How to Construct an Astrolabe, Using Your PC

by Christine Craig

But considere wel, that I ne usurpe nat to have founde this werk of my labour or of myn engin. I nam but a lewd compilatour of the labour of olde Astrologiens, and have hit translated in myn English only for thy doctrine; & with this swerd shal I sleen envye.

—Chaucer, *Treatise on the Astrolabe* ca. 1391

Figure 1
PTOLEMY WITH AN ARMILLARY SPHERE
This painting of Ptolemy with a armillary sphere model is by Joos van Ghent and Pedro Berruguete, ca. 1476.

Introduction to the Astrolabe

There is a tale, both apocryphal and scatological, that Claudius Ptolemy, the Alexandrian astronomer (ca. 90 A.D.-168 A.D.) whose ideas dominated astronomical thought for well over a millennium (Figure 1), got the idea for the planispheric astrolabe while riding a donkey. The armillary sphere he was carrying fell and was flattened by the donkey's hoof into a pile of fresh donkey dung. Upon inspecting the resulting impression, a candle ignited in his mind, leading to the creation of an astronomical instrument so useful, that it outlasted Ptolemaic astronomy itself.

Because the first preserved astrolabes are made of brass and dated since the time of Muhammad, and the first known treatise on the astrolabe was written well before Muhammad, it is unknown when and where the astrolabe was born—surely not full-grown and fully adorned, like Athena from the head of Zeus. Early astrolabes probably long predated the technology for accurately rendering the requisite lines and arcs onto brass. Paper, cloth, and wood were more likely the media for the first astrolabes.

The Muslims attribute the astrolabe to the Greeks, and certainly Greek geometry informed its development. As Greeks moved East, conquering and occupying areas such as Bactria, and areas in India during and after the reign of Alexander the Great, they took Greek culture and technology with them, and they maintained contact with the Mediterranean Greeks.

However, when the Romans conquered the Greeks during the Third Punic War, it seems as if a semi-permeable membrane were applied between the Eastern Greek areas such as Bactria, and the Roman strongholds to the West. Much Greek science, especially new developments, could not penetrate back into that area, but flowed freely into parts of India and much of Asia Minor and North Africa.

These new developments, as well as older knowledge destroyed in the West, became the heritage of the people who would fall under the influence of the Muslims. Whether because of Roman indifference or Greek reluctance, such discoveries as the planispheric astrolabe never penetrated back into the Roman Empire in the West, but had to await the Muslim conquest of Spain a thousand years later to be re-introduced into Europe.

Figure 2
PLANISPHERIC ASTROLABE
A planispheric astrolabe of Persian origin, ca. 1590, on display at the Putnam Gallery in the Harvard University Science Center.

During that millennium, the astrolabe and countless other treasures of Greek culture exclusively enriched the East. It was there that the planispheric astrolabe reached its maturity as an astronomical instrument (Figure 2).

An Analog Computer

The planispheric astrolabe is a two-dimensional analog computer for solving problems related to celestial movements: time, the seasons, and star positions. It is also an observing instrument; the back of the astrolabe is set up, among other things, to measure altitudes of stars and planets, including the daytime Sun. The astrolabe packs a lot of information into a very small space—even more than an adventurer's

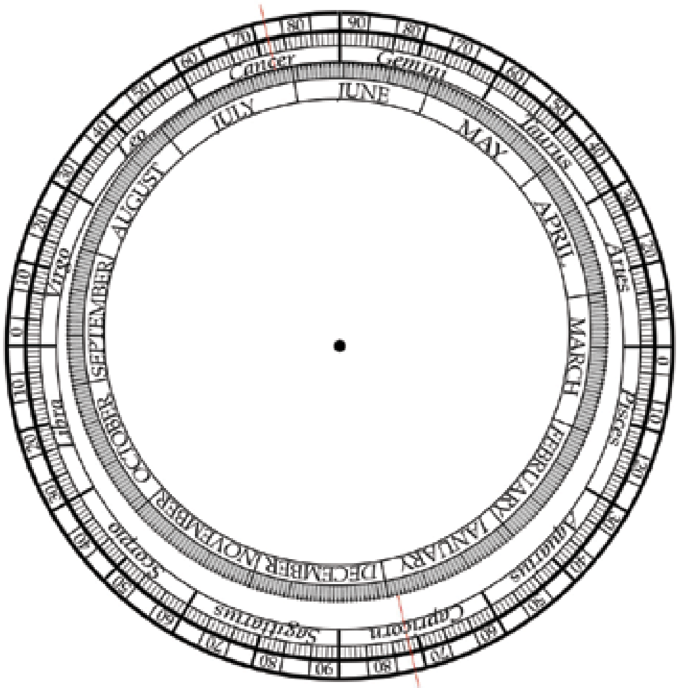

Figure 3
ASTROLABE MATER (BACK)

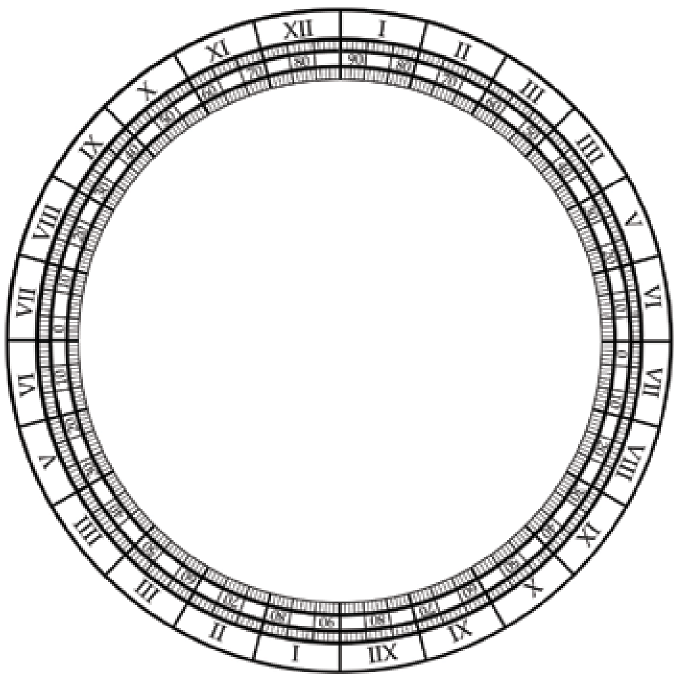

Figure 4
ASTROLABE MATER (FRONT)

wristwatch (although at least one manufacturer—Ulysse-Nardin—made a wristwatch in the 1980s that was a functional, automated astrolabe. You can buy one for only $27,500 online).

The planispheric astrolabe is really just a stereographic projection of all objects of interest on the Celestial Sphere (one like Ptolemy's armillary sphere, complete with ecliptic and useful stars) to a plane coincident with the Equator of the Celestial Sphere. (However, a glance at the work on the astrolabe of the 9th Century Persian astronomer al Farghani shows his plane tangent to the North Pole of the Celestial Sphere). The Equator of the Earth is understood to be coincident with that plane as well. The origin point for the projection is the South Pole of the Celestial Sphere, a convention convenient for those residing north of the Equator on Earth.

The stereographic projection was discovered by the ancient Greeks, and is usually attributed to Hipparchus (ca. 190 B.C.-120 B.C.), although Apollonius of Perga (ca. 262 B.C.-190 B.C.) could well have developed it. It is a useful way to map the heavens onto a flat surface while preserving both circles and angles between objects, as measured on the three-dimensional sphere.

The astrolabe is made up of several moving parts securely attached to the *mater,* which holds and protects the other parts, and also contains essential degree and time or other scales on the outer race or limb of both the front and back.

The back of the astrolabe mater contains degree, calendar, and zodiacal scales (Figure 3). Astrolabe makers often added many useful tables for solving astronomical, time, and trigonometric problems. The back also contains a movable pointer, the *alidade,* attached to the center, with sights for observing a celestial object to find its altitude.

To do this, one would hang the astrolabe on the thumb with the arm held above the eye. Ancient astrolabes contained rings attached to a top piece called the throne for hanging the device on the thumb. The altitude of the object in view could then be read from a scale along the limb of the back.

The front of the astrolabe mater (Figure 4) contains the limb with scales in degrees and hours, and a central circular cavity capable of holding several climate plates, overlain with a movable *rete* (pro-

Figure 5
AN ASTROLABE DISASSEMBLED
An 18th Century astrolabe from North Africa, showing its various parts. The axle and linchpin device are in the foreground.

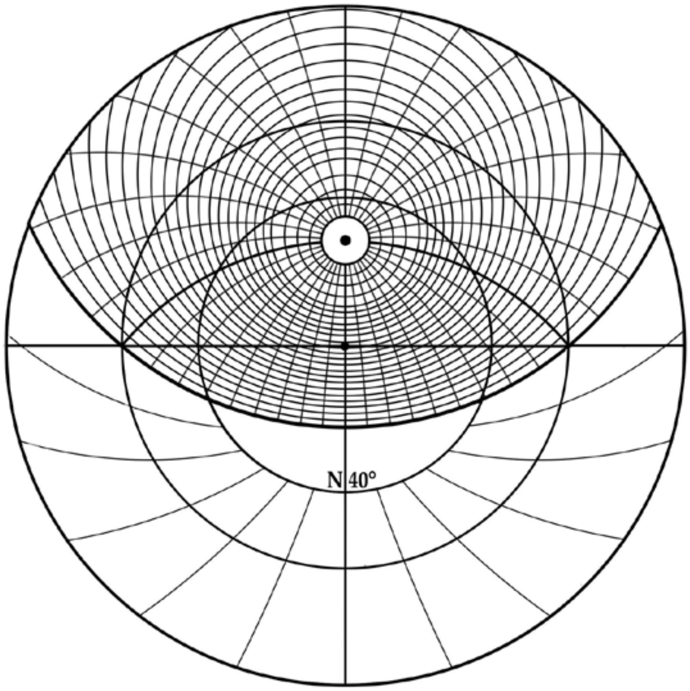

Figure 6
CLIMATE PLATE

nounced reetee), the ecliptic circle with useful stars located on it. Finally, there is a movable graduated pointer called a *rule,* for reading off declinations from the plate, or degrees or hours from the limb.

The whole device is held together with an axle and linchpin device (Figure 5).

Existing ancient astrolabes were made from durable engraved brass, but it stands to reason that most astrolabes were drawn on paper, wood, or similar materials, which were cheaper and more readily available. Unfortunately, those instruments did not survive the ravages of time and human events.

Your instrument will suffer the same fate, unless you plan to engrave or etch your astrolabe markings into brass. But luckily for you, you can preserve the templates for your astrolabe on your computer to be reprinted onto cardstock in the future, in case of the tragic demise of your present astrolabe.

Why Build an Astrolabe?

