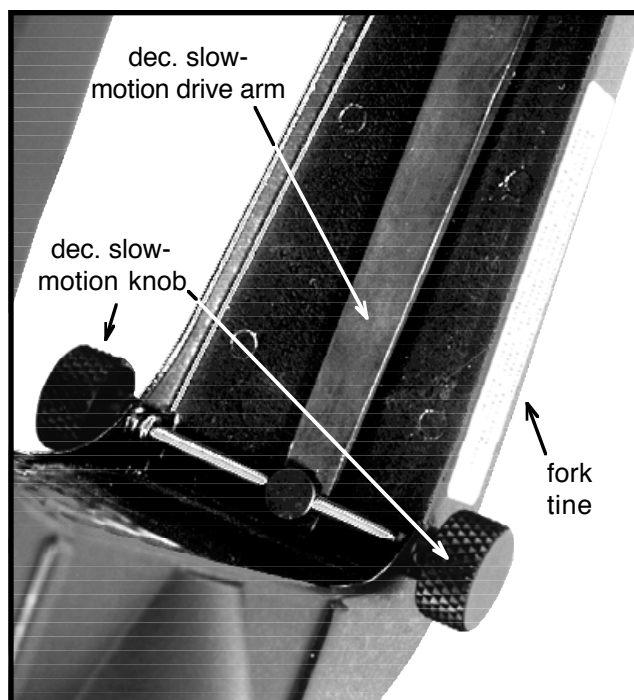


Figure 5 A photograph of the declination slow-motion drive arm. (Note: some Celestron telescopes have only one declination slow-motion knob.)

3. Telescope Assembly

Before assembling the telescope be certain you are familiar with the names and purposes of the parts of the telescope in the previous section and especially important to follow the proper procedures for handling the telescope otherwise it can be damaged. Even the way to carry the telescope is important, otherwise it can be seriously damaged simply by picking it up improperly.

When lifting and carrying the telescope it is best to hold the scope by the fork tines. This approach allows a good grip and puts no strain on any of the locks. While moving the telescope take care to guard against bumping or moving the tube. Whenever the tube is moved to point in a new direction the beginner is wise to recite the sutra: “unlock, move, relock.” Whenever the tube is moved, the first thing to do is unlock one or both of the locks, then move the tube, and finally relock everything after the telescope is properly pointed.

The steps in assembling the telescope are listed below:

1. **Attach the wedge to the pier.** The wedge should be orientated so that when the telescope



Figure 6 The wedge with the bolt installed on the telescope base being slid into the slot on its face.

is attached the forks will point in the general direction of Polaris (for reasons you will learn about later). The bolt holding the wedge should be fastened as tightly as possible. After this, the

