Polar Aligning Your Equatorial Telescope

When a first-time purchaser of an equatorially mounted telescope reports that “the clock drive doesn’t work—nothing stays centered,” the trouble probably lies not in the drive but in the user’s skill at setting up the telescope.

Equatorial mounts with clock drives can provide hands-off tracking of celestial objects. However, for tracking to work as promised, the mount must be aligned to the celestial pole.

**NOTE:** Go To telescopes on fork mounts can be set up to track objects without polar alignment, just an initial alignment on two stars. See p. 326 of *The Backyard Astronomer’s Guide* for advice on this process.

Polar aligning traditional equatorial mounts carries the undeserved reputation for being complex and intimidating. Indeed, for the perfectionist it can be time consuming. But for the vast majority of backyard stargazers, polar alignment need take little more time than what it takes to plunk the telescope mount down with its polar axis aimed in the correct direction.

The time exposure photo at right shows how the mount’s fixed polar axis points north to Polaris. Note that the telescope itself is aimed south, toward a target of interest. As the sky turns around Polaris (as shown by the star trails), the mount turns about its polar axis (as shown by the blurry telescope).

Ah, but how to find Polaris? The Big Dipper’s Pointer Stars aim at Polaris, sitting due north and at an altitude above the horizon equal to your latitude. To polar align a scope you don’t need compasses, GPS receivers, or calculations of magnetic deviation or sidereal time—just aim the polar axis at Polaris. That’s it!

Observers in the Northern Hemisphere have it easy—they have a bright “North Star” to aim at. Polar aligning in the Southern Hemisphere takes more skill as there is no convenient “South Star.”
The Quick Way to Align

Rigorous, time-consuming methods of precise polar alignment are necessary only for advanced astrophotography. For general observing, snapshots of the Moon or wide-angle piggyback exposures, an alignment within one or two degrees of the celestial pole will be adequate. This is accomplished in a few seconds by aiming the polar axis toward Polaris, the North Star, as closely as possible.

Schmidt-Cassegrains can be aimed by peering up one of the fork tines and raising or lowering adjustable tripod legs to achieve approximate alignment. Precise leveling is a waste of time for casual point-and-look viewing. The polar axis of German equatorial mounts can be eyeballed toward Polaris, as shown at left and on the previous page.

More Accurate Methods

For demanding applications, the telescope’s polar axis should be within five arc minutes of the true celestial pole. The north celestial pole is conveniently near Polaris. To be exact, the true pole lies 0.9 degrees from Polaris in the direction of Alkaid, the end star in the handle of the Big Dipper.

For observers in the southern hemisphere, locating the south celestial pole is a little more difficult. It lies one degree from a 5.4-magnitude star in Octans called Sigma Octantis, a barely naked eye star. The finder charts included opposite and on page C7 should help you zero in on the celestial pole, north or south. With charts in hand, the next step is to aim the telescope’s polar axis at the pole.

North Celestial Pole Finder Chart

The Dipper’s Pointer stars aim at Polaris. Then, use this finder chart to help you aim your telescope’s polar axis toward the precise location of the North Celestial Pole. Keep in mind that simply centering Polaris will provide sufficient accuracy for most visual purposes.

Up the Axis

The yellow arrow shoots through the polar axis of this German equatorial mount. This axis needs to be set at an angle equal to your latitude on Earth, then at night aimed due north to Polaris (or due south if you live in the southern hemisphere below the equator).

Aligning a Fork

This SCT is set to 90° declination so the fork arms and main tube both aim to the celestial pole. With the scope set like this, use the wedge’s altitude and azimuth adjustments (or shift the tripod legs) to aim the finderscope, and therefore the main telescope, at the pole. It is important to adjust the finder first so that it indeed does point to exactly the same place in the sky as do the main optics. Note that aligning a Go To fork-mounted scope in this manner is necessary only if you wish to take long-exposure astrophotos.
POLAR-ALIGNING FORK-MOUNTED TELESCOPES

Which one is the polar axis? In fork-mounted telescopes such as Schmidt-Cassegrains, the polar axis is the one around which the forks revolve. The other motion, which swings the tube up and down through the fork arms, is the declination axis. To be polar aligned, the polar axis, and therefore the fork tines, must be aimed at the celestial pole. This requires a “wedge,” usually optional on Go To models.

1. First, adjust the altitude setting on the wedge to an angle equal to your latitude. From a latitude of 40 degrees North, set the angle on the latitude scale to 40 degrees. This can be done at any time, even indoors.