Almost everyone seems to have a PC these days, with Microsoft Office on it. Mostly it is used for e-mail and simple document production, and the expensive software just goes to waste. Constructing our astrolabe will push the limits of one of the applications of Microsoft Office that few people take seriously: PowerPoint. PowerPoint might just be the per-

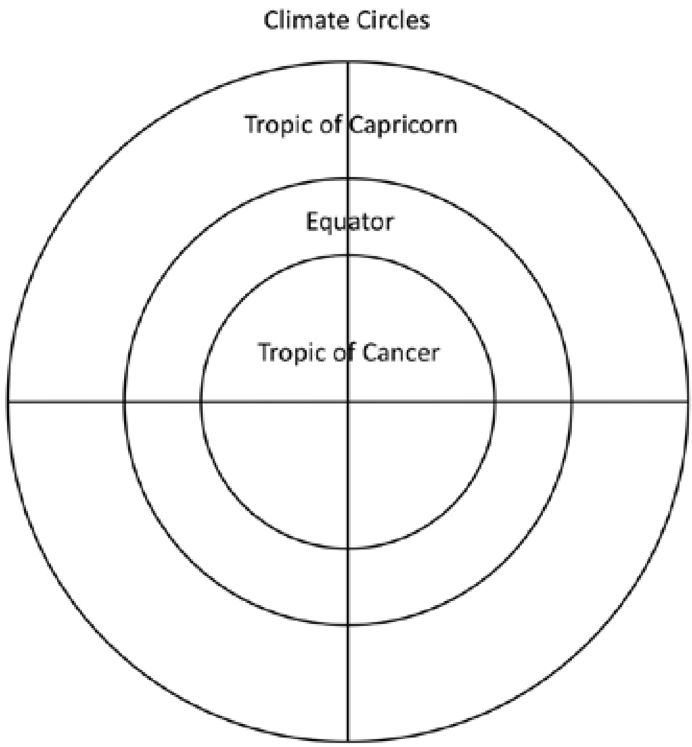

Figure 7
CLIMATE CIRCLES

fect vehicle to introduce people to the power and beauty of an ancient astronomical instrument with relevance even today: the planispheric astrolabe.

Using PowerPoint to construct an astrolabe is as close to constructing the astrolabe with straightedge, compass, and protractor as you can get on a computer. If you can do it with PowerPoint, you can do it on cardstock.

But PowerPoint has many advantages over pencil and paper in adjustability, erasability, and transferability of lines and circles. Further, the whole process, from beginning to end, can be saved on slides to illustrate your progress for posterity.

My aim is to convince people to learn more about astronomy and its history by constructing an astronomical instrument so useful that it may have predated, and certainly outlasted, the Ptolemaic astronomical system. Because the subject is a large one, this article will focus mainly on the construction of one important part of the astrolabe: the *climate plate*.

Elements of the Climate Plate

The heart of the mater is the climate, or latitude plate, which, as its names imply, is different for different latitudes of the Earth (Figure 6). The climate plate is a latitude-specific circular slide rule for calculating solutions to problems dealing with time, season, the Sun, the fixed stars, and even the planets and the Moon, given an ephemeris to locate the planets upon the plate for the time and date of interest.

The other parts of the astrolabe can be used anywhere, but the climate plate must be constructed specifically for the latitude of the observer. In the time of Claudius Ptolemy, the Earth was divided into Climates based on maximum hours of sunlight/darkness, with the Equator being XII, and the North Pole being XXIV. Six or seven climate plates would serve for the known Northern World of Ptolemy.

Nowadays, we measure Earth's latitude by degrees, with the Equator being 0 degrees, and the North Pole being 90 degrees. A reasonable compromise between accuracy and expediency would be a latitude plate for each 5 degrees of latitude where one expected to use the plate.

The climate plate is made up of several types of circles and arcs, which are necessary for its functionality as a measuring instrument. The three main types are the *climate circles,* the *almucantars,* and the *azimuth arcs*.

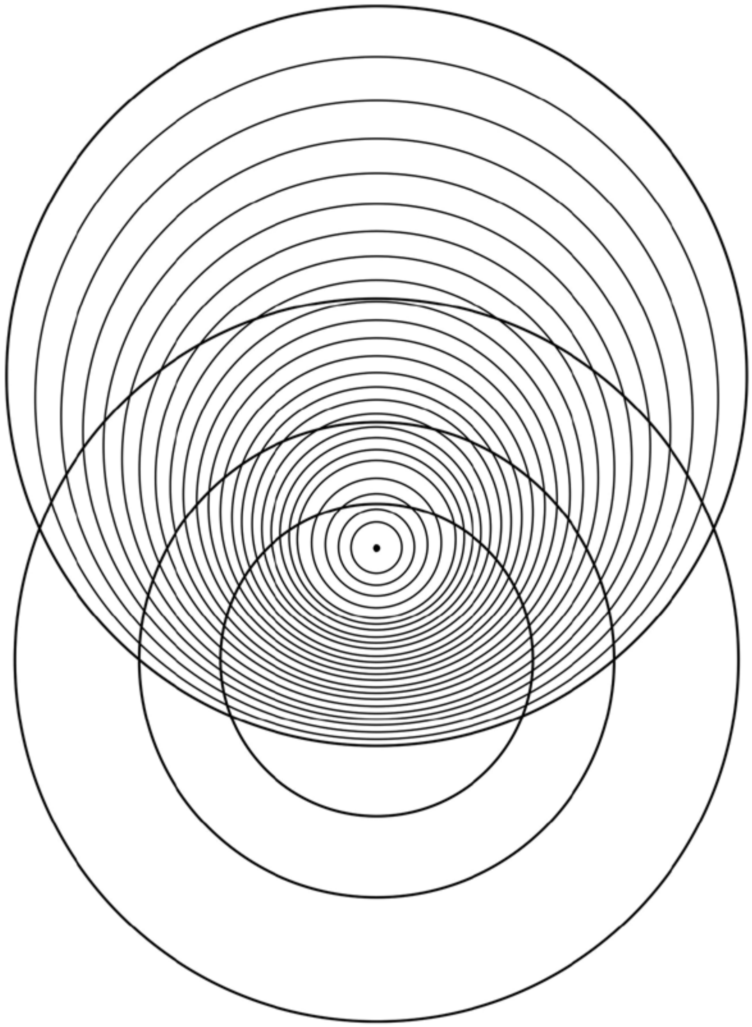

Figure 8
ALMUCANTARS

The climate circles (Figure 7) are circles representing the Tropic of Capricorn, the Equator, and the Tropic of Cancer, as viewed by stereographic projection from the South Celestial Pole. The Tropic of Capricorn is the largest circle, while the Tropic of Cancer is the smallest one. The North Pole would be represented by a point in the center of the three concentric circles.

The almucantars (Figure 8) are a series of nested but non-concentric circles radiating outward from the Zenith (a point at 90 degrees from the Horizon). They represent the altitude, in degrees, of objects of interest above the Horizon, which is the largest circle, at 0 degrees. The larger almucantar circles are cut off by the outer edge of the climate plate—the Tropic of Capricorn circle.

The North Pole is a hole at the center of the plate where the climate plate is attached to the mater, and would correspond to the latitude of your location on Earth.

The third major curves on the climate plate are called azimuth circles (Figure 9), although they are truncated into arcs by the edge of the plate. These arcs, intersecting at the Zenith, represent divisions of the climate plate into degree-segments from East through South through West, and back to East, with East and West designated as 0 degrees, and South and North designated as 90 degrees (this varied among astrolabe makers).

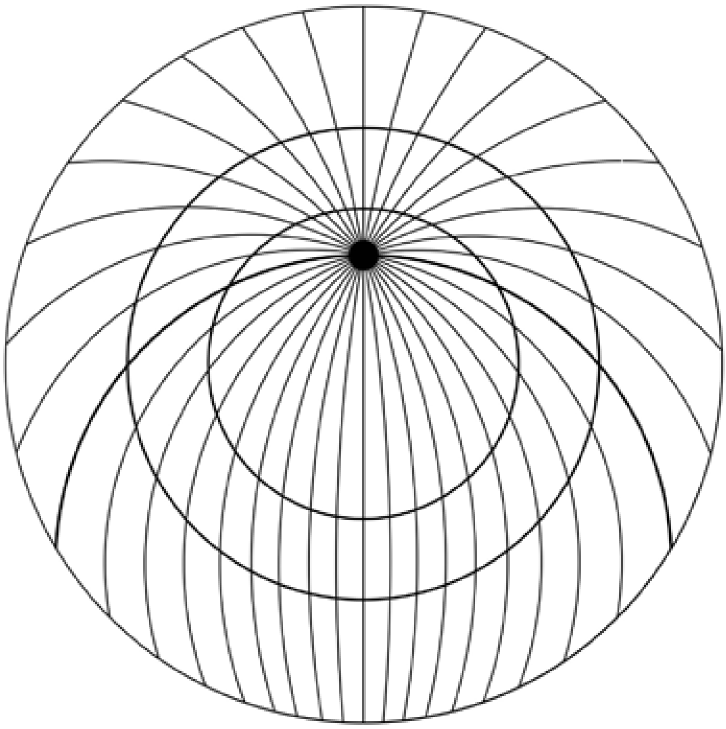

Figure 9
AZIMUTHS

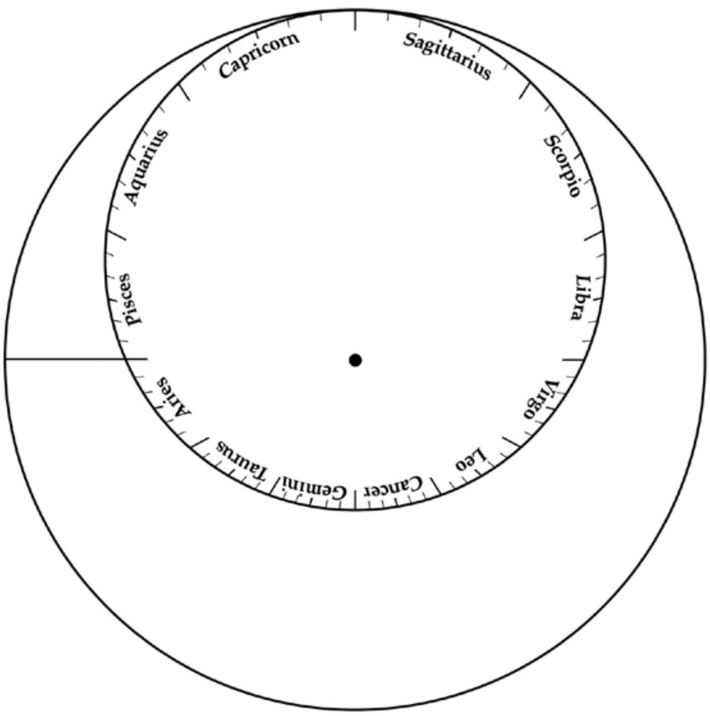

Figure 10
RETE

Building the Climate Plate

We shall now focus on constructing such a plate for 40 degrees North Latitude. Such a plate would be usable throughout a wide swath of the United States, including many of the largest cities, from San Francisco to the Oregon border, St. Louis up to Detroit, and Washington, D.C., up to Boston.

