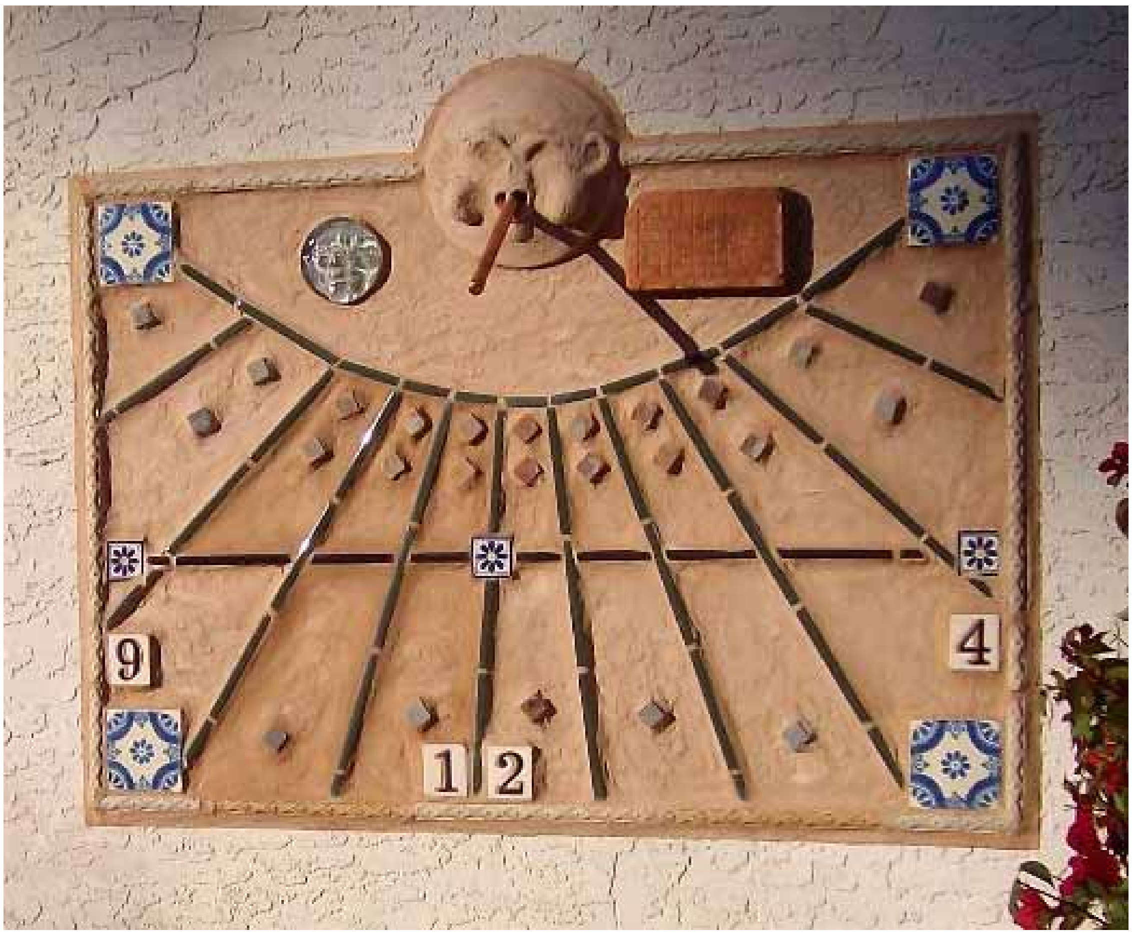
A VERTICAL DIAL FACING TRUE SOUTH IN PHOENIX, ARIZONA

A DIAL USING TILE PIECES



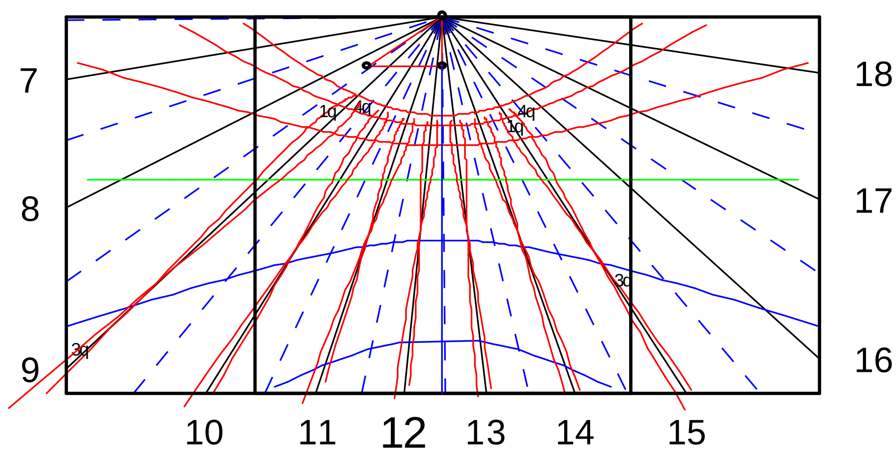
Phoenix, Arizona

caseStudyLargeVdial.doc

December 12, 2011 revised May 31, 2012

www.illustratingshadows.com

A true south facing (I know, boring) vertical wall needed a sundial. It was to fit in about a 3 foot wide area.



