

HOW TO..... SET UP AN EQUATORIAL MOUNT

An equatorial telescope mount differs from the alt-az (altitude - azimuth) mount in that instead of moving in the Earth's horizontal and vertical it moves in the celestial horizontal and vertical and so is inclined to the Earth.



The alt-az is an ideal beginner's mount and is very simple to use. You literally place it where you want to observe from, put the telescope on it, put an eyepiece in the telescope and start observing. It comes in several varieties. It could be a pillar mount where the altitude mechanism is fixed to one side of the telescope, or a tripod where the telescope is usually held in a fork. Or it could be a Dobsonian, known as the Dob. This was developed by the American John Dobson as a very simple home made mount. It consists of a three sided wooden box in which the telescope tube sits in Teflon bearings. The azimuth (horizontal) movement is provided by fixing the box by one pivot point on a base plate.



An alt-az mount is very simple to use and as it moves in the Earth's horizontal and vertical it is easy to move the scope to an object. Its big disadvantage is that unless it is controlled by computer it cannot track a celestial object. This means that as the object is continually drifting across the eyepiece field, you have to keep moving the telescope.

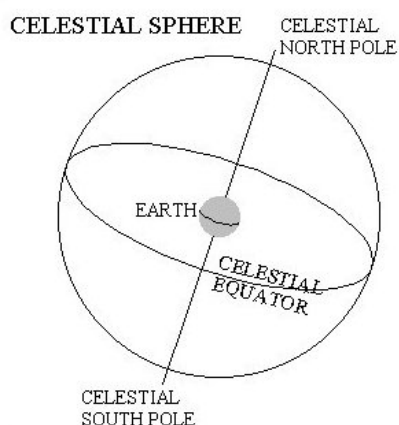


The alt-az mount was out of fashion for a time, but at the time of writing (2006) there are some excellent value for money Dob mounted telescopes on the market.

The equatorial mount makes a telescope far more versatile, especially if it is motor driven, but to most owners its setting up procedure is nothing short of a black art, and instruction manuals translated from the Japanese don't help.

So this is intended to be a user friendly equatorial guide. However, every mount is different, even those that superficially look alike, and you do need to read this in conjunction with your own instruction manual. Although this is written primarily for the UK observer, I have noted where other parts of the world might do things a bit differently.

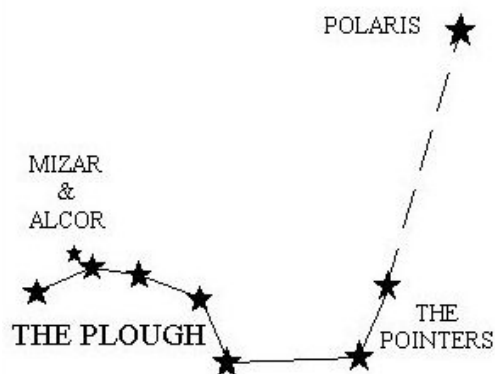
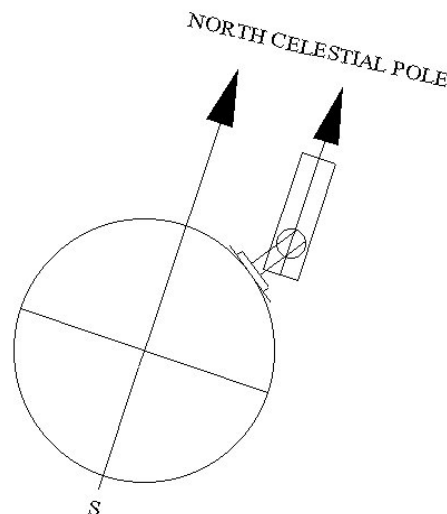
First, let's clear up some terminology that some newcomers to astronomy might find baffling.



Celestial sphere. An imaginary sphere surrounding the Earth. The Earth's axes are projected onto it so that the Earth's poles become the celestial poles, the equator becomes the celestial equator etc.