The first step in constructing the climate plate is to determine the size of the Equator circle, for that will determine the overall size of the plate. The radius of this circle will be used in calculating the sizes of the Tropic of Cancer radius and the Tropic of Capricorn radius. The limb of the mater, with its markings, must lie outside the Tropic of Capricorn circle. The Ecliptic circle of the rete will cycle eccentrically between the Tropics of Cancer and Capricorn circles in its diurnal and seasonal motions (Figure 10).

We will choose the radius of the Equator to be 2 inches for our purposes, giving us an overall dimension for the astrolabe of less than 7.5 inches.

Next we must draw this circle on a blank PowerPoint slide by selecting the **circle object,** clicking it onto the slide, and right-clicking on it to bring up the menu to **Format Shape.** Choose size as 4 (diameter), after checking the **Lock** aspect ratio box. Choose the **Fill** as clear. **No Shadow. Line color** and **thickness** of your choice. **Center** the circle in the center of the slide. Select a **line object** from the **Object Palette.** Click it onto the slide at the center of the circle, and draw it out to the edges of the slide horizontally, bisecting the circle.

You may do the same with a **vertical line.** You now have a cross section of the Celestial Sphere, with the North/South axis and the Equatorial axis displayed. If you wish, you may color the two lines to differentiate them from new lines you will draw on your working slide.

Now duplicate that slide using the **Insert menu/Duplicate Slide.** I note here that it is important to continually duplicate slides to preserve parts of your work while you are constructing your climate plate. Select a **line object** from the **Object Palette.** Click it onto the first slide at the center of the circle, and draw it out to the circumference on the right-hand horizontal radius of the circle.

Next, copy and paste that line onto the same slide to give you a second line to

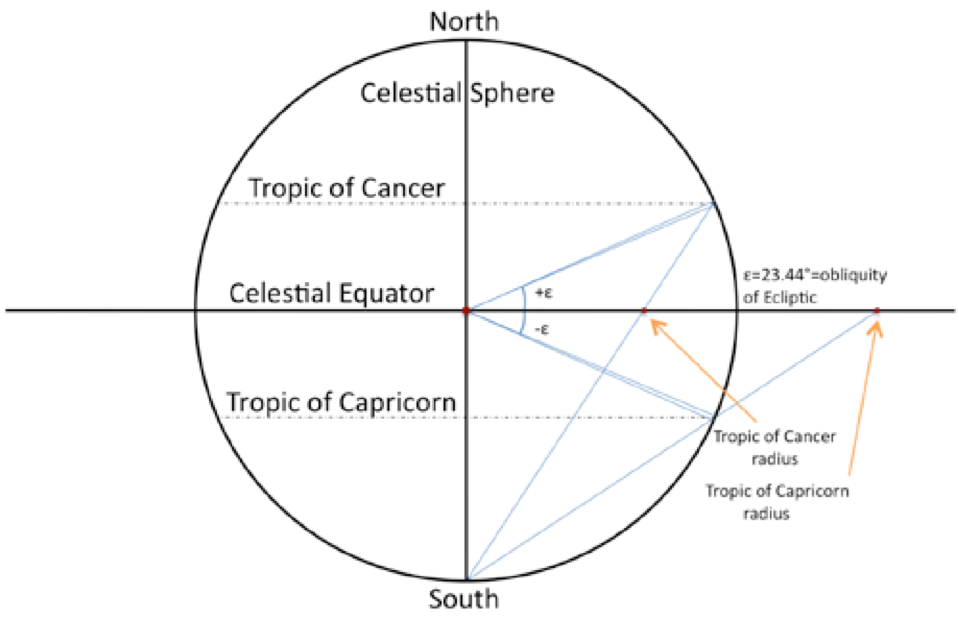

Figure 11
CLIMATE CIRCLE PROJECTION

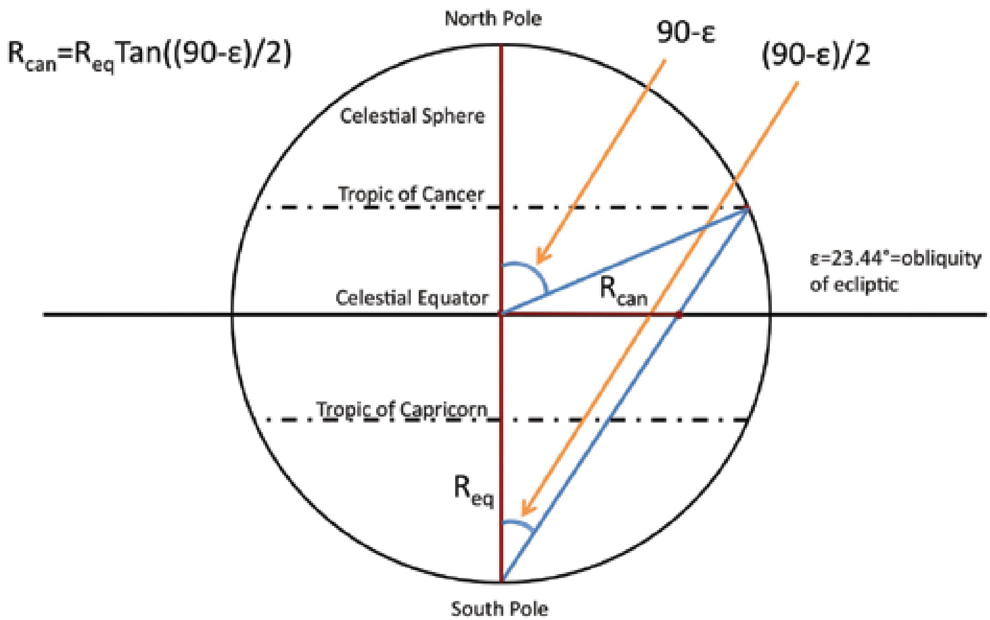

Figure 12
CONSTRUCTING THE CANCER CIRCLE

work with. Now right-click that second line to bring up **Format Shape,** and go to the **Size** submenu. Add the present angle for the obliquity of the Ecliptic to the existing angle in the **Angle** field, and move it so it extends from the center to the circumference.

Then, using the first horizontal line, again copy and paste the line, and next subtract the angle of the obliquity of the Ecliptic from whatever angle is in the Angle field. Move that line so it extends from the center to the circumference.

Because the present angle of the obliquity is about 23.44 degrees, and PowerPoint accepts only integer angles, you are left with the contrivance of producing thin lines at 23 degrees, 24 degrees, and minus 23 and 24 degrees, then splitting the difference at high Zoom in the next operation. Once you have the angles of the obliquity marked on the circumference above and below the Equator, select a **new line,** click it onto the South Pole point, and draw it up to the Tropic of Cancer point.

Take another line and draw it from the South Pole, through the Tropic of Capricorn point, and onto the Equator line. Where each of these lines intersects the Equator line, marks the length of the radius of each circle from the center. To find the length of those radii, you can extend a line to each point from the center, and find the length in the **Size** field. Multiply by 2 to get the diameter of each circle.

Now **select and format** circles of those sizes from the **Object Palette,** and center them concentric with the Equator circle on your duplicate slide (Figure 11). Alternatively, you can figure out the two tropic circles more precisely using trigonometric ratios: Rcan=ReqTan((90– ε)/2) (Figure 12) and Rcap=ReqTan((90+ ε)/2) (Figure 13). Multiply by 2 to get the diameters and place them around the equator circle in the duplicated slide.

Construction of the Almucantar Circles

The next step is to draw the almucantar (altitude) circles. All of this can be done on the same slide, but it would get in-