v-dial and calendar using gnomon linear height
check 11-1

18	17	16	15	14	13	12	11	10	9	8	7	6
-81.5	-64.0	-47.8	-33.0	-19.4	-06.6	05.9	18.7	32.2	47.0	63.1	80.6	-81.5

Hours above horizontal use the 90 reference line below horizontal.

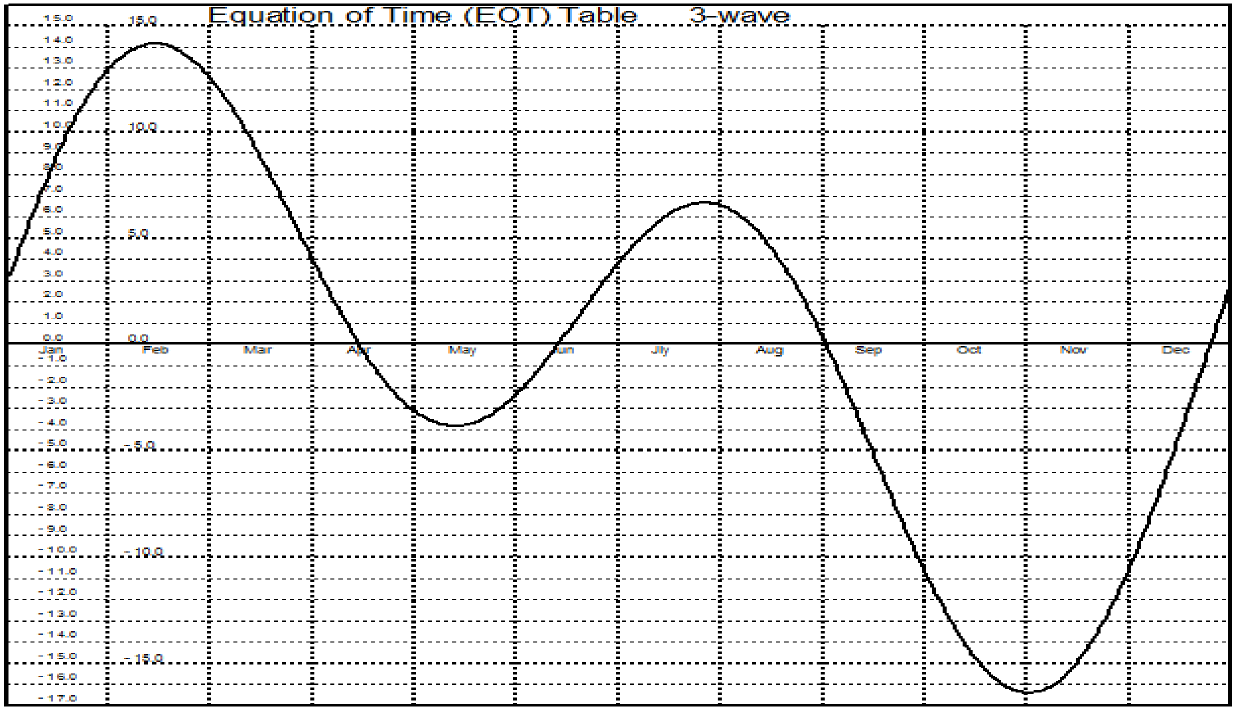
Lat: 33.5 Long: -105.0 co-lat [sh]: 056.5