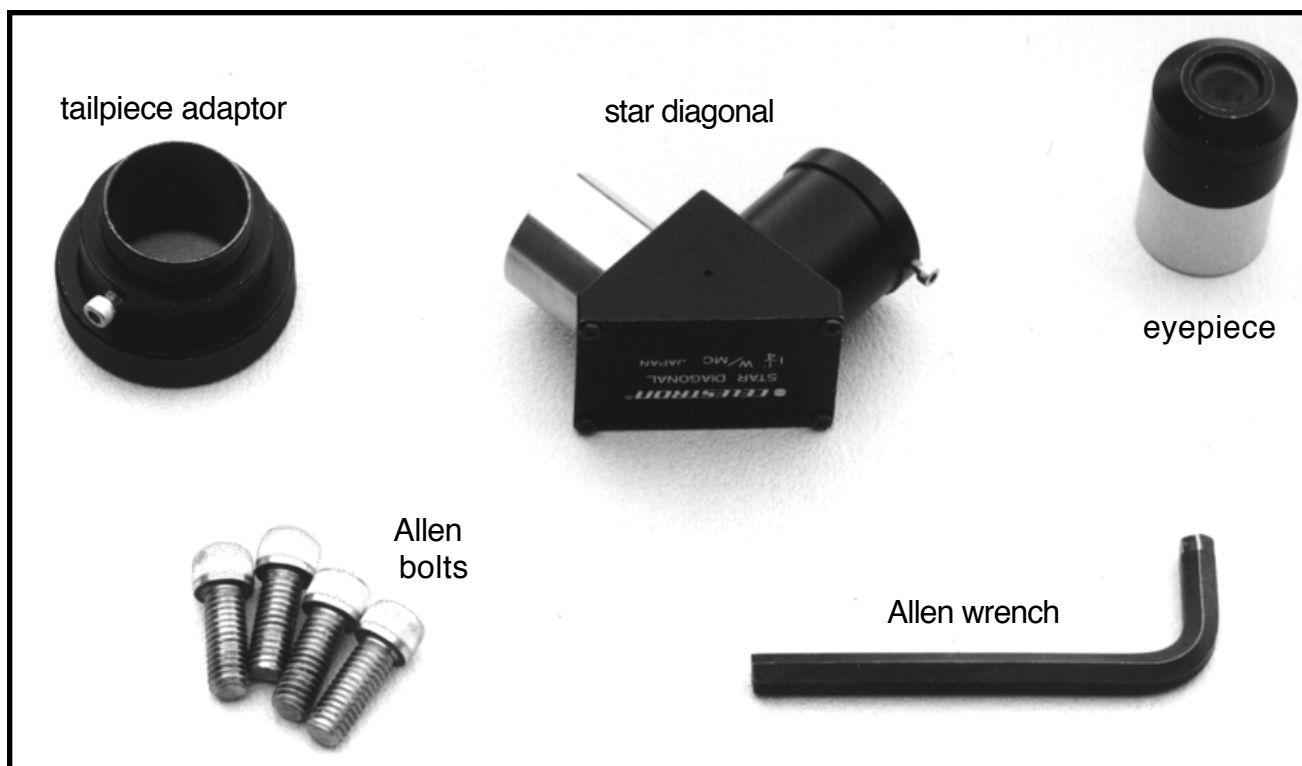


Figure 7 The parts used in telescope assembly.

wedge should not be moved in the course of a normal observing session.

2. **Attach the telescope to the wedge.** See Figure 6. Thread one of the mounting bolts partially into the base of the telescope and, cradling the instruments in one arm, slide its base against the mounting plate of the wedge so that the bolt slips into the slot on the mounting plate. Tighten this first bolt to make the telescope secure but loose enough for the telescope base to be able to move slightly against the wedge mounting plate in order to align the holes for the threading of the other two bolts. While one observing partner continues to hold the telescope as insurance against its falling, the other person can insert the other two bolts through the plate of the wedge and into the base. Secure the bolts—they do not have to be as tight as the bolt holding the wedge down.
3. **Remove the rear cap.**
4. **Attach the tailpiece adaptor.** Hold the tailpiece adaptor flat against the tailpiece and thread the attachment collar on the tailpiece being certain to guard against cross threading.
5. **Insert star diagonal into the tailpiece adaptor.**

The design of the star diagonal and tailpiece adaptor is fully idiot proof. They will fit together only one way. The star diagonal is secured in the tailpiece adaptor by a small thumb screw. This screw is to be loosened each time the star diagonal is rotated to change its orientation and then tightened afterwards.

6. **Insert eyepiece in the star diagonal.** There are two different types of star diagonals in use and the means of securing the eyepiece is different in each. If the tube designed to accept the eyepiece is chrome, then the tube holds the eyepiece by friction. If your eyepiece seems too loose with this type of star diagonal, then you must call your instructor or the lab assistant to adjust it. If the tube designed to accept the eyepiece is black, then the tube holds the eyepiece with a small thumb screw. It is wise in using this screw to loosen it only enough to remove the ocular and no more. This trick guards against the thumb screw falling out and being lost in the dark.
7. **Remove the lens cap (if present).** You are now ready to collimate your finderscope and begin viewing.

