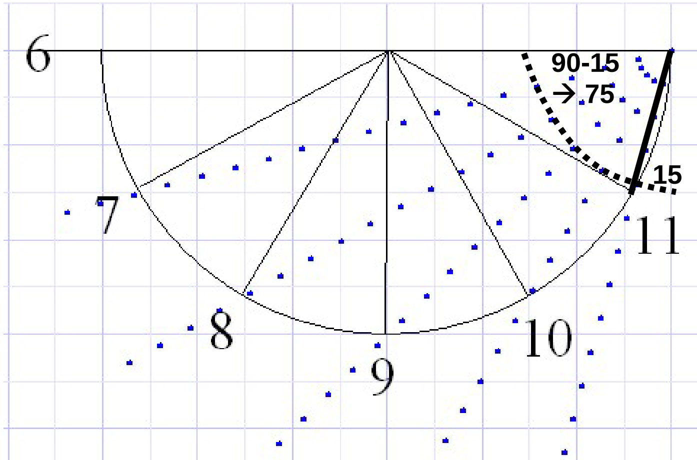
July 23, 2006

A GNOMON-LESS ARMILLARY DIAL

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!

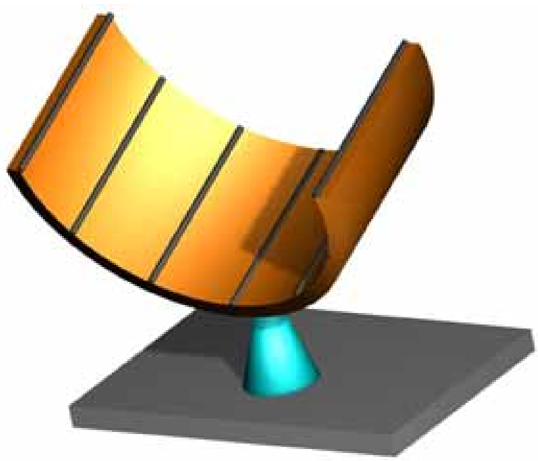


The 15 degree lines are drawn from one edge. Where they intersect the semi-circle is where the hour lines would be. A set of lines from the semi-circle's center drawn to those intercepts shows that the angles of the hour lines from the center are 30 degrees. This is explained simply since each is an 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 drawing using CAD or a word processor with drawing commands is drawn and printed. In the example below it is attached to a 3 inch inner diameter PVC pipe appropriately cut. One set of morning hours and one set of afternoon hours exist. A nodus can be added for calendar information, both edges would then need that nodus.

The armillary is attached with a bracket such that it is at latitude. The edges must be pure, aligned to latitude, and be exactly where the 6 am or 6 pm lines, or the noon lines, are.

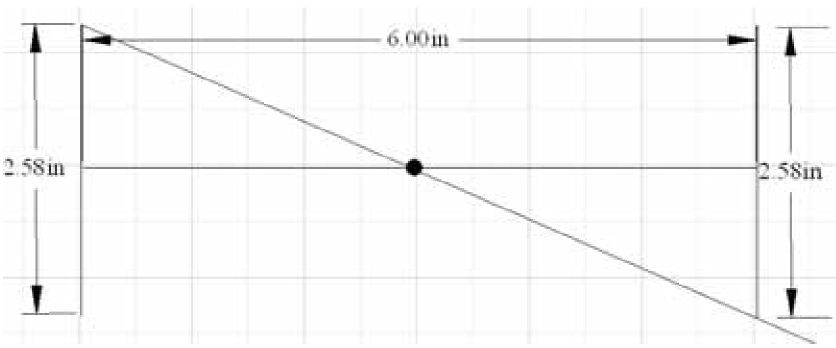
Ensuring that the dial plate is level is also important, specifically the noon to noon (6 am to 6 pm) line must be horizontal.



The dial is aligned with true north, and the time then read. The LAT shows about 8:47 in the morning, to which the EOT, longitude correction, and summer time if desired are added. This was correct to within a minute. See the last page for accuracy comments.

But how wide should the hour strip be? 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 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 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.