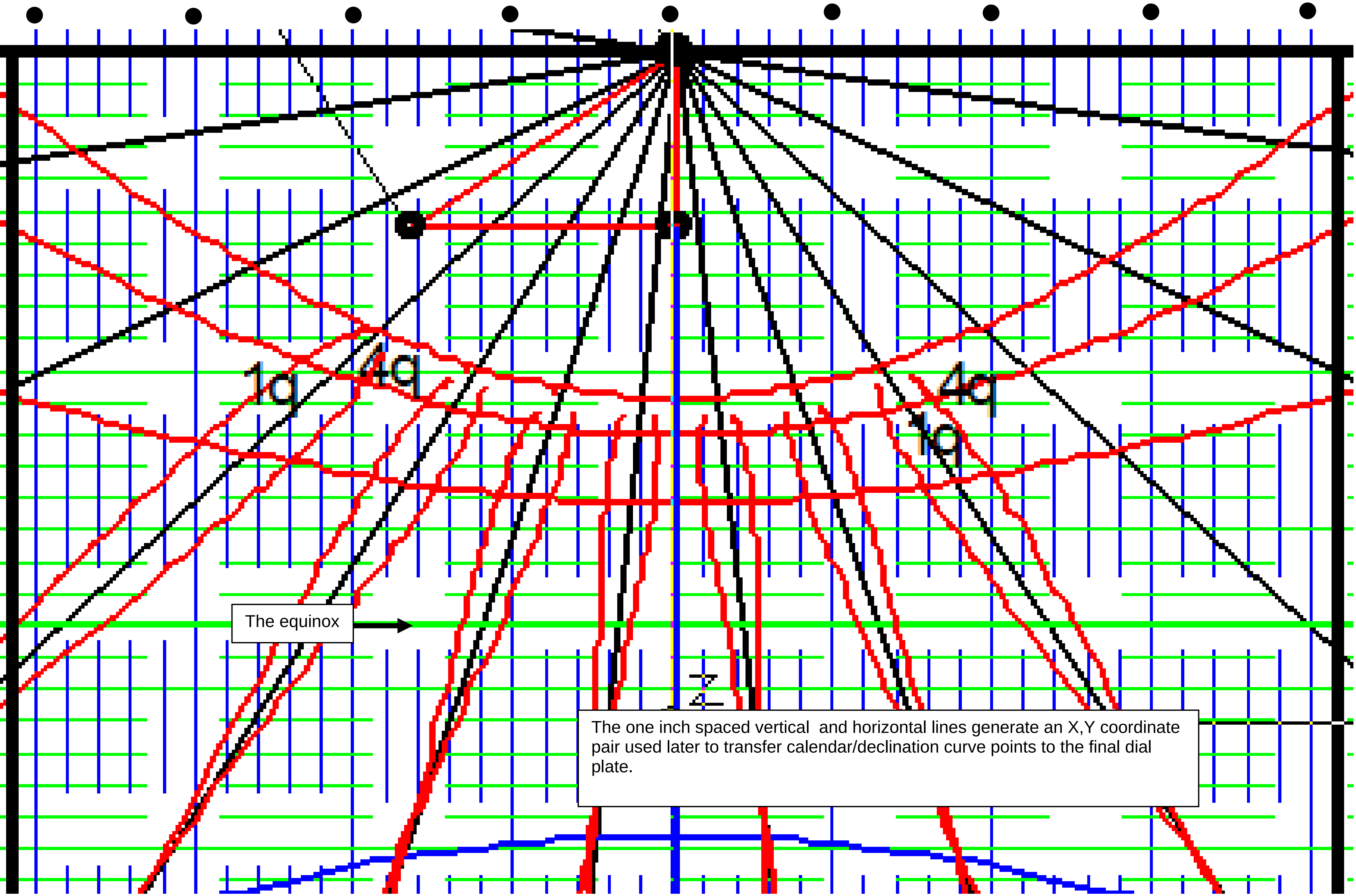
DeltaCAD was used to create the desired dial plate, copied into TurboCAD which is simpler to use when doing some drafting.