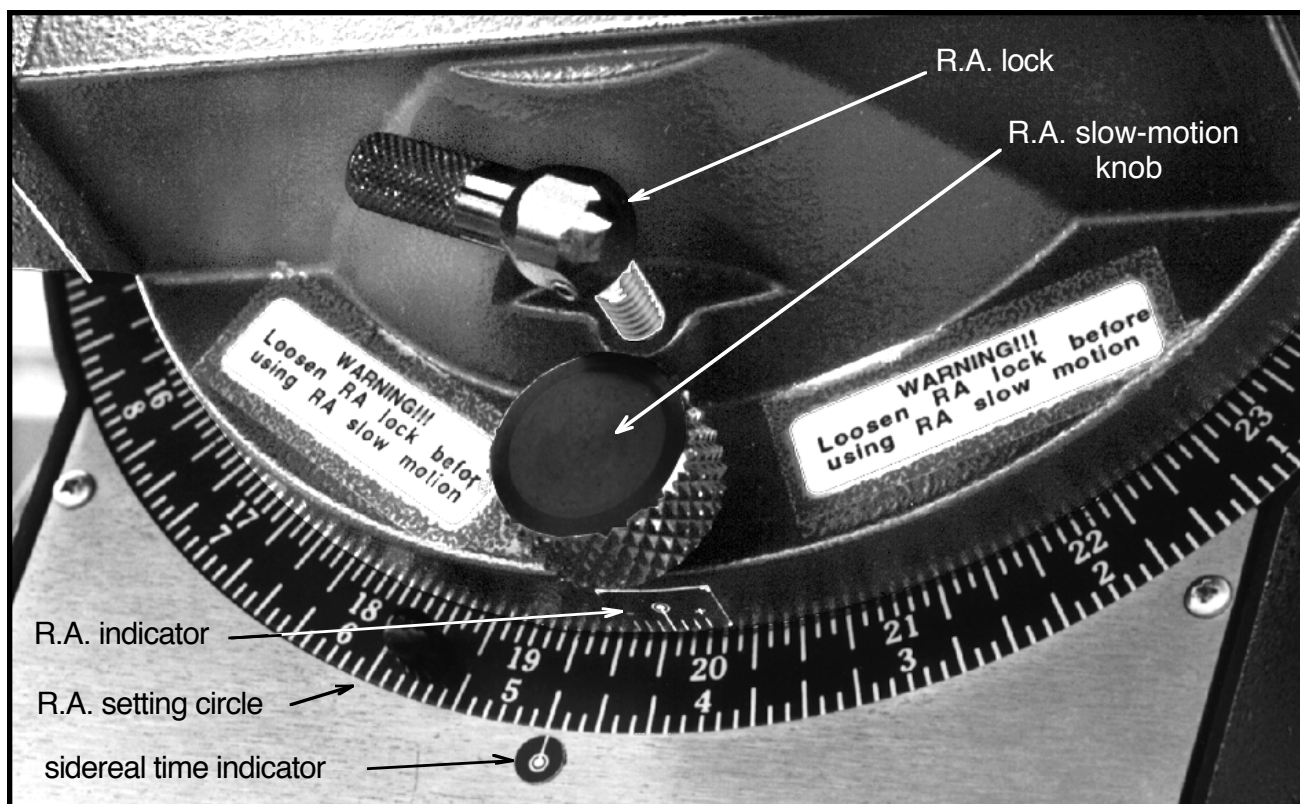


Figure 8 A photograph of the base of the fork tines of a newer Celestron showing the right ascension lock and associated parts. Notice the warning label on the use of the R.A. slow-motion knob. Failure to follow this warning **will** damage the R.A. slow-motion function and make the telescope unusable. The sidereal time indicator is located elsewhere on the base of the older telescopes but its function is similar.

4. Important Cautions

Note: never attempt to use the Celestron telescope or its finderscope to observe the sun.