Azimuth and Altitude. In telescope speak, horizontal and vertical with reference to the ground under your feet. They refer to the way an alt-az mounted telescope moves. When used with reference to an equatorial mount, they refer to the movement of the axes of that mount when setting up, not the way the telescope on it will move.

Declination and Right Ascension. The equivalents in celestial terms are declination and right ascension. They are the projection of latitude and longitude onto the celestial sphere. Just to make them seem more complicated, although declination is referred to in degrees north or south, right ascension is referred to in hours and minutes. This isn't a difficult concept if you think of it in terms of the Earth and twenty four hours equalling three hundred and sixty degrees. One hour of right ascension, therefore, is fifteen degrees, just as on the Earth the time advances or retreats by one hour for every fifteen degrees of longitude. These axes are often abbreviated to RA and dec. The right ascension axis is also referred to as the **polar axis**, since it lies parallel to Earth's north-south axis and points at the Pole Star in the northern hemisphere. Right ascension and declination are particularly useful for identifying the position of stars and other celestial objects because unlike altitude and azimuth they are not dependant on the observer's position on the Earth or the time. 30° of azimuth is in the same place at any time of the night or day, but the stars lying on it will change. A star which has a right ascension of 0 hr will always have a right ascension of 0 hr, but will move throughout the night and from night to night.



Polaris. The Pole Star, virtually on the northern celestial pole. Polaris is one of the easiest stars to find. Look north for the Plough, or Dipper as it's sometimes known. The Plough's 'Pointers' don't point exactly at Polaris, but near enough. The distance from the nearest 'pointer' is about the same as the length of the Plough. Don't be confused by the end star of Draco, which is closer and less bright. The Plough is not a constellation in its own right but the brightest part of Ursa Major, the Great

Bear. The Plough is circumpolar from Britain, which means it is visible all year and swings round in a circle as if it was tied to Polaris by a piece of string, but it is not always the same way up, so expect to see it left of north, right of north, on one end or the other, low in the sky and the 'right way up' or high in the sky and upside down, depending on the time of year. Polaris is the brightest star in Ursa Minor, the Little Bear, which looks a bit like a smaller, less bright, reversed image of the Plough.

From further south than the UK, the Plough may not be circumpolar and so may not be visible all year round. Southern hemisphere observers, obviously, do not align their telescopes with the north celestial pole. There is no equivalent of Polaris at the south pole. Instructions with some mounts do include a section on how to set up to the south celestial pole.

Meridian. A line drawn from north to south celestial poles through a point directly over your head. Celestial objects reach their highest point on the meridian. When an object reaches its highest point it is said to **culminate**. If your mount is the type with a counterweight on a long arm, objects near culmination are best avoided except for a quick look since you will need to move the telescope from one side of the mount to the other either side of culmination.

Equator. In this context the celestial equator, which is inclined to the horizontal. In the UK it is highest to the south and below the horizon to the north.

Setting circles. Graduated rings on both axes of the mount. They can help with setting up and enable you to get close to an object by knowing its RA and dec. RA and dec can be found in star atlases like Norton's and any planetarium type computer software, for example SkyMap.

Why 'set up' the mount?

How accurately you set up an equatorial mount depends on what you want to use it for. If you are merely visually observing and don't mind correcting the direction the telescope is pointing in both directions, you can be fairly rough and ready. If you are making a long observation, particularly if the mount is driven - you might be showing something to friends or doing some photography - you'll need to take a bit more time and do things more precisely. If the tracking is good you should then only need to move or drive the scope in RA. Photography will need the most careful setting up, or you will find that tracking your object is impossible and the stars will be trails or wiggles.

There are several ways in which you might move your telescope to track a celestial object. A basic mount will have knobs to twiddle. Rather than keep twiddling those knobs to keep what you are looking at centred, you may find it easier to move the telescope so that the object is just off the side of the eyepiece then leave everything alone while you watch it drift across. There will be no movement in the scope to degrade the image. This is also by far the easiest way to use an alt-az mounted scope.