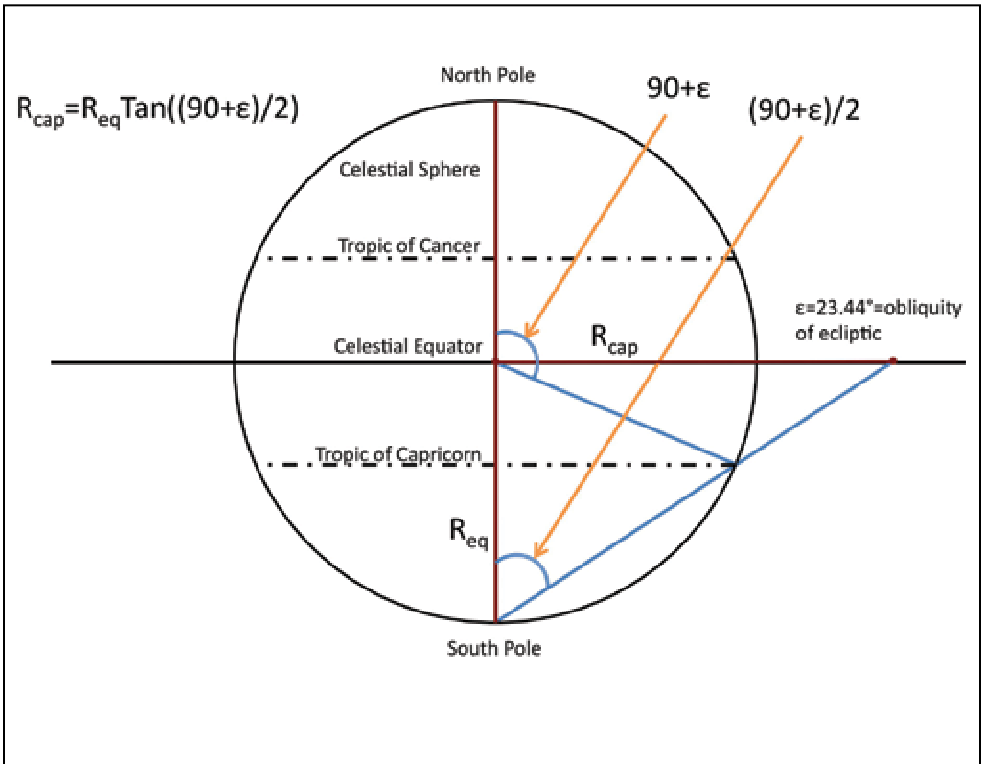

Figure 13
CONSTRUCTING THE CAPRICORN CIRCLE

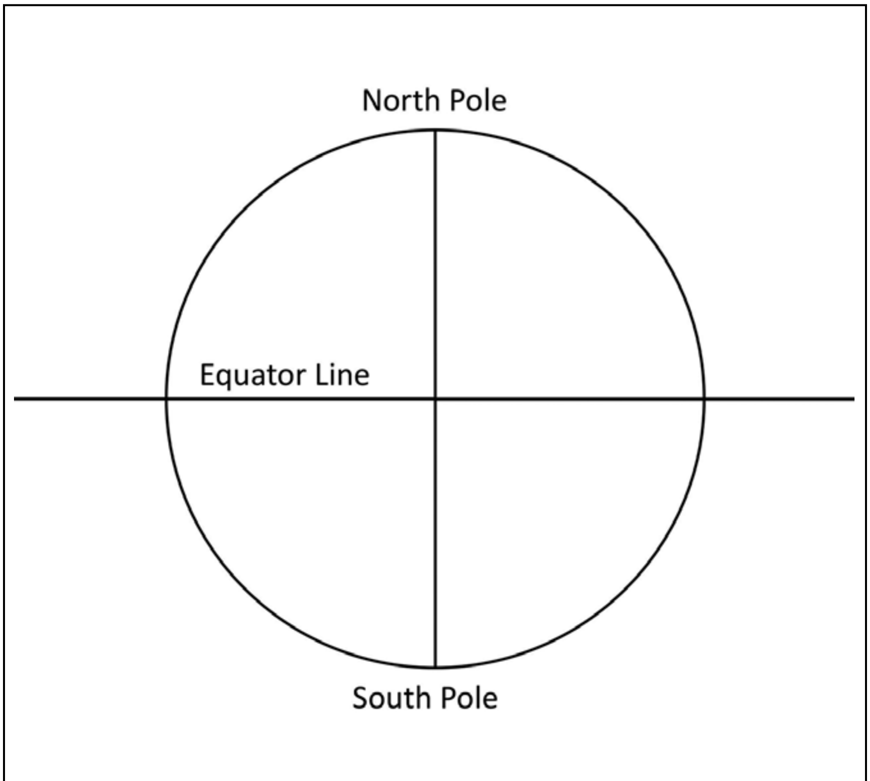

Figure 14
NORTH-SOUTH-EQUATOR CROSSHAIRS

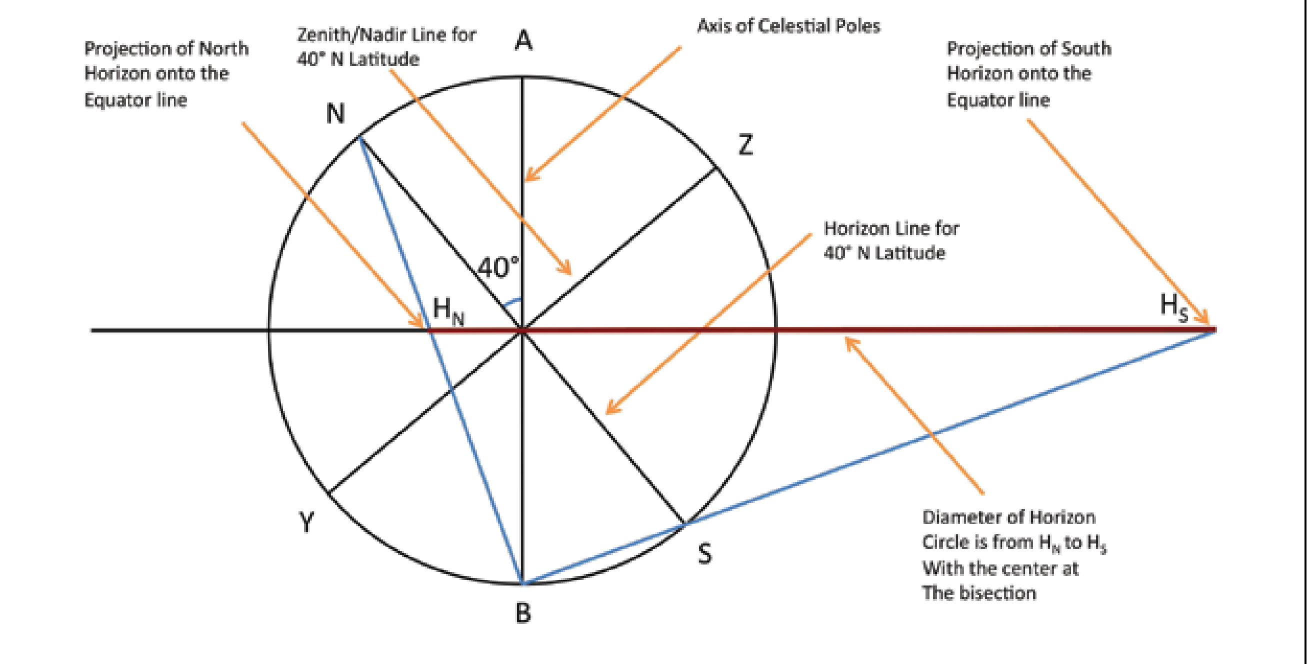

Figure 15
CONSTRUCTING THE HORIZON CIRCLE

credibly cluttered and hard to place the lines. Also, some of the almucantar circles, especially the Horizon circle, are very large, so it is best to create a new slide using the same-size circle as the Equator circle, but moving it to the left of center by 2.5 inches.

Divide the circle vertically and horizontally by selecting line objects and clicking them into place (as in Figure 14). The vertical diameter represents the North/South Poles of the Celestial Sphere. The horizontal line should be extended to the limits of the slide. It is a cross section of the plane of projection at the Equator of the Celestial Sphere. It also represents the Meridian of the astrolabe under construction, with South to the right and North on the projection point of the Celestial North Pole (at the circle's origin). Create a duplicate slide at this point.

Now **paste** a new line from the origin of the circle to the top, on top of the vertical diameter line. **Copy and paste** that line onto the slide so you have two working lines to use next. Right click the newly pasted vertical line and go to the **Size** window. Whatever the angle says for the vertical line, add 40 degrees to it and enter that in the rotation field.

Move your line to the origin so that it is a radius pointing 40 degrees to the left of vertical, and extend it to the circle circumference in both directions, making sure it passes through the center. This line is your Horizon line for a latitude of 40 degrees. The Celestial North Pole is 40 degrees clockwise from the North Horizon.

Now **copy and paste** your original vertical line again, this time subtracting 50 degrees from it. Put it at the origin, and extend it to the circle circumference in both directions, making sure it passes through the center. This line is the Zenith/Nadir line. It is 90 degrees from the North Horizon.

Select a new line from the **Object Palette** and click it onto the South Pole of the Celestial Sphere. Extend it to the North Horizon point on the circle circumference. Where this line meets the Equator line is the projection of the North Horizon point onto the astrolabe plate.

Repeat, by extending lines to the South Horizon point, the Zenith point, and the North Pole point (projected to the origin of the circle). **Mark** the projection points for the Zenith and North Pole with tiny colored circles. The distance from the North Horizon projection point to the South Horizon projection point (Figure 15) gives the diameter and location of the Horizon circle to be created on the climate plate.

Create a circle of this diameter just like the earlier circles, and position it so that the North and South Horizon projection points are on the circumference of the circle—if you were using compass and straightedge, you would bisect the line between the projection points, and use the compass to draw the circle (Figure 16). Now, **select** that circle and **copy and paste** it onto your duplicate slide.

You may alternatively figure out your Horizon circle diameter using trigonometric ratios (Figure 17).

The rest of the almucantar circles can be constructed the same way (see Figure 18), by finding the angles for each altitude up to 90 degrees (the Zenith), projecting from the South Celestial Pole to get the north and south diameter points for the necessary circle, and placing the circle on the slide. The construction, moved to the climate circles, and including the Horizon circle and the almucantar circle for 50 degrees, is shown in Figure 19.

Note that while the 50-degree circle will be a circle in the final plate, the Ho-

