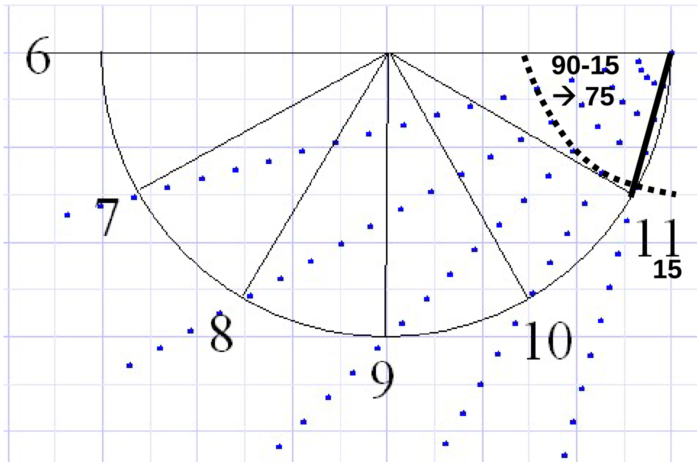
August 6, 2006

CASE STUDY ~ TWO GNOMON-LESS ARMILLARY DIALS SIDE BY SIDE SOMETIMES KNOWN AS AN OPEN BOOK DIAL

This dial will be for Silver City, NM, whose coordinates are:

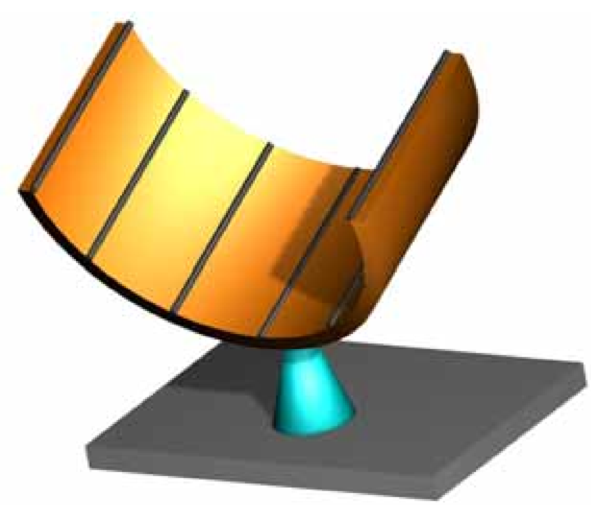
location lat:	32.75° N	The dial plate from 7 am to 5 pm will be
location long:	108.2° W	a maximum of 16 inches east to west
magnetic declination:	10.6° E	and 8 inches top to bottom (approximately)

First, a few notes on how these dial work. An armillary dial can use the edges of the armillary as the gnomon, there would be one edge for the a.m. hours, the east edge, while the west edge would be the p.m. hours. The geometric figure below might suggest that calculating the angles would be difficult. However, simplicity itself reigns!



The 15 degree lines are drawn from one edge. Where they intersect the semi-circle is where the hour lines would be. A set of lines from the semi-circle's center drawn to those intercepts shows that the angles of the hour lines from the center are 30 degrees.

This is explained simply since each is an isosoles triangle. Since an angle at the base is 75 degrees, being 90 degrees minus the 15, and since the other base angle must be the same as both are on the circumference, and both go to the semi-circle's center, then they total 150 degrees, leaving 30 when subtracted from 180. Thus, 30 degree radials from the dial center are drawn, which can easily be translated into linear distances once the radius of the semicircle is known.