When operating the telescope, technique is everything. Give the telescope the greatest of care. If you attend to the following cautions, the telescopes will give semester after semester of faithful service.

1. Do not force any movements. Unlock, move and relock to adjust anything on the scope.
2. Always stop turning any slow-motion knob if you feel more than the slightest resistance.
3. Lift and carry the telescope by the fork tines only.
4. Never unbolt the telescope from the wedge unless someone is holding it.
5. Do not touch any glass surface. The oils and acids in fingerprints will deteriorate the anti-reflection coating on the lenses.
6. Do not attempt to clean any dirty glass surfaces. Tell your instructor or the lab assistant. Cleaning requires special fluids and tissues. The antireflection coatings are soft and even kleenex tissue is like sandpaper to these coatings.
7. Do not store mechanical parts such as bolts and wrenches with the eyepieces and the star diagonal.
8. Since the glass parts are fragile, please be very careful and guard against breakage.
9. All optical parts (eyepieces and star diagonal) must be stored in proper containers (pill bottle or ziploc baggie).
10. Don't take the eyepieces apart.
11. Think first before doing! Or ask.

5. Finderscope Collimation

The field of view of the Celestron telescope is relatively small even at low powers. Finding even bright objects without some optical aid is difficult. Finding fainter objects would be a matter of luck, even for the skilled observer. To overcome this limitation the telescope is equipped with an excellent finderscope, a low-power, wide field of view telescope similar which facilitates locating an object in the field of view of the main telescope.

The finderscope eyepiece is fitted with cross hairs composed of fine wire. Their purpose is to provide an aiming point in the large field of view of the finderscope. The idea is that when some object is dead center behind the cross hairs of the finderscope, then it will also be centered in the field of view of the main telescope. In order for this idea to be true, the finderscope has to be collimated, that is adjusted to point in exactly the same direction as the main telescope

When a finderscope is installed on a telescope, the mounting bracket is designed so that the finderscope points in approximately the same direction as the telescope, usually within one or two degrees of each other. (The full moon has a diameter of about one-half of a degree). Thus the two are almost collimated as they come from the factory. All that is left is final adjustment to bring the two into collimation. In theory the two should remain in collimation, but the breakdown and reassembly of the telescopes results in small misalignments which must be corrected before a night's observing can begin.

The first step after assembly is to check finderscope collimation. The steps in checking finderscope collimation are listed below:

1. **Focus the finderscope.** If your finderscope has a focusing adjustment, focus the finderscope for your eye. Some finderscopes are fixed focus, and some allow for focusing by turning a rubberized collar. In your main telescope use the eyepiece with the longest focal length).
2. **Select an object.** Select an object. This selection is important. It should be on the Earth and at least 500 meters away. It should be easily found and easily distinguishable from the things

around it. At night select a object shown against a lighter background if possible.. A tower with three red lights is a poor choice because it is difficult to be sure of which red light is visible in the main telescope. The student might have the telescope pointing at one light while the finderscope is actually centered on another. The observer could think that collimation was perfect but actually the telescope would be cross-eyed.

3. **Center the finderscope on the object.** Loosen the telescope locks, grasp the telescope by the tailpiece and the tailpiece adaptor and point the finderscope at the object. Center the middle of that object exactly behind the "X" of the crosshairs. Retighten the telescope locks.
4. **Check the main telescope for the object.** Look through the main telescope. If the same object is centered in the field of view of view, then the finderscope doesn't need collimation and the nights work can begin. Otherwise see #5.
5. **The object is visible but not centered in the telescope.** If the object is visible but isn't in the exact center of the main telescope, then a small amount of adjustment is needed. See the next procedure in this section. Otherwise see #6.
6. **The object is not visible in the telescope at all.** If the object is not even present in the field of view of the telescope, then the finderscope must be collimated from scratch. See the paragraph below.