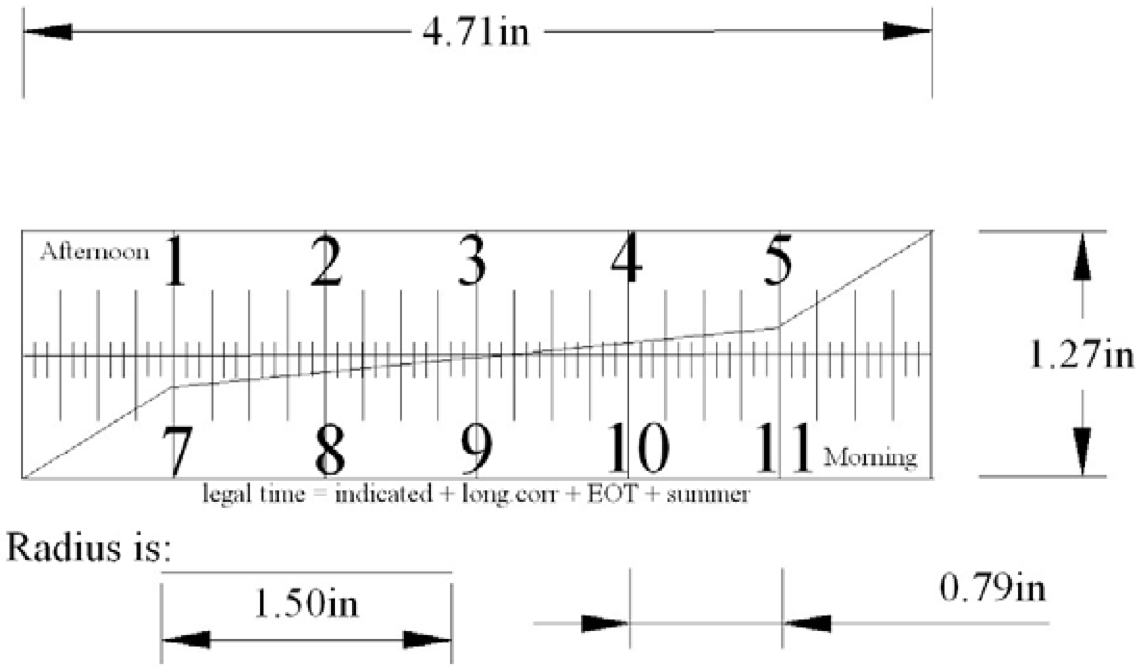
In this case, we can halve the length of the style. Thus a six inch diameter semi-circle need only have a width of 2.58 inches, or in more general terms, the width of the dial plate, summer to winter, is 2.58/6 inches or 0.48 times the diameter.

Alternatively, the dial plate has a breadth from 6 am to noon, or noon to 6 pm is 3.1316 times the radius. Thus a 6 inch diameter semi-circle would have a dial plate whose breadth was 9.428 inches. And 2.58 divided by 9.428 yields 0.27.

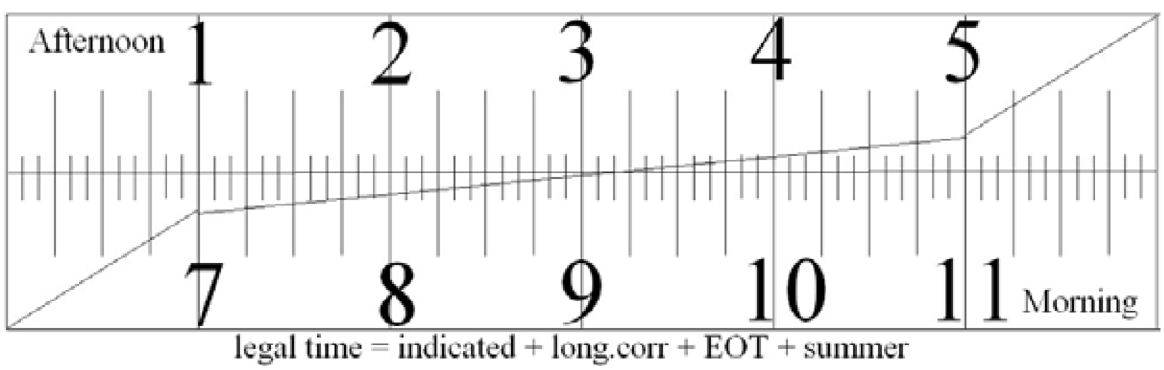
All the above figures were based on empirical CAD (computer aided design). How well does that match a trigonometric approach? The tangent of 23.5 is 0.4348, and that times 6 is 2.61. Obviously 2.61 is the more accurate number to use, however the use of CAD adds to an understanding of what is going on. 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.