2. At the observing site, place the telescope so that its forks are aimed northward. Roughly level the telescope tripod if you wish, but precise leveling is not necessary.

3. Swing the tube so that it reads 90 degrees declination on the circles on the side of the tube, and lock it there. This should put the tube parallel to the forks. For Go To scopes lacking circles use the software routines in the controller to aim at Polaris.

4. Move the telescope left to right to center the pole in the finderscope (or for rough alignment, centering Polaris will suffice). Do this by moving the whole tripod or by using the fine azimuth adjustments on the wedge. Do not alter the telescope tube’s declination or right ascension.

5. Move the telescope up and down to center the pole in the finderscope. (For this to work the finder must be aligned so it points precisely where the main optics point, an adjustment you can perform in the daytime.) This may mean raising or lowering a tripod leg (it is usually best to have a tripod leg pointing south for this) or using fine altitude adjustments on the wedge. Again, do not move the declination axis.

6. It may be necessary to adjust the azimuth and altitude a few times to refine the aim point. With practice, you’ll find that the process takes only 5 to 10 minutes. To aim at the north celestial pole, move the entire telescope so that the finderscope cross hairs are 0.9 degrees from Polaris along a line toward the end star in the Big Dipper’s handle. If that star is not visible, use a line joining Polaris and Epsilon Cassiopeia, the first star in the distinctive W shape, but still offset toward the Big Dipper’s handle.

Calibrating the Declination Circle

To locate the pole with the finderscope, the declination setting-circle reading must be accurate. In other words, when the telescope is set at 90 degrees declination, the tube must be aimed at the same spot that the polar axis is. Declination circles can slip, so a setting of 90 degrees may not in fact be 90 degrees.

To bring the tube parallel to the polar axis, look into the eyepiece of the main telescope at low power, and watch the stars as you rotate the telescope around the polar axis. Do the stars circle the center of the field? If the telescope is truly set to 90 degrees declination, they will. If not, move the telescope slightly in declination to see whether the situation improves. Keep adjusting the declination until the stars move in concentric circles (they are designed to move), and set it to show 90 degrees. Once centered, the declination circle should not need calibrating like this again.
The main problem with this method is that it can be difficult to find the correct pole location, since it lies in a blank area of sky. Moreover, it is easy to move off the pole star by the required amount but in the wrong direction. In straight-through finderscopes, the sky appears upside down, in right-angle finderscopes, the sky is right side up but flipped left to right. Most finderscopes have a field of view about six degrees wide, which means that when the true celestial pole is in the center, the pole star (Polaris or Sigma Octantis) is about one-third the way from the center to the edge of the field.

ALIGNING GERMAN EQUATORIAL MOUNTS

The finderscope method described above can be applied to all telescopes on German equatorial mounts. The declination axis on such mounts has the telescope on one end and the counterweight on the other. The polar axis—the one the clock drive turns—has the declination axis attached to it and is the part of the mount that must be aimed at the pole.

First, set the angle of the polar axis to your present latitude with the adjustment at the base of the mount—usually a large bolt with a graduated dial showing 0 to 90 degrees. Extra care should be taken, though, because the whole mount can flop down when this bolt is loosened. If the telescope has a graduated dial, set the latitude angle and tighten the bolt. The latitude adjustment should be made only once, when the instrument is purchased, unless the telescope is transported north or south to a new latitude (traveling east or west makes no difference).

If the equatorial mount does not have a graduated circle for a local latitude setting, follow the steps in the next paragraph; otherwise, skip ahead.

Latitude adjustment: At the observing site, place the telescope so that the polar axis aims as close to Polaris as possible using the eyeball method. Adjust the tripod legs to level the base of the mount. (This is one case when you do have to level the mount. Some mounts have bubble levels for this purpose.) Swing the tube in declination so that it is at 90 degrees as read on the declination circle—the circle nearest the tube or the counterweight. The tube is then parallel to the polar axis and is pointed in the same direction. Lock both axes. Carefully loosen the bolt that clamps the tilt of the polar axis, and adjust it until Polaris is seen in the finderscope midway between the top and bottom of the field (not necessarily centered, just midway). Now, tighten the bolt, and that should set the latitude angle. This procedure is necessary only once.