The goal here is to somehow center the main telescope on the selected object, and then adjust the finderscope screws to cause the finderscope crosshairs to point to the very same object. In this section when the procedure says exactly centered, it means exact. The finderscope's usefulness as a finding aid is directly dependent on how carefully and exactly this task is done. The following steps will lead you through the process. Proceed to the appropriate step below depending on how great the misalignment is as determined above.

1. **If your selected object is in the finderscope but not visible in the main telescope begin the**

collimation process here. As noted above the finderscope is aimed within a few degrees of your main scope because the bracket holding the finderscope causes the two of them to point in the same approximate direction.

2a. Find the object in the main telescope method

1. Since you are close to the target only small adjustments are needed. There are two techniques. Try them both and use the one which works best for you. First, in the finderscope scan the area around the target object for clues on nearby things to look for in the main telescope that might lead you to the object. Next, look through the main telescope, loosen only one of the locks holding the telescope axes, and move the telescope very slightly back and forth while looking in the main telescope for the selected object or recognizable nearby things. Try the same technique with the other axis until you get the object in the field of view. Once you have the object in the field of view of the telescope, go on to step 3. If you have difficulties with this method try the technique suggested in step 2b below.

2b. Find the object in the main telescope method

2. Some observers can aim the telescope by sighting along the tube and place the desired object somewhere in the field of view of the main telescope. The idea here is to hold the tail-piece and its adaptor while backing away from the telescope by the length of your arm. The object in the field of view of the telescope should appear to be sitting right on the end of the tube when your eye is situated such that you can see none of the tube. See Figure 12. Once you have the selected object in the field of view of the telescope, go on to step 3.

- 3. Center the object in the field of view.** Using the slow motion controls to position the object exactly in the center of the field of view of the telescope. (Note that for changes in declination, the declination slow-motion control is used with the declination lock in the locked position; but for changes in right ascension, the right ascension lock must be partly loosened before the right ascension slow motion knob is turned.) Once this step is done the locks and the slow-motion controls are not adjusted again until col-

limation is complete. The telescope is now pointing at the object and the step is to make the finderscope point in exactly that same direction by adjusting its aim using the screws which hold it in its bracket.

- 4. Check the finderscope mount.** Check and make sure that the screws holding the finderscope in its mount are lightly finger tight. If any part feels loose, ask your instructor or teaching assistant.
- 5. Adjust the finderscope screws.** Look through the finderscope. You should see your collimation object but it will not be exactly behind the "X" of the crosshairs. Without moving the telescope turn the adjustment screws on the front ring of the finderscope mount and watch which way the crosshairs move. If you have them, do not use the screws on the rear mounting ring. The adjusting screws are always worked in pairs, loosening one, tightening the other, and always keeping the screws lightly finger tight on the finderscope. Select any pair then loosen one screw a half turn while tightening the other a half turn. Evaluate how the crosshairs appeared to move when you turned the screws. Did they get closer to the object? If not, then reverse what you just did and try another pair of screws. Using various pairs of screws you should be able to move the finderscope so that the point where the crosshairs meet is exactly centered on the collimation object.
- 6. Check the collimation.** Check to make sure the object is still centered in the main scope. If it isn't, something moved and you must return to step 3 or earlier depending on how much it was moved. If it is centered, collimation is done for the rest of the evening. You should not touch the finderscope screws again unless your finderscope is bumped out of collimation.

It is significant that there is so much space in this handbook on finderscope collimation. This task should be done perfectly or at least very well in order for your telescope to be fully functional. It is also the most involved technique a beginning astronomer has to learn, and reading about it before trying to do it can be a great benefit. Be familiar with the task by

6. Finding Bright Objects and Using the Telescope

Note: never attempt to use the Celestron telescope or its finderscope to observe the sun. The Celestron telescope has a large light gathering power designed for faint objects and it must be modified with special accessories to convert it to solar use. Ignoring these fact can result in serious permanent eye damage and blindness.

This section details the techniques for using a telescope. It includes focusing the finderscope, using the finderscope to find bright objects, working with the locks and slow-motion controls, focusing the main telescope, and tips on observing.