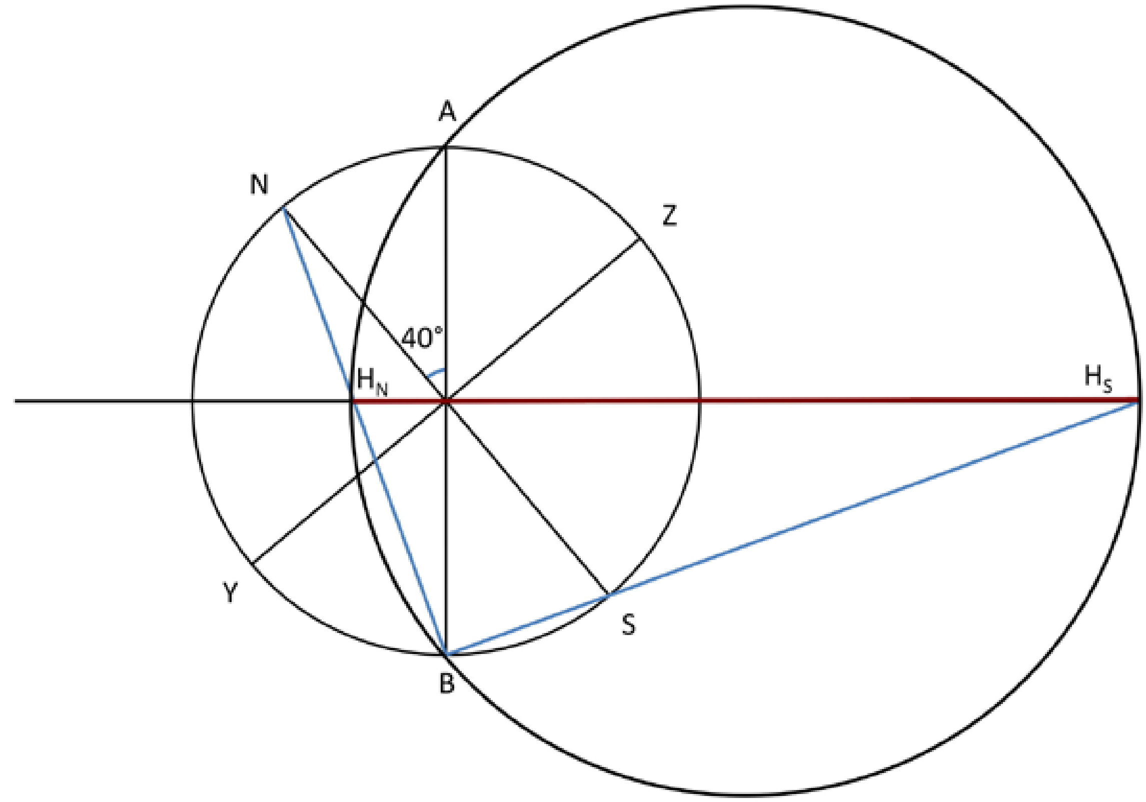

Figure 16
THE CONSTRUCTED HORIZON CIRCLE

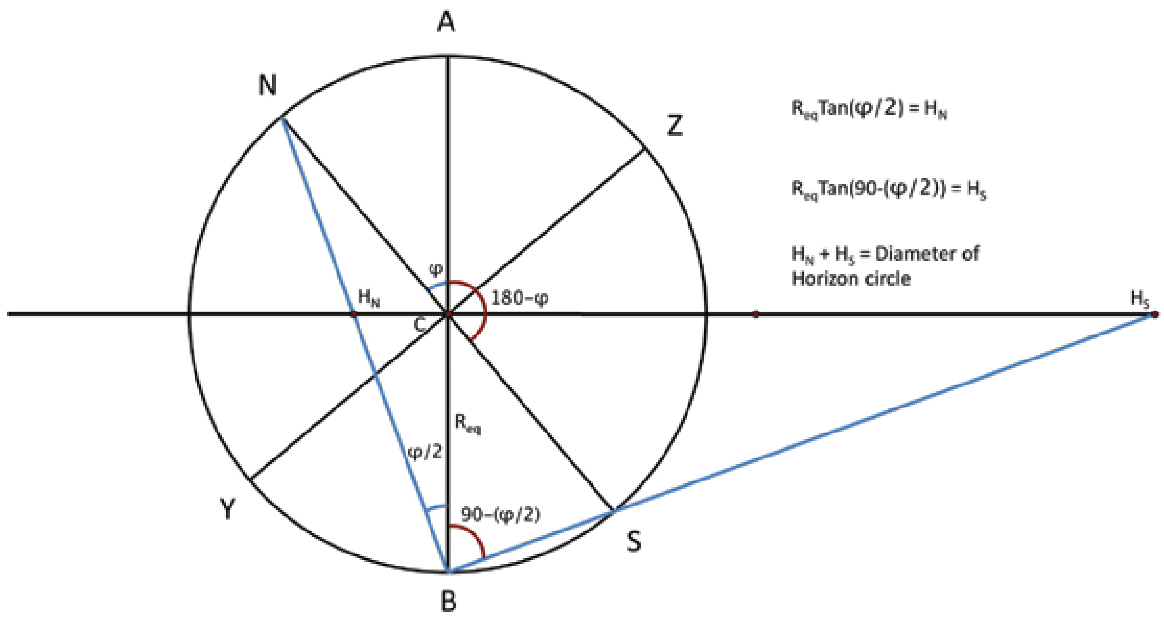

Figure 17
THE TRIGONOMETRY OF THE HORIZON CIRCLE

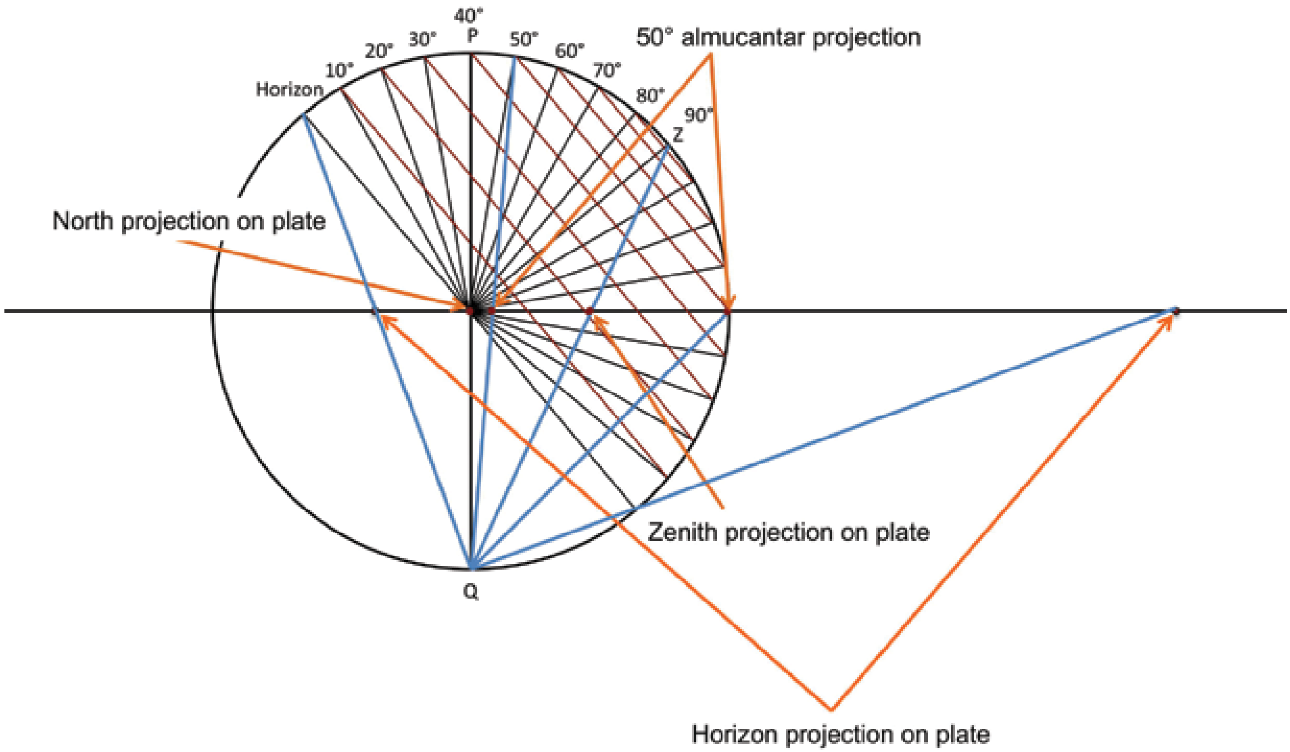

Figure 18
ALMUCANTAR PROJECTIONS

rizon circle will be an arc cut off by the Tropic of Capricorn circle. Figure 20 shows all of the almucantar circles in 3-degree intervals from 0 degrees to 60 degrees, and in 5-degree intervals from 60 degrees to 80 degrees.

The 50-degree circle from the previous slide is superimposed in red to illustrate where it falls on the plate. You will find it valuable to **Zoom** in and out during the construction of the almucantar circles.

Constructing the Azimuth Circles

After constructing the almucantar circles, the next phase is to construct the azimuth circles. If the almucantar circles are viewed as dividing the heavens up into equal altitude zones from the Horizon to the Zenith, the azimuth circles divide the heavens from Zenith to Nadir into equal angle zones from East through South to West to North, then back to the East, like the segments of an orange. When projected onto the climate plate, each azimuth circle has both the Zenith and the Nadir as points on its circumference, but each has a different origin ranged out on a line which is the perpendicular bisector of the line connecting the projection points of the Zenith and Nadir.

If you create a circle connecting the Zenith and Nadir projection points as a diameter, the perpendicular diameter of that circle would be the line of circle centers for the azimuth circle projections (Figure 21). That circle symmetric about the Meridian line is called Prime Vertical (Figure 22).

To find the other azimuth circles, we must find their center points along the line of centers. A line drawn from each center to the Zenith or Nadir projection point will define that circles radius. Doubling that radius will give us the diameters for the circles we need. To find the centers of the circles, we must measure angles from the Zenith to the line of centers equal to the angles of the azimuths we wish to draw.

If we wish to have azimuth circles for each 10 degrees, then lines with these angles must intersect the line of centers on both sides of the Meridian for each 10 degrees. The intersections define the azimuth circle centers, and the lines define the azimuth radii. Prime Vertical is the special case of a 0-degree angle. The other special case is the 90-degree angle, which is an infinitely large circle indistinguishable from the Meridian itself.

Because the azimuth circles become very large along the line of centers, we will align that line of centers left to right on the slide upon a copy of the three climate circles centered on the slide. Don't forget to **Zoom** liberally. As with the almucantar circles, we start with a centered circle of diameter 4. **Select** a line with the qualities desired, **copy and paste** that line to have a working copy, and use that line to create the angles we need.

Figure 23 gives the Prime Vertical circle and the two 40-degree azimuth circles. The slide had to be reduced to 75 percent to fit the 40-degree circles into