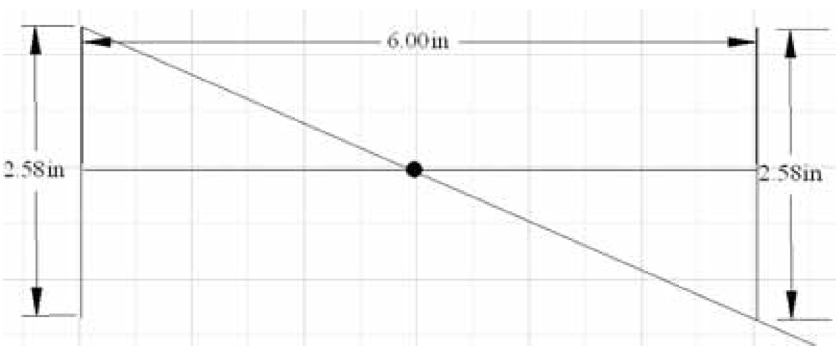
A nodus can be added for calendar information, both edges would then need that nodus. However, those calendar lines might look somewhat confusing as they would diverge since the nodus to dial plate point of impact increases with the time from noon. The armillary must be set at latitude. The edges must be pure, thus also aligned to latitude, and be exactly where the 6 am or 6 pm lines, or the noon lines, are.

However, such a dial can be rotated, and can be longitude corrected.

This system can be analyzed in more detail, and a 3 inch radius or 6 inch diameter will be used as a basis for that study.

What is the width of the armillary dial plate? Using geometric projections whereby we rotate a view from the top sideways, so the plan view is rotated to the profile view. For a three inch radius semi-circle, or a six inch diameter semi-circle, the maximum spread for the 23.5 degree declination would be twice 2.58 inches, or 5.2 inches. Or in more general terms, the solar declination spread is a bit under the diameter.

However, this assumes a nodus is used. It must be remembered that the gnomon-less dial has two styles, and if declination lines or calendar lines will not be used, then all that is needed is to ensure that the style's shadow is always on the dial plate. So the southernmost tip of the style can be used for the winter shadow, and the northernmost tip for the summer shadow.

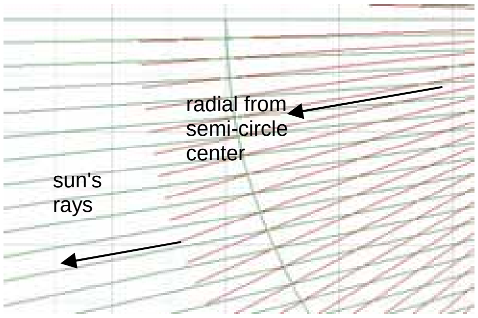


In this case, we can halve the length of the style, and thus dial plate. Thus a six inch diameter semi-circle need only have a width of 2.58 inches, or in more general terms, the width of the dial plate, summer to winter, is 2.58/6 inches or 0.48 times the diameter. Or in very loose terms, the dial plate is about as wide as its radius.

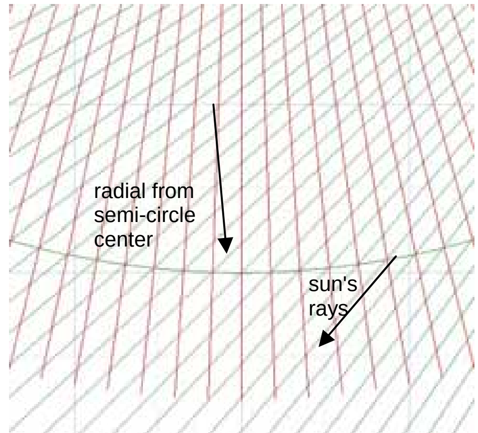
Alternatively, the dial plate has a breadth from 6 am to noon, or noon to 6 pm of 3.1316 (pi) times the radius. Thus a 6 inch diameter semi-circle would have a dial plate whose breadth of the hour span was 9.428 inches. And 2.58 divided by 9.428 yields 0.27 which we shall verify next.

The above figures were based on empirical CAD (computer aided design). How well does that match a trigonometric approach? The tangent of 23.5 is 0.4348, and that times 6 is 2.61. Obviously 2.61 is the more accurate number to use, however the use of CAD adds to an understanding of what is going on. Using 2.61 as the true figure of the minimum style's length in order to keep the shadow on the dial plate, the ratio of dial plate (6 am to noon) to summer-winter range is: 2.61 to 9.428, or 0.276, which again is close to the empirical 0.27.