First check the focus of your finderscope. Some finderscopes are fixed focus, and some allow for focusing by turning a rubberized collar or some other arrangement. Ask your instructor or lab assistant if you are unsure. If your finderscope has a focusing adjustment, then focus the finderscope for your eye using a distant object on the horizon or in the sky.

The major hurdle for the beginning astronomer is finding the object to be observed. Various methods are used to locate sky objects with a telescope, ranging from coarse naked eye sighting along the tube to precise pinpointing by the use of setting circles. Don't expect to find much of interest in the sky by random sweeping. The sky is large compared to the field of view of your telescope and you really must know exactly what you are looking for and how to get there.

There are two methods commonly used to find bright objects and place them in the field of view of the main telescope. Try them

both and use the method that works best for you. The first technique, called the **two eye method**, is fast and easy and does a very good job if you can make it work for you. Grasp the telescope by the tailpiece, loosen the locks on both axes, and point the telescope in the direction of the object you are seeking. Keep the locks undone and look through the telescope with one eye while you keep the other eye on the object—that is keep both eyes open. This way you will see two images superimposed: one image is of the finderscope field of view with the crosshairs and the other is the object in the sky which you are trying to acquire.

Next move the telescope by the tailpiece in such a way that the finderscope crosshairs seen with one eye appears to move toward the object seen with the other eye. As you continue to move the telescope in this fashion the object will suddenly jump into the finderscope field of view after which you should lock both axes so as not to lose the object. Next loosen one axis at a time and move the telescope until the object is close to the "X" of the crosshairs after which the slow-motion controls will allow it to be centered behind the "X." (Note that for changes in declination, the declination slow-motion control is used with the declination lock in the locked position; but for changes in right ascension, the right ascension lock must be partly loosened before the right ascension slow motion knob is turned.) Now your object should be visible in the main telescope.

For those people who have difficulty with the two eye method, the other approach involves sighting along the tube of the main telescope. To begin grasp the telescope by the tailpiece, loosen the locks on both axes,

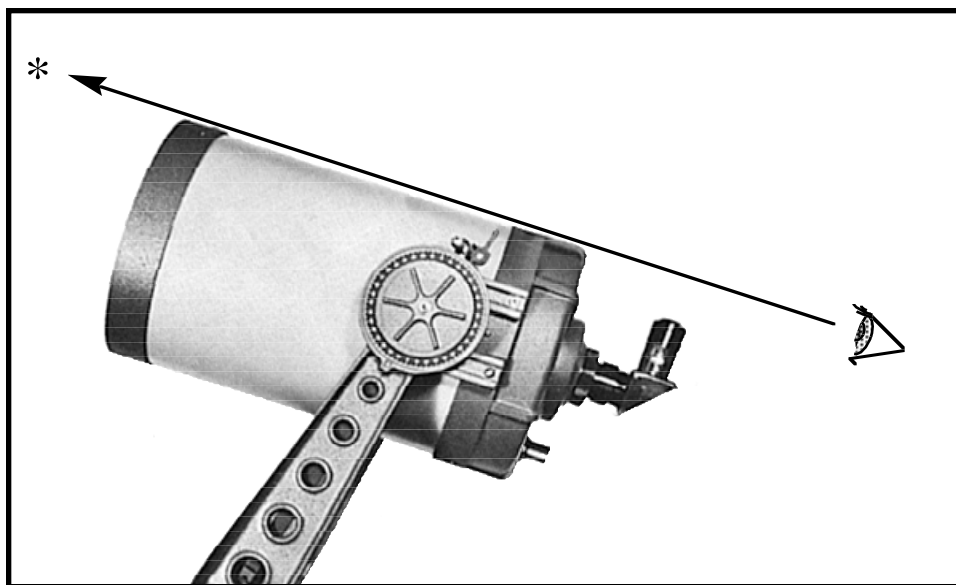


Figure 9 A drawing demonstrating the geometry of sighting a star along the top of the telescope tube. The observer's eye should be as far back as possible and none of the tube should be seen, but both the front and rear rings on the tube should be visible and the star should appear to sit on the front ring.