If you have motor drive, it might be on one or both axes. If it is only on one it will be on the RA or polar axis, since this is the one which actually tracks the movement of objects across the sky. If you use the telescope for prime focus photography you should have drives on both axes. For piggyback photography you only need to drive on the RA axis, but your setting up should be as precise as you can achieve.

The principle behind setting up an equatorial mount is to align the right ascension or polar axis so that it moves the telescope across the sky on the same track as the stars and other celestial objects. By finding the object you wish to observe you have set the correct declination, and the telescope will only need to move in RA while you observe it. This is why, if you have a mount which is only driven on one axis, it will be the RA axis. For prime focus photography, that is using the telescope as a very large camera lens, the drive motors will probably not be accurate enough, hence the need to correct, and therefore drive, both axes.

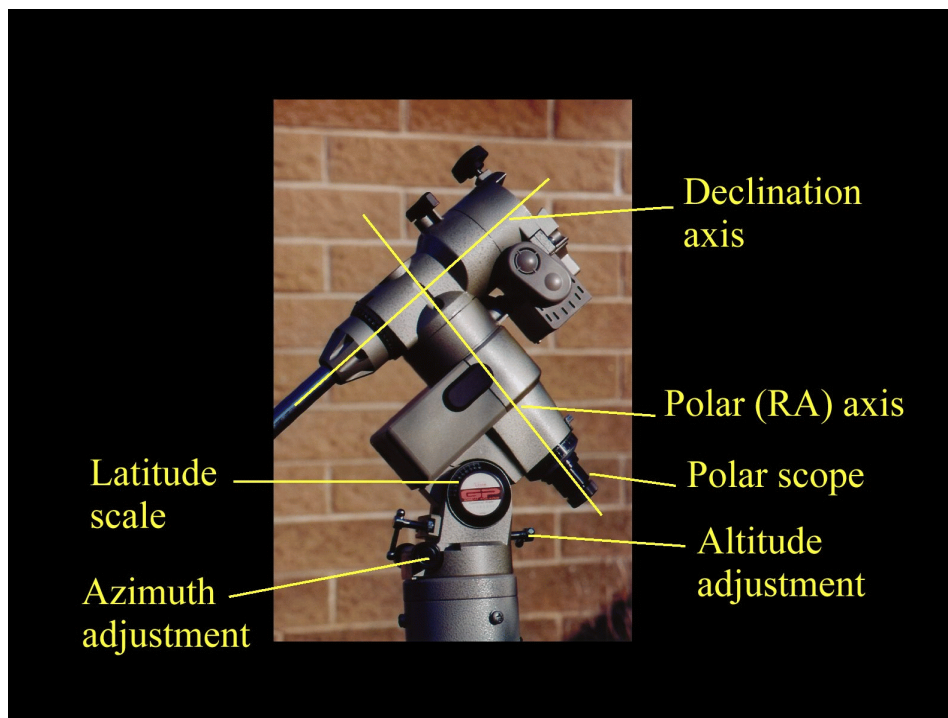
The photos that appear in this article are mainly of the Vixen GP mount. Although your mount may look different the principles of setting up are the same. First you set up roughly (Step One), and this may be as far as you choose to go. Everything after that has the effect of refining that rough alignment and making the tracking more accurate.

The Vixen mount is probably one of the easiest equatorial mounts to set up, because it has all sorts of features designed to make it easy. It has a spirit level, a latitude scale, a polar alignment scope built into the RA axis and it has provision to set your observing date and time, all of which make it possible to do all the alignment just by looking at Polaris. It is also one of the most expensive mounts. Your mount may have all or just some of these features.

An equatorial mount with dedicated computer control should make use of the computer to make the adjustments which here are done manually. The principle will be the same but the method may be totally different. Refer to your own instructions.

Before you do anything else....