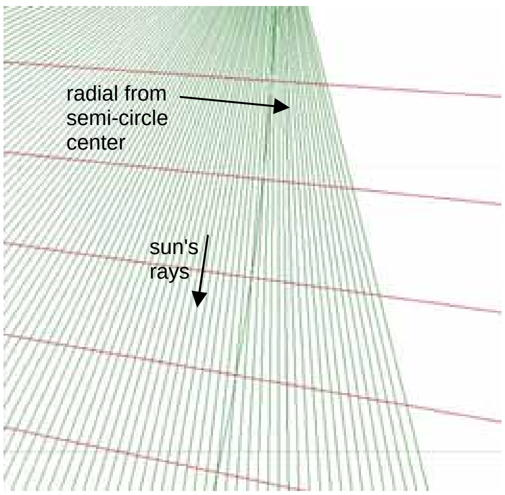
Solar ray examples and notes on hour line accuracy



To the left are shown 1 degree lines from the opposite style which is to the right, and 2 degree lines from the semi-circle center which is from the top. The sun's lines intersect perfectly, they are close to perpendicular with the dial plate, so accuracy is highest.

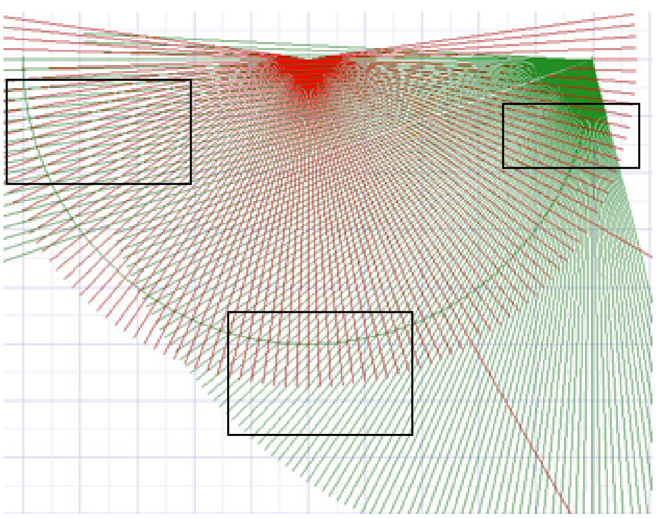


To the right are shown 1 degree lines from the style which is to the right, and 2 degree lines from the semi-circle center which is from the top. The sun's lines intersect perfectly, they are about 45 degrees with the dial plate, so accuracy is still good.



To the left are shown 1 degree lines from the style which is to the top right, and 2 degree lines from the semi-circle center which is from the top left. The sun's lines intersect perfectly, they are close to flat with the dial plate, so accuracy is lowest.

The accuracy, or rather sensitivity, decreases around noon. For the perfectionist, a small polar dial can be added for an hour either side of noon.

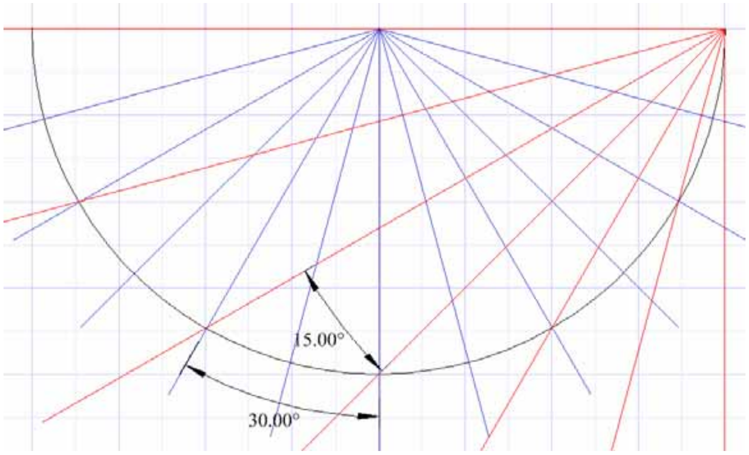


On the left the complete picture of 1 degree solar rays and their intersection with the 2 degree radials from the semi-circles center can be seen, and the three boxes correspond to the three expanded pictures above.