A 3 inch diameter pipe, has a radius of 1.5 inches, its dial plate measures (from noon to 6) about 4.71 inches, thus the summer to winter range is: 1.27 inches.

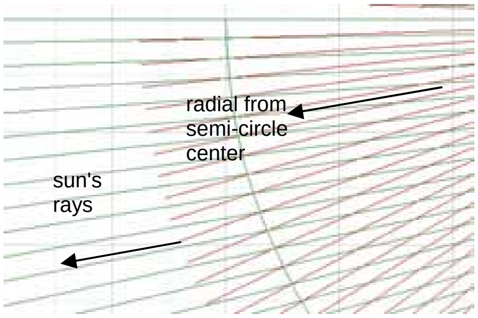
Here below is such a dial plate for a 3 inch inner diameter pipe, cut in half.



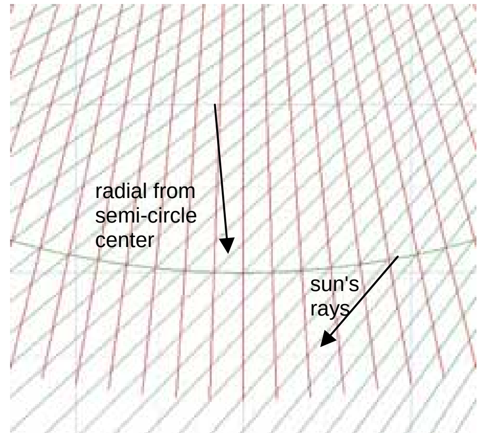
Below is just the dial plate itself with no measurements. This picture can be scaled to any desired size.



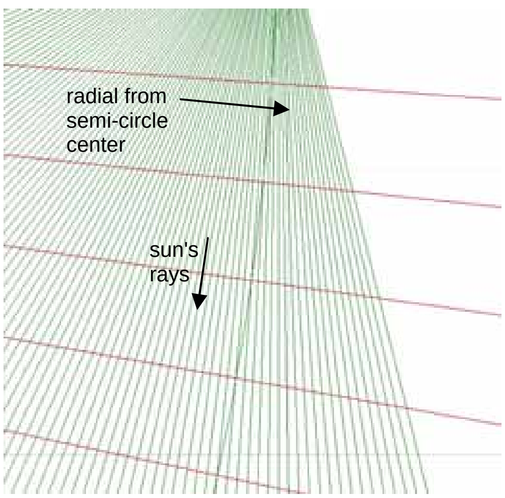
For the doubting Thomases – here are solar ray examples and notes on hour line accuracy



Here on the left we see 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.

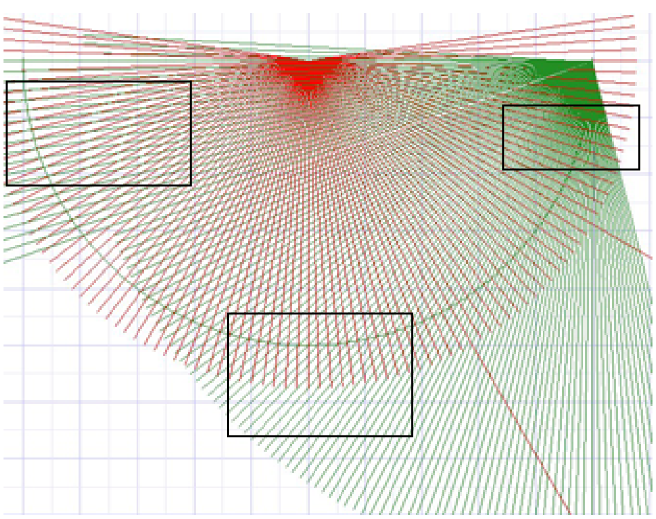


Here on the right we see 1 degree lines from the style which is to the right, and 2 degree lines from the semi-circle center which is from the top. The sun's lines intersect perfectly, they are about 45 degrees with the dial plate, so accuracy is still good.



Here on the left we see 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.