First set the mount on a level surface. Don't expect good tracking if you set up on a rough surface, for example your lawn or a field. Don't set up on a slope - once you have the weight of the scope on the mount and start moving it, it could overbalance and do a lot of expensive damage. To set up accurately you need to be able to see the Pole Star and possibly several others as well - to do a rough set up you may or may not need to, depending on your mount. Read your own manual. Make sure that you can see everything you want to see from where you are, bearing in mind that the scope will be looking from a lower elevation than your standing eyes. Get down to its level and check that the view of what you want to look at is unobstructed by trees and the like, and that it will remain so for a reasonable time. Remember that everything will move with time. Stars in the south describe an arc from left to right. Those to the west or east also move to the right, but those to the west head towards the horizon while those to the east get higher. To the north the stars swing in an anticlockwise circle around Polaris. If you're only doing a rough set up you can pick up the scope and move it, but you'll still have to align the RA (polar) axis with north every time, so it's better if you don't move it unless you really have to.

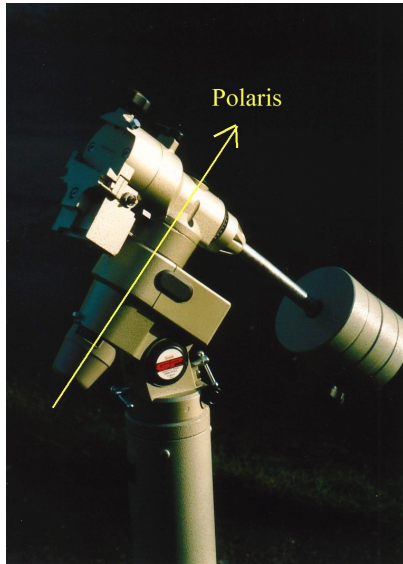


Step One - the rough alignment

First level the mount if you can. If you align by using the latitude scale alone the mount must be level, otherwise 0° latitude is unlikely to be 0° and the 51° of the southern UK could be anywhere. There may be a spirit level built into the mount and should be a means of adjusting the tripod legs or pillar feet.

Assuming your mount has a latitude scale, you will need to know the latitude of your observing location. Use the altitude adjustment screw(s) to adjust the axis such that the scale indicates your latitude. This places the polar axis at approximately the right altitude to find

the Pole Star. You can do it before you leave home and unless you take the mount somewhere with a different latitude you shouldn't have to do it again. The photo on page above shows the adjustment screws and knobs for the GP mount. Point the RA or polar axis towards the north. You will find that using a compass makes it easier, but don't hold the compass too close to the mount as it may deflect the needle. If you have already set the latitude, you have finished the rough setup. If you haven't, or if your mount is not level, then you need to point the polar axis at Polaris.



Step Two - The Polaris point

The Vixen mount has a polar scope fitted in the RA axis. You may not have one, but you may still have provision, ie a hole, for one. If your mount is so equipped you may need to turn the declination axis so that the hole is unobstructed. Now look through the scope or the hole and use the altitude and azimuth adjusting screws to put Polaris in the centre. Not all mounts have azimuth adjustment and you might have to move the whole mount.

If you don't have a means of looking through the polar axis you must use the telescope. With the polar axis pointed towards north move the telescope so that it is parallel to the polar axis and lock it in that position. In this position the declination setting circle should read 90° , since the Pole Star is on (actually very near to) the celestial north pole,

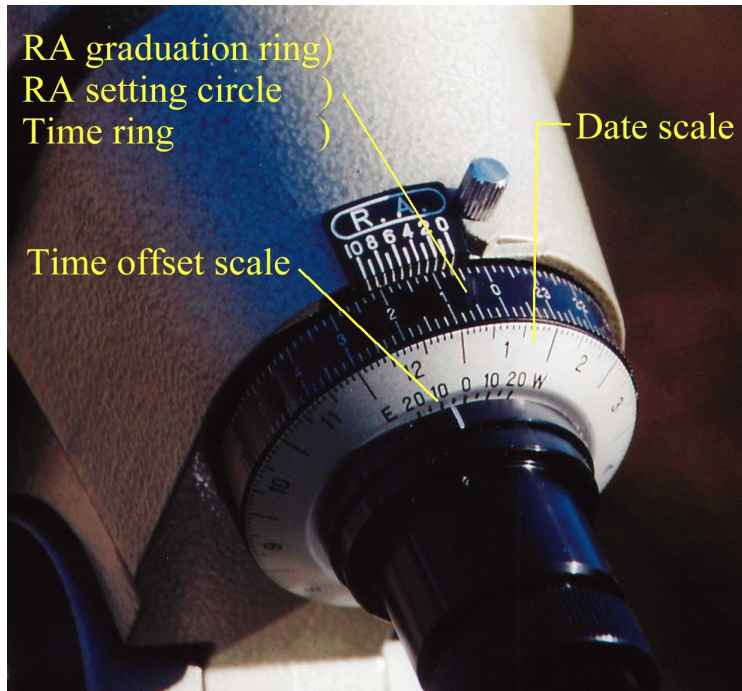
declination 90° north. Again adjust the mount in altitude and azimuth, this time to put Polaris in the centre of the eyepiece, but without moving the telescope. If you don't have adjustment in azimuth you will have to shift the whole mount slightly.