All these pictorials were done with TurboCAD.

The above pages lay the foundation for the dual gnomon-less armillary to be placed on a column, which will be described in the following pages.

The dial will be two gnomon-less armillary semi-circles, each rotated so one shows morning hours, the other displays afternoon information. The dial plate will be two semi circles, back to back, canted at 30 degrees, and will be longitude corrected.

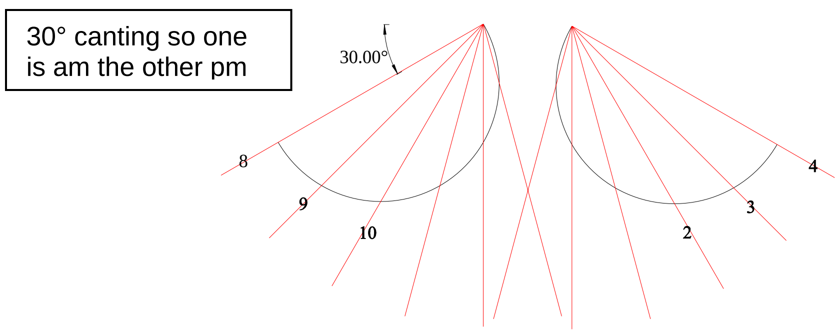


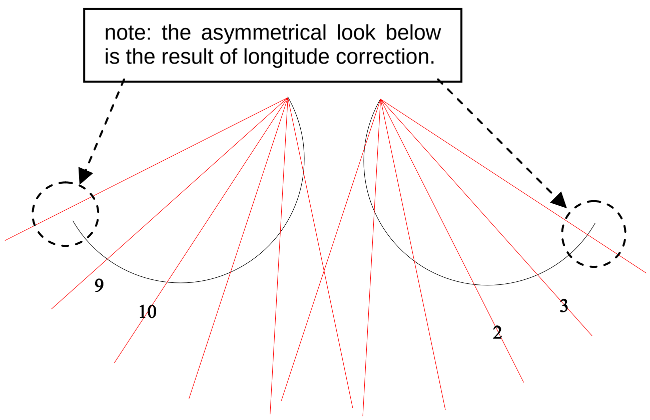
With a gnomon-less armillary, the normal 15 degrees per hour is still 15 degrees from the style, but becomes 30 degrees per hour from the center, as shown to the left, and as discussed on the preceding pages.

In this case, two such armillary dials will be back to back, canted at 30 degrees.

The 30 degrees was selected as it was functional as well as pleasing to the eye.

As a result they can show time from 8 in the morning until 4 in the evening, local apparent time or LAT, although longitude correction will modify this by almost 13 minutes.





rotated 3.2 degrees to show a later time (108.2 minus 105 degrees)

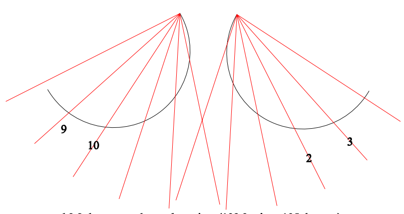
To the left, the radials have been rotated 3.2 degrees, being the dial location (108.2) minus the legal meridian longitude (105). This is how longitude correction is applied to a dial when the basis for the dial design is the 15 degrees per hour radials. Except for armillary and equatorial dials, moving a dial plate relative to the stylus does not retain relative angles thus as a rule it is an incorrect method of adjusting a dial.

The process used for the two armillary semi-circles matches that of the single armillary. Tracings are used and each tracing will have its own 15 degree radials, rotated for the longitude correction.

