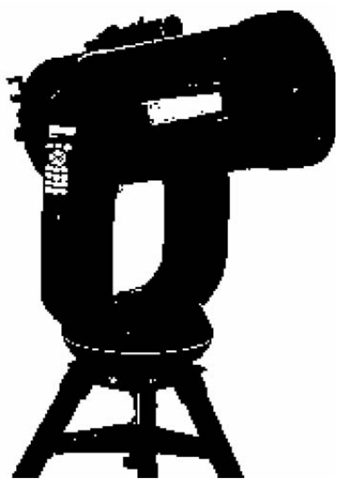
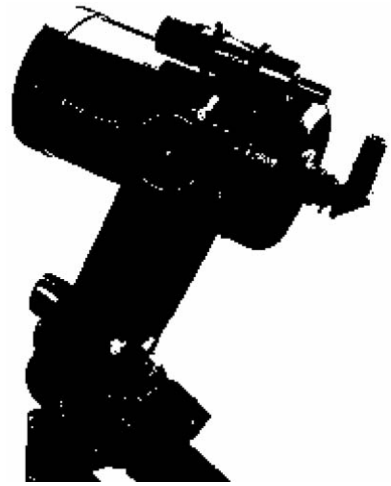
Polar Alignment

Even the most casual observer knows that the Sun and stars move across the sky. These objects appear to move because the Earth rotates on its axis every day. In order for you to observe an object for any length of time, your telescope must track the sky in one way or another.

Many modern computerized telescopes have the option of working in “Alt-Azimuth” mode. This typically works fine for visual use but if you want to do astrophotography or your telescope is not computerized you must use an “equatorial” mount that is polar aligned. Equatorial mounts work by having their polar axis aligned with the Earth's rotational axis and then using a motor drive to turn the telescope to track the stars. If your telescope works in alt-azimuth more, you do not need to read further.



Fork Mount in Alt-Azimuth Mode



Fork Mount in Equatorial Mode

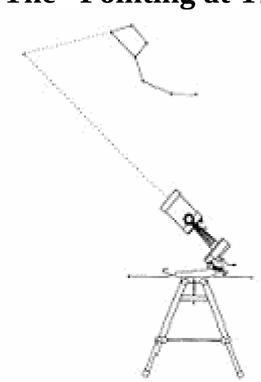
German Equatorial Mount

Most telescope mounts consist of two axes that are perpendicular to each other. With these two axes, your telescope can point practically anywhere. In equatorial mounts, these two axes are called the polar axis and the declination axis.
The first step in polar alignment is to set the latitude angle of the polar axis. The polar axis must be angled from horizontal by the same amount as the latitude of your observing location. If you observe at 35 degrees from the equator that angle is 35 degrees. If you observe at the North Pole, that angle is 90 degrees.
The second step in polar alignment is to point your latitude adjusted polar axis due North. Celestial North not Magnetic North as the magnetic North Pole can be several degrees from true North. In theory, these two steps are all that is needed to track the stars. In practice, the quality of your tracking depends on the quality of your alignment.

The "Pointing at Polaris" Method

If you are only planning on some casual visual observing, set your latitude adjusted telescope down and eyeball the polar axis toward Polaris, the North Star. That will be sufficient for your drive motor to keep an object in a low power eyepiece for ten or fifteen minutes.
If you intend to do any kind of imaging, you will to have a much better alignment done. There are two main methods of refined polar alignment, the "Pointing at True North" method and the "Drift Alignment" method. The first method can be done quickly and provides sufficient accuracy for planetary or short term imaging. The second method can take much longer but is the only method that can achieve perfect polar alignment.