This may be as far as you want to go. If so, start observing.

If the tracking is too far out, you are making a long visual observation and you don't want the object you are observing to drift, or if you are using the telescope for photography, you will need to refine the alignment further. There are several methods of doing this. Your type of mount will determine which you can use, or you may wish to use both if alignment is critical.

Step Three - If you have a polar scope....

If you have a mount with a polar scope and time and date rings, the first thing to do, if you have not already done so, is to level the mount and ensure that Polaris is visible in the polar scope.



Next you need to align the polar axis scope to the correct date and time, since Polaris is not perfectly on the north celestial pole and its position does shift slightly. On the back end of the polar axis you should find adjusting rings for date and time. Some of them may normally be capped under the polar scope cover. Use this in conjunction with your own mount's instructions. On my mount you have to loosen a grub screw while you make some of the adjustments then tighten it again while you complete the setting up. If you need to do this, this is the point where you loosen it. My instructions say 'find the difference between your longitude

and the standard time meridian for your zone and set this on the time meridian offset scale'. What this means in the UK is that you set your longitude, east or west of the indicator for east or west of Greenwich. In other parts of the world there may be a local meridian. Next set zero on the RA graduation ring (RA setting circle) to the RA indicator, which in the case of my mount is a cast pointer which the grub screw is set into, and not overly obvious. Now tighten the grub screw. This locks one of the rings so you can move one against the other.

Next you need to turn the polar (RA) axis of the scope to set the date and time at which you are observing. One of the rings will be marked from zero to twelve (months). On my mount this shares the same ring as the scale for the longitude adjustment you made earlier. This is the date ring and you have to work out your observing date as a fraction of a month. The setting circle, which again you used earlier, is graduated from zero to 24 hours and now represents the time in Universal Time (UT) or GMT for UK observers. Like the longitude adjustment, in other parts of the world this may be set to a local datum. Turn the RA axis round so that your observing date and time are set against each other. The image above shows roughly 0100 for the beginning of January.

And that was the easy bit.....! All that was done to set the polar axis to the position of Polaris at the correct time and date, but none of it will have been perfect, so

You may have an illuminator to make the markings in the polar scope easier to see in the dark. If you have, then turn it on, and if it's not built into the mount fit it to the scope. If you don't have one you may need a helper with a red torch.

Go back to the polar scope altitude and azimuth adjusting screws and while looking through the polar scope make adjustments to bring Polaris into the correct position. This will probably be a circle. You may need to focus the scope first. To be really precise you may need to make an additional correction for the fact that the stars do shift their positions relative to Earth slightly over time. A brand new telescope shouldn't need this adjustment. One that's more than a few years old may have run out of marked adjustment and you may have to estimate it.

Step Four - Or if you don't....

If you don't have a polar scope you will need to use the 'drift' method of alignment. This should anyway be more accurate than the Polaris method of alignment since Polaris is not perfectly on the celestial pole, and if alignment is really critical you may need to use both. First you need to equip your telescope with the highest magnification eyepiece you possess. Ideally it should have cross hairs in it, and if your alignment really is crucial you should acquire one, but for general work it should not be necessary.