The two semicircles are tacked together with an epoxy and allowed to set overnight. Later the upper space between the curved dial plates as well as the lower space adjacent to the mounting paver will be filled with mortar.

When cured, the pair of dial plates is rotated and placed on a sheet of paper which has a horizontal line, the bottoms of the dial plates rest on this horizontal line.

Then the outline is traced. And perpendicular to that horizontal line are drawn lines up to the styles. From those styles are drawn the 15 degree hour angles, adjusted for the longitude correction.



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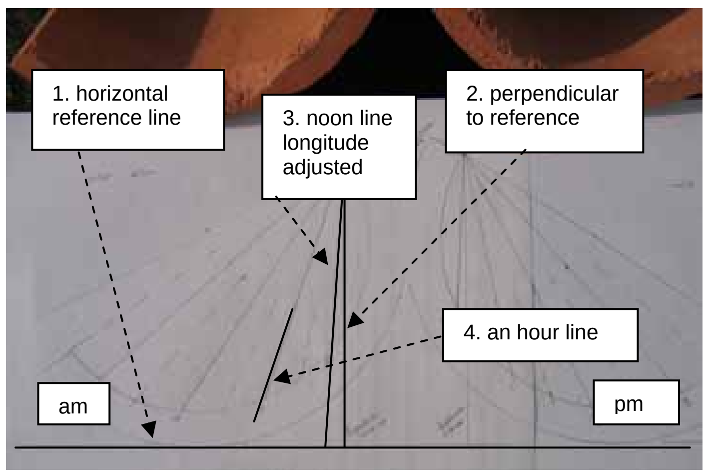
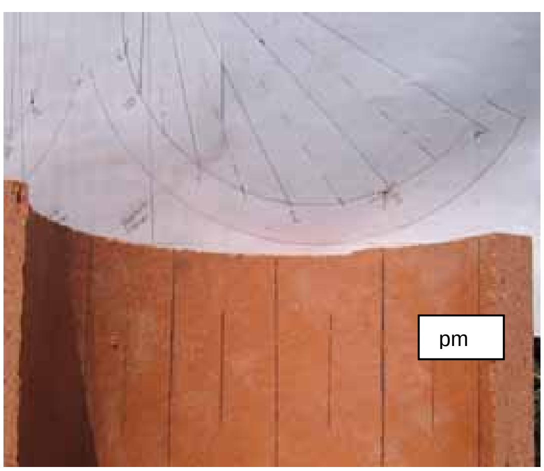


The dial plate is returned to the outline drawing, see below, and the hour lines as well as half hour lines marked where the paper meets the edge of the armillary dial plate.



This methods works well on dial plates that are uneven, and these semi-circles cut from a flu liner are not of a constant radius.

A right triangle tool was used with the surface on the style and an edge aligned on the hour and half hour index mark. An long lines drawn for the hour, half length centered lines drawn for the half hour.

Those lines were then engraved with a Dremel engraver.

The dial plate was then engraved with a Dremel engraver. Two small "T"s were made, one had the half and quarter hour detents, these were small nails in the 1/4 inch wood. A second template was needed for the hours.

Again, a face mask was used, as were glasses as a precaution.

The two dial plates were then given a small amount of epoxy to affix them to the concrete paver. When being set on a column, then of course mortar will be added.

Building the column this dial would rest on was standard procedure. Except that after the 2 inch by 1 foot square, base paver was set, the author was distracted by another work project and Alfonzo the contractor who was working on re-stuccoing the barn, decided that the base paver should align with the fence, and not with true north. Positive intentions, but not discovered when the author returned to complete the column.

So the column was built up but part way it was time for a cup of tea. After the cup of tea, work resumed however the author mistakenly didn't alternate one layer of bricks.

So when it was finished, the final paver used to rest the dial plate was no longer correct, and one set of bricks looked out of place. The resolution was to align the final dial plate by offsetting it from the paver it would rest on.

To the left the realigned dial plate can be seen, and below the dial rests in a serene part of the garden. It was tested and found to be within a couple of minutes.