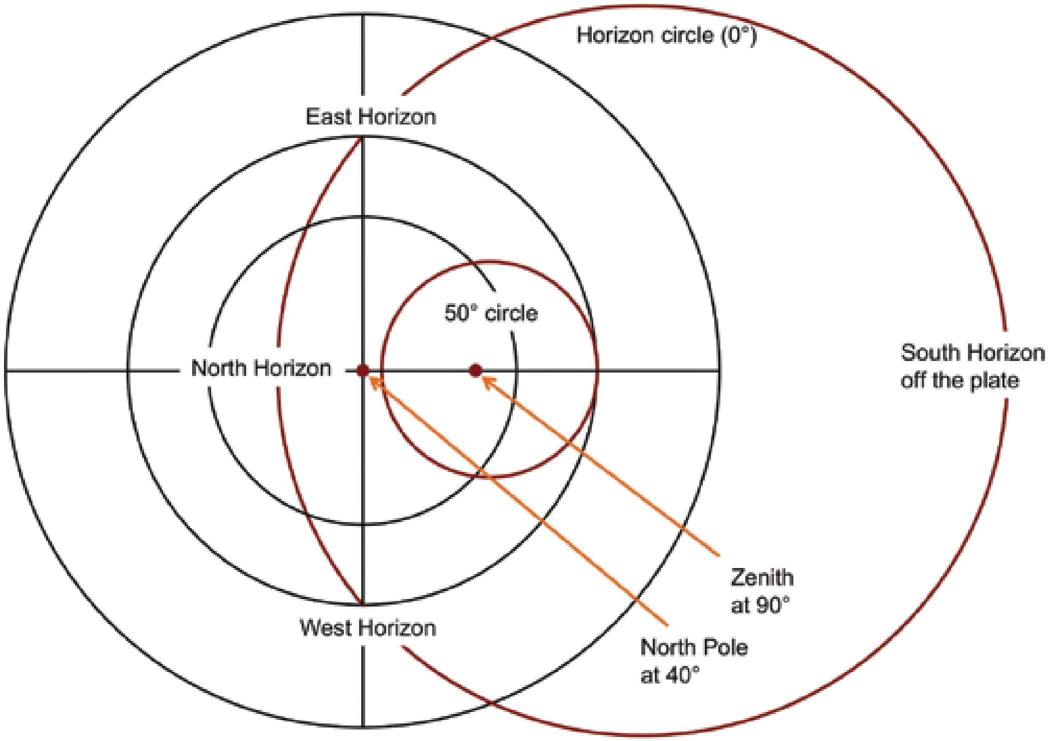

Figure 19
ALMUCANTAR RELATIONSHIPS

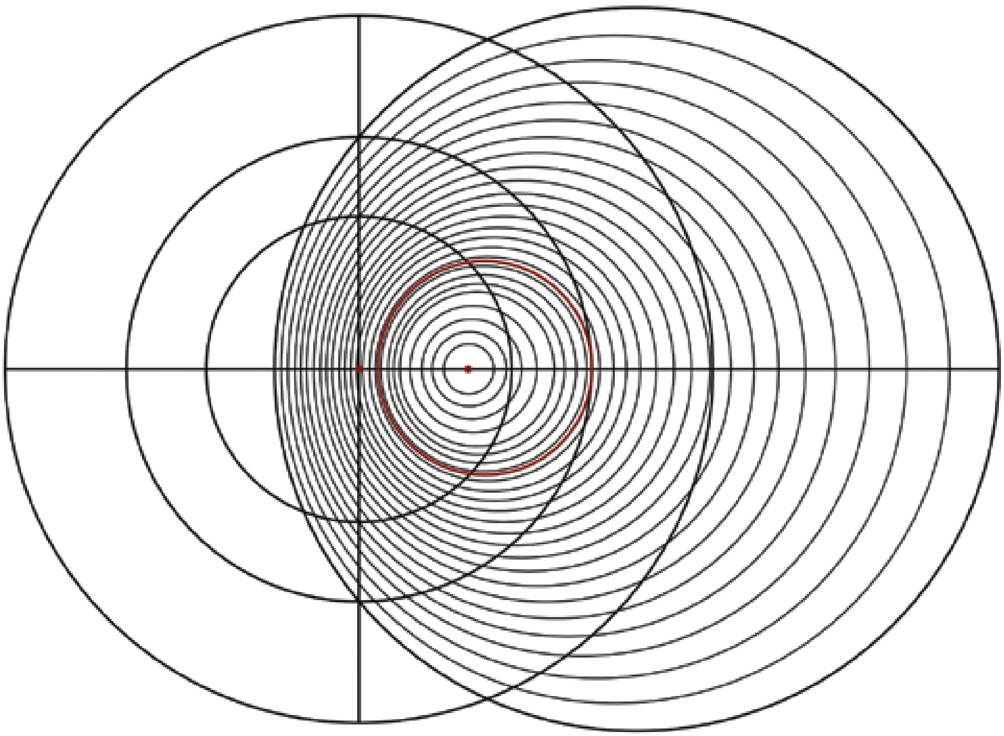

Figure 20
ALL ALMUCANTARS

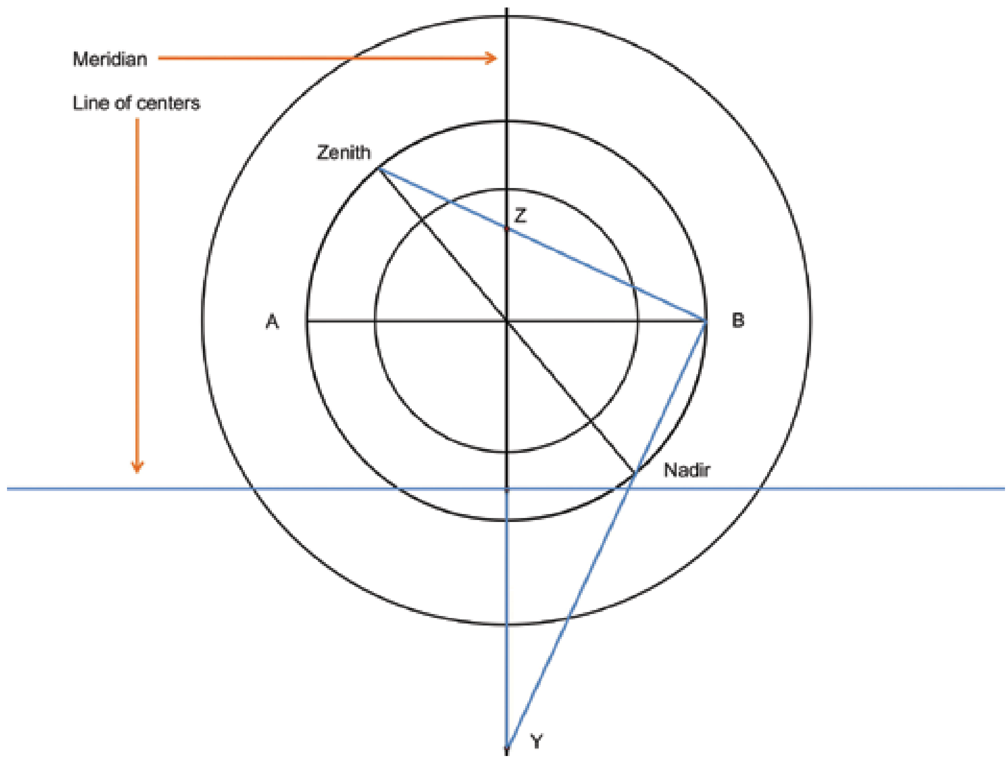

Figure 21
AZIMUTH LINE OF CENTERS

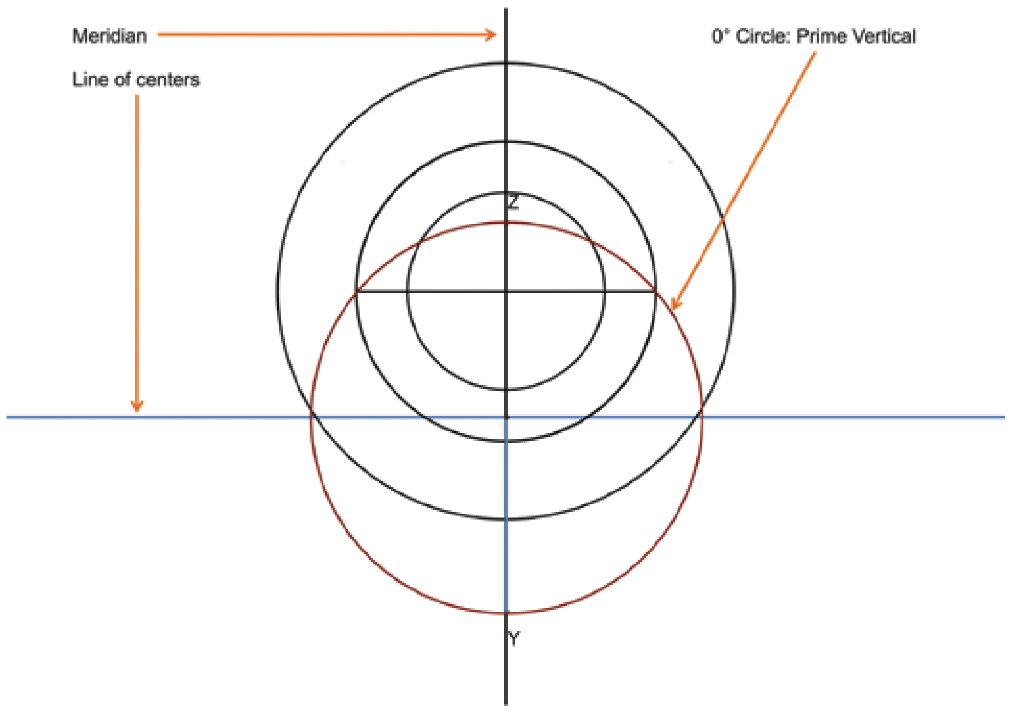

Figure 22
AZIMUTH PRIME VERTICAL

the figure. Figure 24 shows all the circles in place, and Figure 25 shows them highly reduced to fit on the slide.

The azimuth circles as seen on the final astrolabe climate plate are only arcs, since they are only expressed above the Horizon circle and are bounded, as are the almucantar circles, by the Tropic of Capricorn. As with the almucantar circles, a **ring object** will be later be used to block out those parts of the circles outside the desired bounds.

Assembling the Parts

Now that we have created the climate circles, the almucantars, and the azimuth circles, we have all the major elements necessary for the climate plate. The next step is to assemble them together. If you built your almucantars upon your climate circle slide, they are already assembled.

If you used a new circle of diameter 4 inches, you must add the Tropic of Cancer and Tropic of Capricorn circles to your almucantar slide, concentric with your Equator circle. These circles, and their horizontal and vertical diameter lines, must be right-clicked after selecting, to bring up the menu. Then choose **Arrange,** and **Bring to Front** for each of them.

Once you have your almucantars on your climate circles, you need to group all of the elements, then rotate the group 90 degrees counter-clockwise. To finish off the construction, you must put an opaque **white ring** around the Horizon circle to remove the azimuth lines from the area below it, since they are needed only above the horizon.

Select **Donut** from the **objects** and size it so the inside ring just fits around the Horizon circle. The ring fill should be opaque white to match the background (Figure 26). This group will now be copied and pasted onto your azimuth circle slide, making sure that the 4-diameter circles coincide.

Now, go to the **Object Palette** and select the **Donut** object. Click it onto your slide, **format** it to