Next you need to find a star which is ideally close to the meridian and the celestial equator. In the UK this means that the star will lie to the south, since the celestial equator is below the horizon to the north. The equator (0° declination) is about 40° in altitude to the south from the UK. You can use software to find a star, but bear in mind that you will need to set the time at which you will be observing.

Centre the star in your eyepiece then move the telescope slightly in declination in the direction of Polaris. Watch which way your star moves. The direction in which it moves indicates south in the field of view. Now recentre the star and lock the declination axis so the telescope can only move in right ascension. If the mount is driven in RA engage it. If it isn't then you can either use the manual controls to follow it (in RA alone) or leave everything alone for a few minutes then move the telescope in RA to find it again. After a few minutes centre the star in RA and see if it has moved from the centre in declination. If it hasn't, move to the next star (below). If it has, then remembering the direction you established as south - if the star has drifted south the polar axis is east of the celestial pole and needs to move west. If the star has drifted north, it's the other way round. Adjust the azimuth of the polar axis to correct it. Obviously this is easier if your mount has azimuth adjustment on the axis, which not all have. Go through the procedure again until the star can be tracked for several minutes with no drift.

Next you need a star either to the east or west, and again ideally close to the celestial equator, but this means virtually on the horizon, so pick one no more than 40° up and preferably lower. Assuming you have a star to the east, establish south as before, and follow the same procedure of tracking or moving in RA only. Now if the star has drifted south the polar axis is too low, north and it's too high. Correct in altitude this time, for which the mount will have adjustment. If you have chosen a star to the west, everything is reversed. Again you may need to adjust the mount several times.

Using stars in these positions produces the maximum errors, and as ever the amount of drift you can tolerate, and therefore the amount of effort you put into correcting it, depends on how you intend to use the telescope.

Other things to know

The way in which an equatorial mounted telescope moves can be a bit of a mystery, especially when moving to 'the other side of the mount'. Many equatorial mounts use a counterweight to balance the scope. This type is called a German mount. The Vixen GP mount used to illustrate this article is a German mount. Never allow the arm the counterweight is on to rise above the horizontal. If, when you point the telescope at an object, it does, you need to move to the other side of the mount. You will need to do this if the object you are looking at culminates, ie crosses the meridian. First tumble the telescope tube, ie turn it head over bum. Now it's pointing 180 degrees in the wrong direction. Swivel it back round on the mount and all should be well with the counterweight. Until you walk into it, of course. Fork or horseshoe mounted telescopes, where the scope is mounted centrally, don't have counterweights. If you have a catadioptric, or short tube, telescope, it may well be on a horseshoe mount. They don't have the same problem with culmination, but you may find that at times the eyepiece gets in a position where it is awkward to use.

If your polar alignment is good and the image still drifts in the eyepiece, there could be several reasons.

★ If the mount is driven and the motors are powered off batteries:
The batteries could be going flat, or they could be suffering from the cold. Batteries don't like cold, frosty, starlit nights. Take power from a vehicle or mains supply if you can.

★ The telescope might not be balanced correctly.
Move the telescope tube so that it is to one side of the mount then loosen all the clamps, but keep a hand under the telescope tube so it can't swing and be damaged. Watch to see if the telescope tube rises or falls on the mount, or about its own axis. If it tilts about the mount, adjust the position of the counterweight, which will be on the arm on a German mount and on the telescope on a fork mount. If it swivels around its own axis and is the type of tube mounted in ring clamps, adjust the position of the tube in its clamps. If not there should again be an adjustment on the telescope. You'll need to make adjustments for adding weight to the telescope, or removing it, for example fitting a different finder scope or using a camera.



Probably not many people use setting circles these days. If your telescope has the benefit of computer guidance you definitely don't need them. If it hasn't, even if you find objects by star hopping, they might prove useful and save time. You need the right ascension and declination of the object you want to find. This could come from a star atlas (be sure you're using the correct epoch - the current one is 2000) or a computer database. Position the telescope such that those positions are shown on the RA and declination setting circles and in theory your desired object should be in the eyepiece. In practice it's unlikely, but it shouldn't be too far away.