and point the telescope in the direction of the object you are seeking. Keep the locks undone while you hold the telescope at arms length and sight along the telescope tube in such a way that none of the tube is visible and the object appears to be sitting on the far end of the telescope tube. If done properly the object should be in the field of view of the finderscope after which you can follow the procedure described at the end of the paragraph above to get the object in the main telescope. The geometry of this method is depicted in figure 12.

Once the object is in the main telescope the telescope will have to be focused for each different observer. Each person's eyes are different and these differences can be corrected with the focus adjustment. An observer can view and focus with or without glasses. Never turn the focus knob unless some distinct form of light can be seen in the eyepiece. The verb "focus" means to make sharper, not to make something miraculous appear.

The Celestron telescope design allows for focusing from infinity to as close as about 25 feet. A considerable amount of focus adjustment is required to move the focus from infinity focus as is required in

astronomy to 25 feet as used in nature study. If you are trying to focus the telescope and you are turning the focus adjustment in the clockwise direction, then you are moving the focus in the direction of focusing on very nearby objects. In astronomy all objects are at infinity and theoretically at the same focus adjustment. In practice with groups of observers having different eyesight, a turn or two of focus adjustment, but no more, might be necessary to obtain clear focus. If the person who used the telescope before you ignorantly turned the focus adjustment all the way to close focus hoping to "get something in focus," then an equal amount of adjustment will be required to reverse the mistake. In these situations, it is often wise to get the help your lab instructor who is expert at detecting this problem, unless you are certain of the situation.

Unless someone before you has grossly misadjusted the focus or it has been used inside for some lab exercise, one or two turns of the focus knob should be plenty to bring a distant subject into focus. An image that is far out of focus will look like a big white light or, if the misadjustment is not too bad, a donut of light, the hole actually being a silhouette of the secondary mirror and its support. An out of focus object will get

smaller as the focus improves, with the smallest image being the one that is in the best focus. As you focus watch the image carefully trying to see that position of perfect focus. The better your job at focusing, the more you will be able to see.

Once you have focused on an object, take your time to observe what you see. You should notice that the image may “dance” around due to turbulence in the earth’s atmosphere. (Some dancing can be due to vibrations in the telescope mounting or tube and these can be much reduced by simply placing one finger against the back of the tube and applying a slight steady lateral pressure.) This turbulence is the same phenomenon which causes the stars to twinkle and it affects the observing condition we call seeing which is a measure of how steady the image is. On nights of poor seeing the atmosphere causes the image to look bigger and to dance around more. On nights of good seeing the image is smaller and moves very little; much more detail is visible. But the seeing conditions are not constant and even on a poor night, the atmosphere can be steady for a split second, allowing the carefully observer to glimpse small details such as the Great Red Spot on Jupiter or the polar cap on Mars.

When you look through a telescope

watch for those moments of good seeing. That is when you will see the views that are missed by the careless or impatient observer. These brief moments of good seeing are the reason why an artist with a telescope can make an accurate and more detailed drawing than a photograph can because turbulence makes the image move during the course of the photographic exposure while the artist can freeze in his mind an image of the object during those split seconds of good or excellent seeing that occur even on nights of average or poor observing conditions.

This kind of observing requires practice to develop. The experienced observer with a trained eye can see subtle colors and details that are missed by the observer new to astronomy. Take every opportunity as a beginning observer to extend your vision and look for those subtle features on objects that can be seen with our telescopes. Look for a minute or two—not the five or ten seconds that is typical of most beginners. Also keep your hand on the focus and adjust it slightly each way to be sure to obtain that perfect focus. Remember if there is wind or other sources of vibration to keep one finger on the back of the telescope applying very slight lateral pressure to dampen some of the vibration.