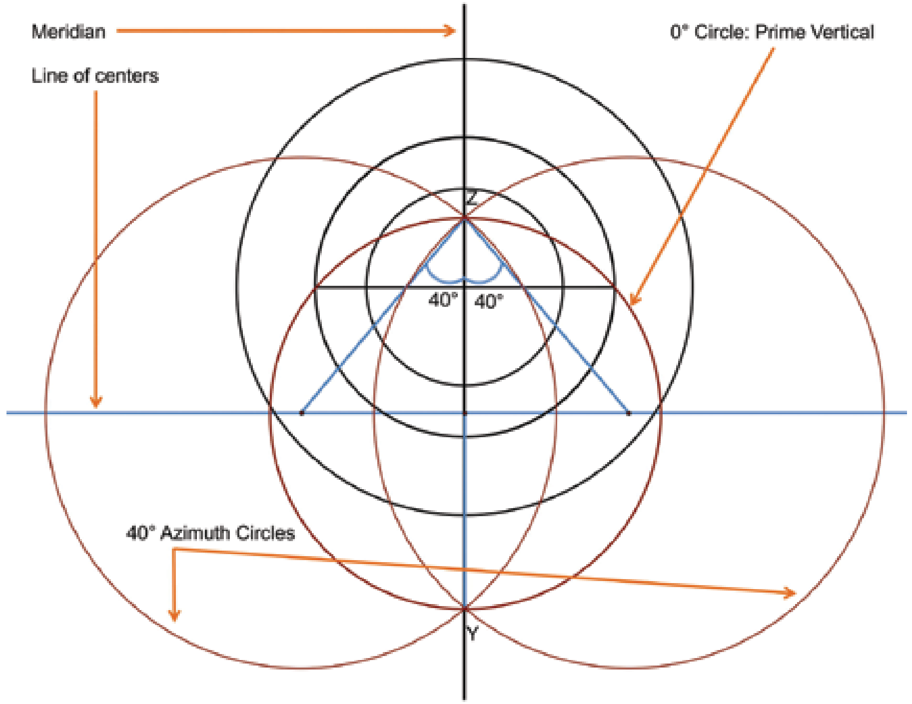

Figure 23
AZIMUTH 40-DEGREE CIRCLES

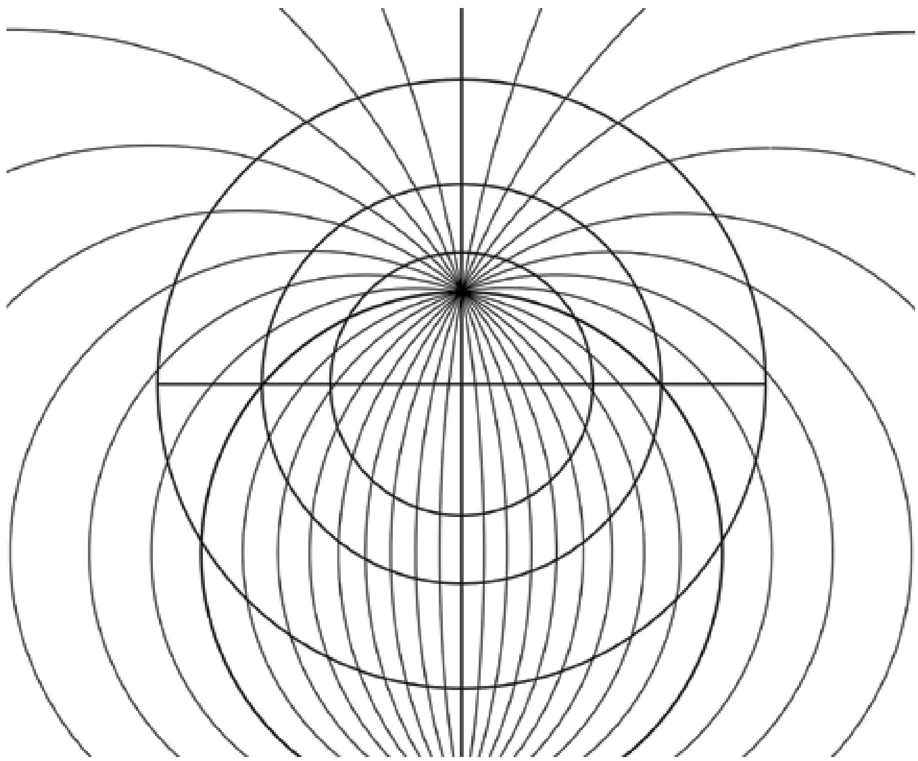

Figure 24
ALL AZIMUTHS

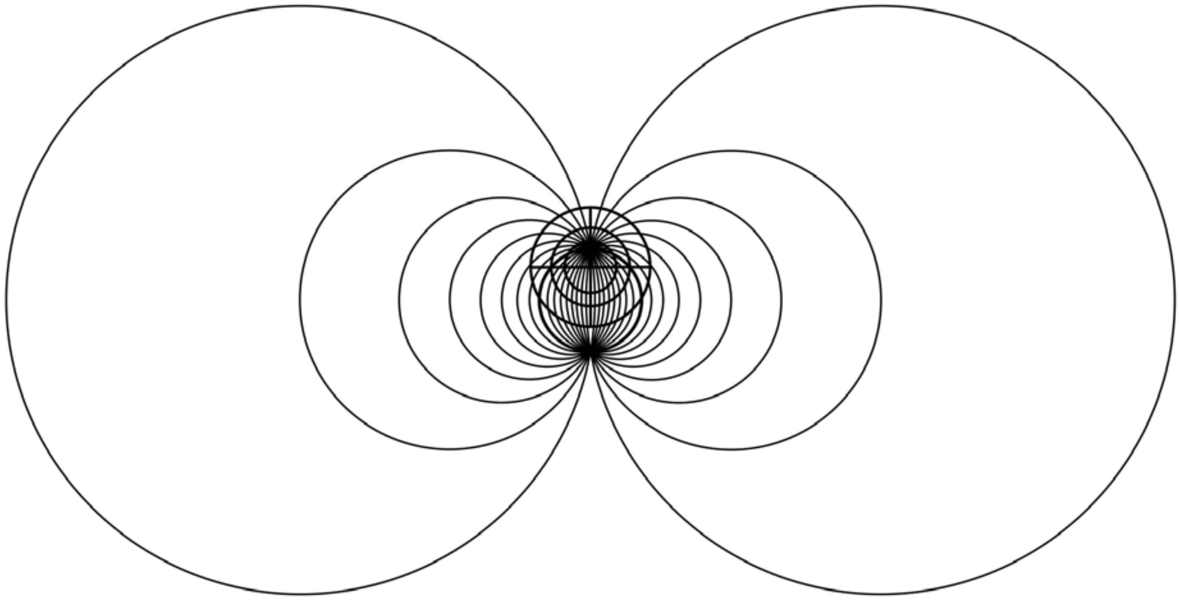

Figure 25
AZIMUTHS VIEWED IN THE SMALL

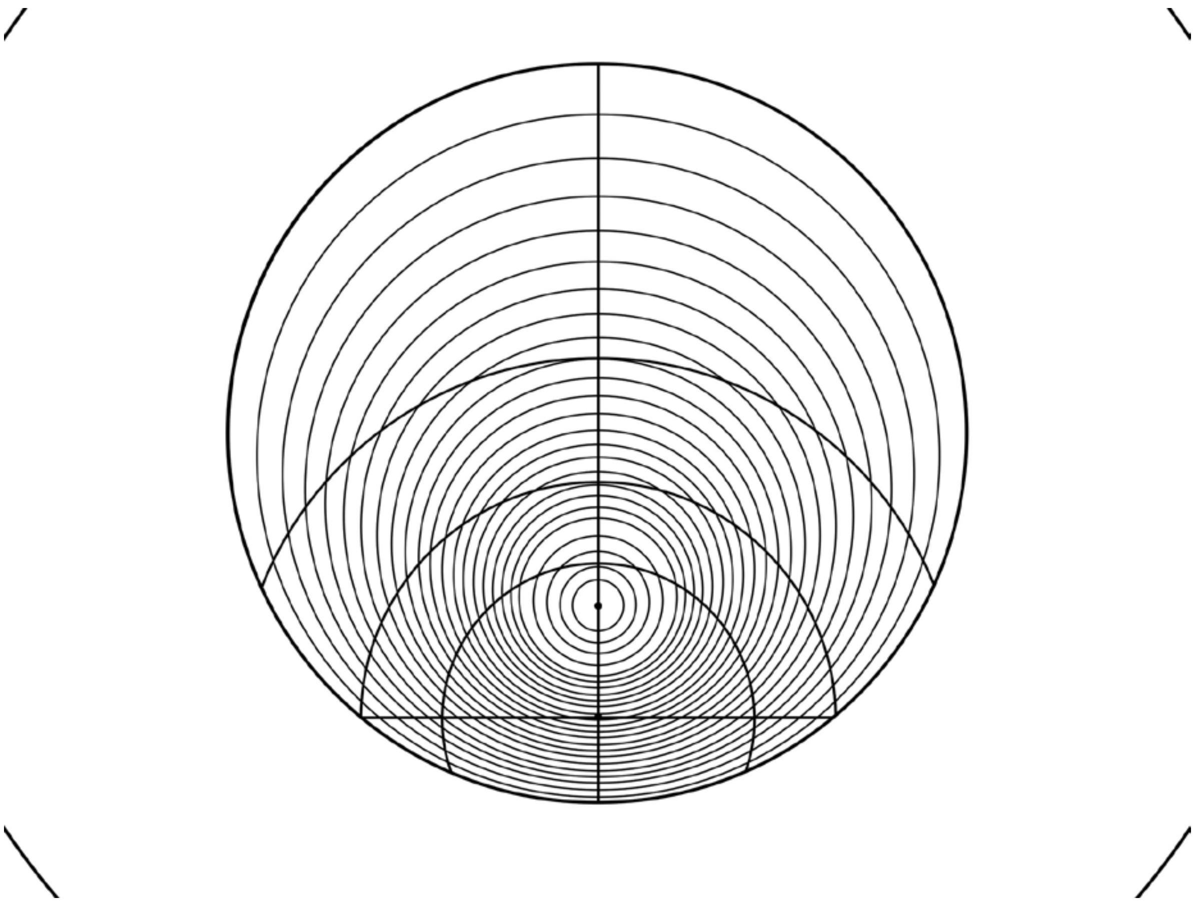

Figure 26
AZIMUTHS WITH RING FILL

white, no shadow, with lines to match your other lines, and set the diameter to 12. Center it on your circles. Next, click the **yellow box,** and drag it so the inner edge of the ring coincides with the Tropic of Capricorn circle. Small position adjustments can be made using the **keyboard arrows** to nudge the shape.

All lines outside of the Tropic of Capricorn circle have now been covered by your ring fill .

Because the three climate circles with their vertical diameters do need to be seen below the Horizon circle, they must be selected and brought to the front by right-clicking each circle, clicking **Arrange,** and then clicking **Bring to Front.** The horizontal diameter may be included or left off the plate. One more, a **tiny ring** will be used to fill the space between the 80-degree almucantar circle and the Zenith point at 90 degrees (Figure 27).

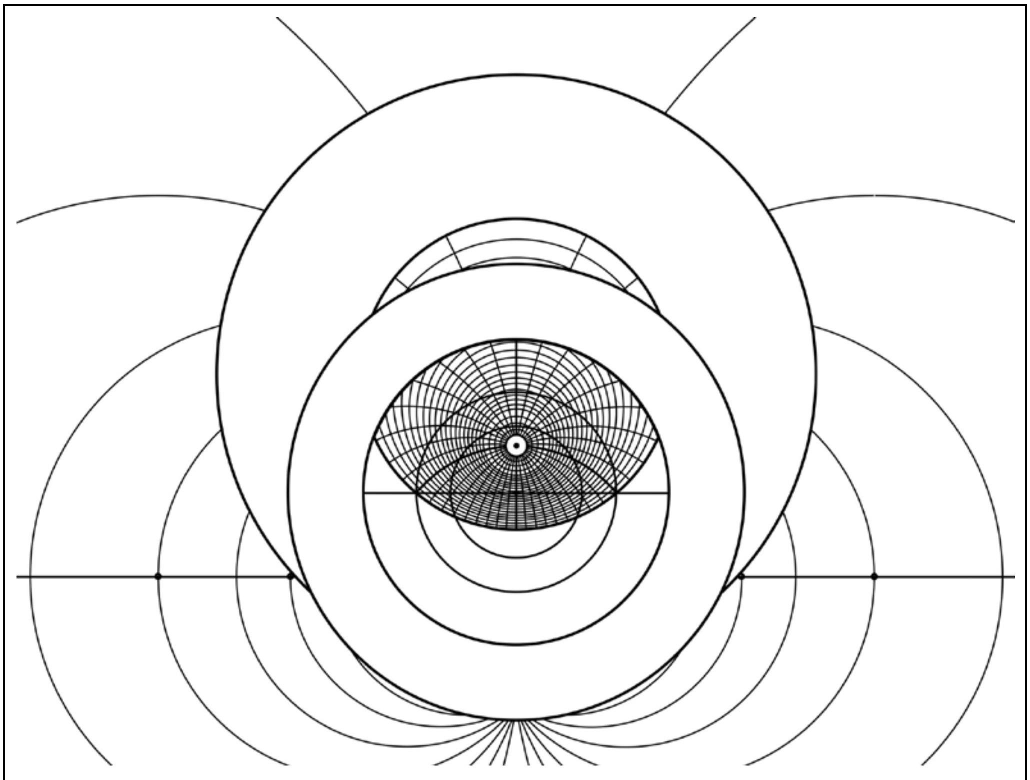

Figure 27
ANOTHER RING FILL ADDED

Figure 28 shows the cropped climate plate, ready to be labeled.