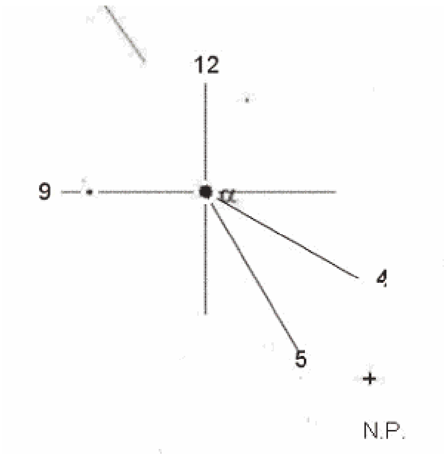
The "Pointing at True North" Method

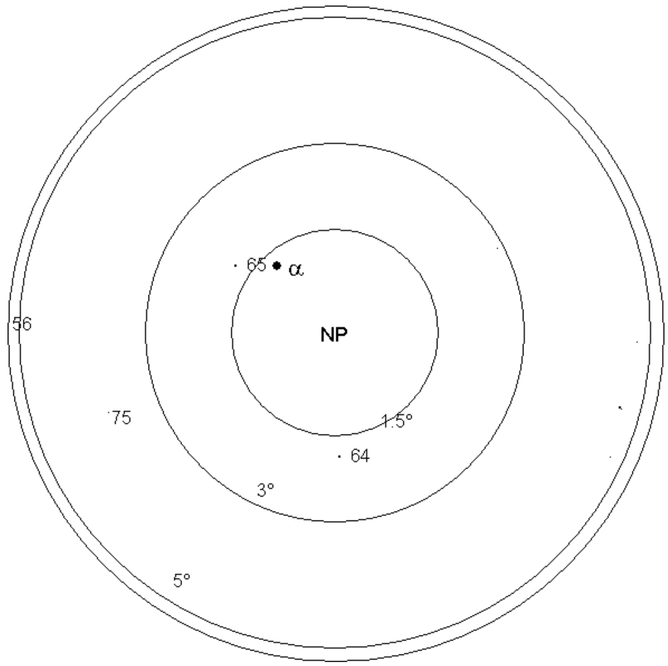


Turn your telescope in declination until it reaches 90 degrees and is looking roughly North. Look through your finder scope and watch the cross hairs as you rotate the telescope on the polar axis. Odds are the cross hairs will make a small arc in the sky. The size of this arc depends on the angle between the optical axis and the polar axis and is a measure of how far your telescope is from that 90-degree angle. The point that the polar axis is pointed at is inside that arc. Adjust the declination of your telescope and try again. If the motion of the cross hairs is worse, you went the wrong way.

If it is better, but motion is still evident then go a little further. At some point, the sky will still rotate as you move the telescope about the polar axis but the cross hairs will remain stationary. At that point, your telescope's finder is parallel to its polar axis. If you can place the cross hairs on the North Celestial Pole, you will be very close. One of the few astronomical advantages of living in the Northern Hemisphere is Polaris. This relatively bright star lies about 1 degree from the North Celestial Pole. Shift your telescope mount until you can see Polaris in your finder. If you look closely, you will see a dimmer star about a half degree from Polaris. In your mind, place a clock face in the sky centered on

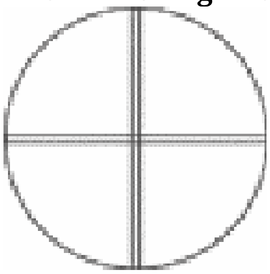
Polaris with this other star at 9 o'clock. With that orientation, the NCP lies at about 4:45 and twice as far from Polaris as the 9 o'clock star. Below you will see two depictions of the scene. The view on the left is centered on Polaris showing this 4:45 orientation. The other is centered on the North Pole with concentric 5°, 3°, and 1.5° circles. The 5° circle is typical of a finder scope. The dimmest stars shown are about magnitude 7.5 also about what a typical finder would show. The labels, such as 75 and 64, represent each star's magnitude. With a little practice, your telescope can be aligned within 5 minutes.





As mentioned before, this method will give you a relatively precise alignment that will be sufficient for planetary imaging or other short exposure imaging (less than a few minutes). How long you can go depends on the accuracy of your alignment because the stars will start to rotate within your image as you take longer exposures.

The "Drift Alignment" Method



This alignment method allows you to point your polar axis as close to true North as you want because you correct the alignment as the telescope tracks objects. The direction and magnitude of the drift is an indication of which direction and how far your telescope is from true North. This method relatively simple and straightforward but can take quite a bit of time to accomplish.

A reticle is required, either a reticle eyepiece or a software reticle used with your camera. The imaging product K3CCDTools provides a reticle that can be used in conjunction with an imaging device for alignment. Version 1 is freeware if you can find it. In either case, the reticle is used to measure the amount of drift. Align the crosshairs with the cardinal points. In my experience, if you try to deduce the directions you will probably make a mistake causing an increase in frustration and a waste in time. To determine the directions, place a star in the field of view close to or at the center. Turn off the mount's tracking and let the star drift due west. Rotate the crosshairs to match the drift. Now you know west and east and need to determine north and south. Use your red flashlight and while watching the reticle, approach the objective from the north or south and see where the light comes from. Now you know the four directions with no room for error.

Two stars are required. Both need to be within 5 degrees of the celestial equator. One needs to be near the eastern horizon and the other near the meridian (that is, due South). First, consider the star near the meridian. Ideally, it should be within ½ hour of the meridian. Center it in the reticle. If the star drifts south, then the polar axis is too far east. If the star drifts north, the polar axis is too far west. Make the adjustments needed to eliminate drift. Once drift has been eliminated, you can move to the second star.
The second star should be 15 to 20 degrees from the eastern horizon. If this star drifts south, the polar axis is too low. If it drifts north, the polar axis is too high. As before, make adjustments to eliminate drift. If you have no suitable star near the eastern horizon, try the western horizon and reverse the instructions. That is, north would mean low and south would mean high. Once these adjustments are made, you may need to repeat the process in iterations until all drift is eliminated. As you get closer, the star will take longer to drift by the same amount. Drift alignment can take quite a bit of effort but it can also align your telescope with the Earth's axis as closely as you desire.

Note: If your mount is resting on a concrete slab and you are using a camera/software approach and you step up the mount (slab) to adjust the star, watch the screen as you do. Your weight can cause a small deviation in the star's position which could mask drift or make you think there was drift when there was none.

Summary

Polar alignment is not difficult or complicated. You should remember that you only need a polar alignment that is as good as you need. You do not need a perfect alignment to look at the Moon from your driveway but you will for a 2-hour image of the Ring Nebula.

Using the methods detailed above, you can achieve an alignment that is as close to perfect as you desire.

This document was developed by Jim Dixon for the Central Arkansas Astronomical Society (www.caasastro.org).