After the latitude adjustment is made and the telescope is leveled, the polar axis will be at the correct angle if it is aimed toward Polaris. On subsequent setups, with the tube at 90 degrees declination, use the fine altitude and azimuth adjustments on the mount to move the telescope left and right and up and down to center the pole area in the finderscope. If your telescope has no fine adjustments, alter the height of the south-pointing tripod leg and nudge the tripod left or right.

Most German equatorial mounts with Go To computers also need to be polar aligned in order to find objects well. This can be done with the old-fashioned method (i.e., sighting up the polar axis). However, software routines can automatically swing the scope to where Polaris should be. You then use the mount’s altitude and azimuth adjustments to center Polaris to polar align.

Polar Alignment Sighting Scopes

Polar-alignment scopes in the polar axis have reticles that show how far to offset from Polaris in order to center on the true celestial pole. (Other marks help in lining up the South Celestial Pole.) This is the pattern in one type of polar scope, but others are similar, with spots for key “guide stars” or at the very least a crosshair to show you the line from the Dipper through Polaris, to the true pole, and on to Cassiopeia. Don’t fuss with dialing in sidereal time—simply rotate the polar scope and adjust the mount until the guide star slots or Dipper-to-Pole line coincides with the real sky. Note that polar scopes convert the image so the true pole appears here to be offset toward Cassiopeia from the pole star.
**More Precise Methods**

Serious astrophotographers require stars to stay within a few arc seconds of their intended spot for an hour or more. This requires high-precision alignment.

### THE SINGLE-STAR METHOD

This technique was described by Dennis DiCiccio in the December 1986 Sky & Telescope. With practice, it takes only 10 minutes. First, follow the steps in the previous section to align the mount with the celestial pole. Then aim the telescope at a bright star near the celestial equator whose right ascension is known, preferably in coordinates for the current year (see the table opposite).

Using the mount’s fine altitude and azimuth adjustments, move it until Polaris is in the center of the field of a medium-power eyepiece. Do not move the declination or right ascension motions. Once Polaris is in the center, unlock the telescope and swing it back to the calibration star. Adjust the right ascension circle again if necessary. Repeat the procedure. Each repetition requires high-precision alignment.

### THE TWO-STAR METHOD

This procedure is more time-consuming but for perfectionists, it is the method of choice. When setting up a permanent site or a backyard observatory, it is also the best way to achieve the final alignment of the mount.

First, use a simpler method to roughly polar-align. Then aim the telescope at a star on the celestial equator due south. If possible, put an illuminated-reticle eyepiece in the telescope, and align the cross hairs so that they run parallel to the lines of right ascension and declination motion. Ensure that the drive is running. Now, watch the star carefully. Ignore any drift it makes east or west in right ascension, but watch for a drift in declination, that is, north or south. It may take a few minutes to show up.

- If the star drifts **north**, the polar axis is aimed too far west (it is to the left of the actual pole in the northern-hemisphere).
- If the star drifts **south**, the polar axis is aimed too far east (to the right of the pole).

Be careful. Make sure you know which way north is in the eyepiece. Move the mount in azimuth in the appropriate direction, then go back to the star, and watch again. Has the drift improved? No drift should appear even after 20 minutes.

Once this stage is satisfactory, point the telescope at another star on the celestial equator, but one that is rising in the east. Observe it for a while, again ignoring any drift it makes east or west in right ascension, but watch for a drift in declination, that is, north or south. It may take a few minutes to show up.

- If the star drifts **north**, the polar axis is aimed too far south (it is above the pole).
- If the star drifts **south**, the polar axis is aimed too low (it is below the pole).

Adjust the altitude of the polar axis accordingly. As long as the initial setup was good, only a small adjustment should be required. Now, go back to the east star, and watch again. The drift should improve. Repeat all the steps. If this is done in the southern hemisphere, substitute **south** everywhere we have said **north**, and vice versa. Clearly, such a tedious procedure is best reserved for permanent setups or for times when only perfection will do.

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**Alignment, Go To Style**

Some computerized Go To telescopes, such as the fork-mounted models, do not require polar alignment to find and track objects. However, they do need to initially aim at two stars, a process also called “alignment.” However, Go To scopes on German equatorial mounts, such as Meade’s LX55 and Celestron’s C9.5 and Advanced Series, do require at least rough alignment of the polar axis to the celestial pole in order to find and track objects accurately. Meade’s Autostar, Celestron’s NexStar, and systems from other manufacturers contain software routines to aid polar alignment that are computerized versions of the “single-star” method described opposite — they automatically aim at where Polaris should be.