Labeling the Climate Plate

How you label your climate plate is to a large degree a matter of choice. Too much labeling gets cluttered, while too little can lead to extra work while using the astrolabe. The almucantar circles are labeled from 0 degrees at the Horizon circle, to 80 degrees near the Zenith. The plate used as an example, has almucantars every 3 degrees to 60 degrees, then every 5 degrees to 80 degrees. In that case, labeling every 12 degrees to 60 degrees, and every 10 degrees to 80 degrees would work.

The azimuths are labeled 0 degrees west where the Horizon circle meets the Equator circle on the right of your climate plate. On the left, it is labeled 0 degrees east. Where the Horizon circle meets the vertical line passing through the center of the plate, is labeled 90 degrees north.

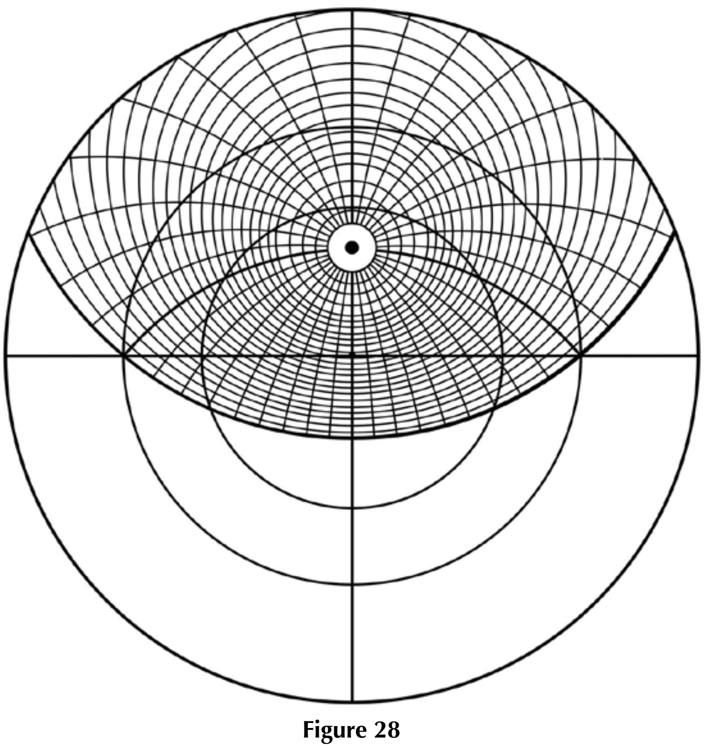

Figure 28
CROPPED CLIMATE PLATE BEFORE LABELING

South, of course, is off the top of the

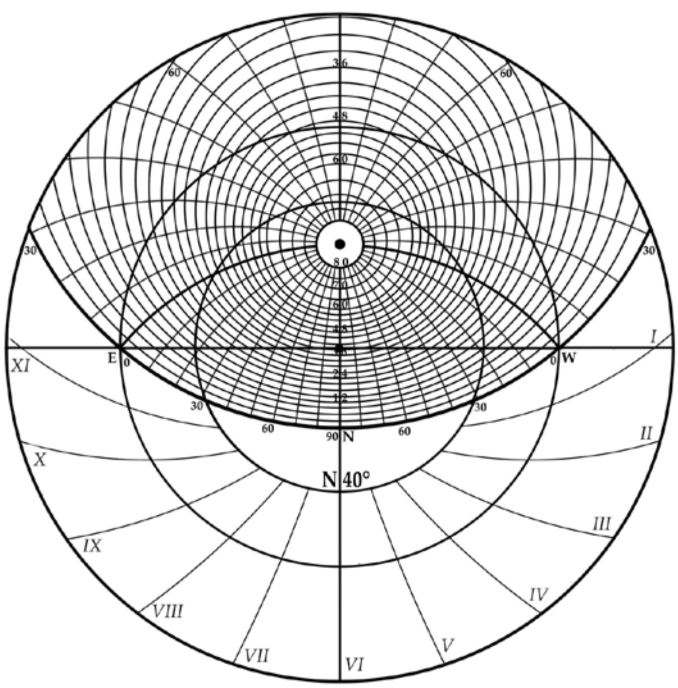

Figure 29
CLIMATE PLATE LABELED

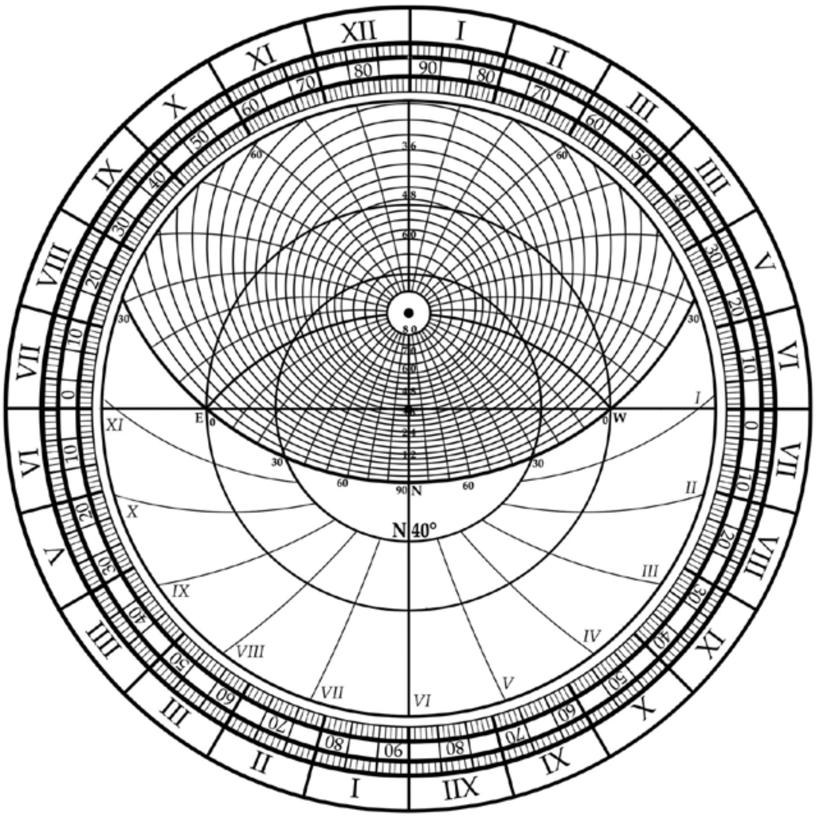

Figure 30
MATER AND CLIMATE PLATE COMBINED

plate, but the top of the plate is 90 degrees in the south direction. Figure 29 shows the climate plate labeled. Since I have seasonal hours on my plate, I labeled them clockwise from I to XI (see below). Figure 30 shows the climate plate placed onto the front of the mater I created in PowerPoint.

Seasonal Hours

Ancient climate plates had other arcs on them as well. Often they had seasonal hour arcs filling the mostly empty area under the Horizon circle. These divided the day or night into 12 equal parts, whose hour-lengths depended on the season. Rather than have more hours of daylight in the Summer, there were just 12 longer hours of daylight.

Conversely, the 12 hours of night would each be shorter by a proportional amount. These lines are often called unequal hour lines, but a better name might be proportional hours, since each hour occupies a proportional 12th of the day or night. Ancient astrolabes also often had inscribed on them arcs representing the 12 houses of heaven useful to astrologers.

Figure 29 shows an astrolabe climate plate with the seasonal hours marked in. If you were to take a series of circles representing latitudes between the Tropics of Cancer and Capricorn, all cut off by the sweep of the arc of the Horizon circle, and divide each of those many circles into 12 equal parts below the Horizon circle (the Equator would be 180 degrees divided by 12, which is 15 degrees each), a set of smooth arcs connecting the divisions from the Tropic of Capricorn to the Tropic of Cancer would represent the 12 seasonal hours.

In practice, this can be accomplished very closely by just dividing the three climate circles of the astrolabe plate into their 12 equal segments, then finding circles that contain each set of 3 points on the circumferences. That works fine for compass and straightedge (and a good eraser), but for PowerPoint, it leaves a set of arcs above the climate circle, which cannot be removed by the ring maneuver used earlier.

One can, however, use the curve line to trace over the arcs of the seasonal hour circles from the tropic of Capricorn to the Tropic of Cancer. You do this by **selecting** the **curve line** and clicking it at the Tropic of Capricorn.

Move a little smoothly along the hour

Figure 31
THE ALMOST-COMPLETED ASTROLABE

The photos illustrate a simple astrolabe in the finishing stages of construction. The mater front with climate plate, and the mater back, were printed onto cardstock and glued to a sturdy cardboard circle. The rete (as yet without stars and constellations), was printed onto acetate. The front rule (as yet without declination hatches), and the back alidade were cut from container plastic; cardstock was glued on top. Holes were carefully made in all the parts to receive the bolt and nut.

At the top of the instrument, another hole was made to receive a bolt from which to hang a lanyard. A thumb can be inserted therein so the astrolabe can be held at arms length to sight stars and planets. Once the front rule has been marked with declination hatches, it can be used in conjunction with the astrolabe and an ephemeris to mark prominent stars/constellations onto the rete, if desired.

line and click. Repeat that action until you reach the tropic of Cancer. Then **double click** to **release** the line. A smooth curve should appear. Format the curve to your specifications and move on to the next arc. After you have created your seasonal hours, you can simply erase the circles you used as templates.

You've Made Your Climate Plate. Now What?

Now that you have created your climate plate for the astrolabe, you will no doubt wish to use it. That, of course, requires creating the mater front limb scales, the rete (with useful stars), as well as at least a simplified mater back with scales. You will also need to make a rule for the front and an alidade for the back.

These things can all be created on the computer, and almost all can be created using PowerPoint, using techniques similar to those you have already used to design the climate plate.

You are also most likely itching to know how to use this device to solve medieval problems related to time, season, the Sun, and the fixed stars. Luck is with you. There are several good websites focussing on the astrolabe, but the best I have found is "The Astrolabe." This is a very useful site, where there is a wealth of resources related to the astrolabe.

One very fun part of the site presents the Electric Astrolabe (one running on computer code of the DOS variety). This is a very instructional program for people running Windows XP or below. For other operating systems, a DOS emulator, called DOSBox must be used. With the Electric Astrolabe, you can easily find out where the planets will be at chosen times in the past or future, just by entering your date and location. It is a wonderful tool for learning how the astrolabe works. I highly recommend that you try out this program.

The person who created this site, James E. Morrison (Janus), has recently published a book about the astrolabe, which is well worth the money. This book, *The Astrolabe* (Classical Science Press), is very complete, giving the history, the astronomy, the trigonometry, how to use it, and even how to construct one.

Another resource I have found very valuable is the book, *The History & Practice of Ancient Astronomy,* by James Evans (Oxford University Press). Although only a small portion of the book deals with the astrolabe, per se, you can learn a lot about the ancient astronomy that informed the development of the astrolabe. The first astrolabe I built was from instructions and templates in his book.

Finally, if you really wish to know how the astrolabe was used in medieval times, treat yourself to reading Chaucer's *Treatise on the Astrolabe,* written around 1391 to his sone Lowis, a 10-year-old.