The next page shows the DeltaCAD drawing inserted into TurboCAD, and with one inch spaced vertical and horizontal lines used subsequently for X,Y coordinate pairs for calendar or declination curve drafting on the final dial plate.

The dial is 40 inches across and 25 to 30 inches vertically.

The EOT ready for a depiction of 7 inches by 4.25 inches




1q
4q
4q
1q
The equinox
The one inch spaced vertical and horizontal lines generate an X,Y coordinate pair used later to transfer calendar/declination curve points to the final dial plate.

The hour line angles from the "illustratingShadows.xls" spreadsheet.

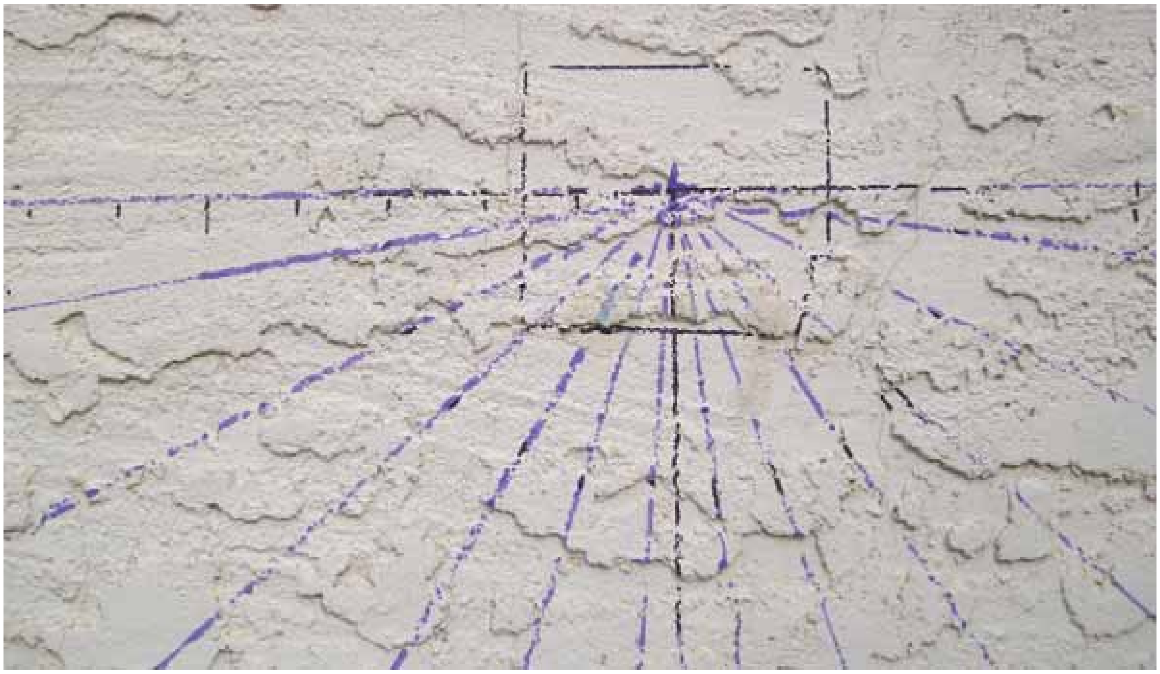
Latitude	33.5	Hour line angles for simple dials
TIME OF DAY		
am	pm	VERTICAL
12.00	12.00	0.00
11.50	0.50	6.27
11.00	1.00	12.60
10.50	1.50	19.06
10.00	2.00	25.71
9.50	2.50	32.61
9.00	3.00	39.82
8.50	3.50	47.38
8.00	4.00	55.30
7.50	4.50	63.59
7.00	5.00	72.19
6.50	5.50	81.03
6.00	6.00	90.00

These have no longitude correction

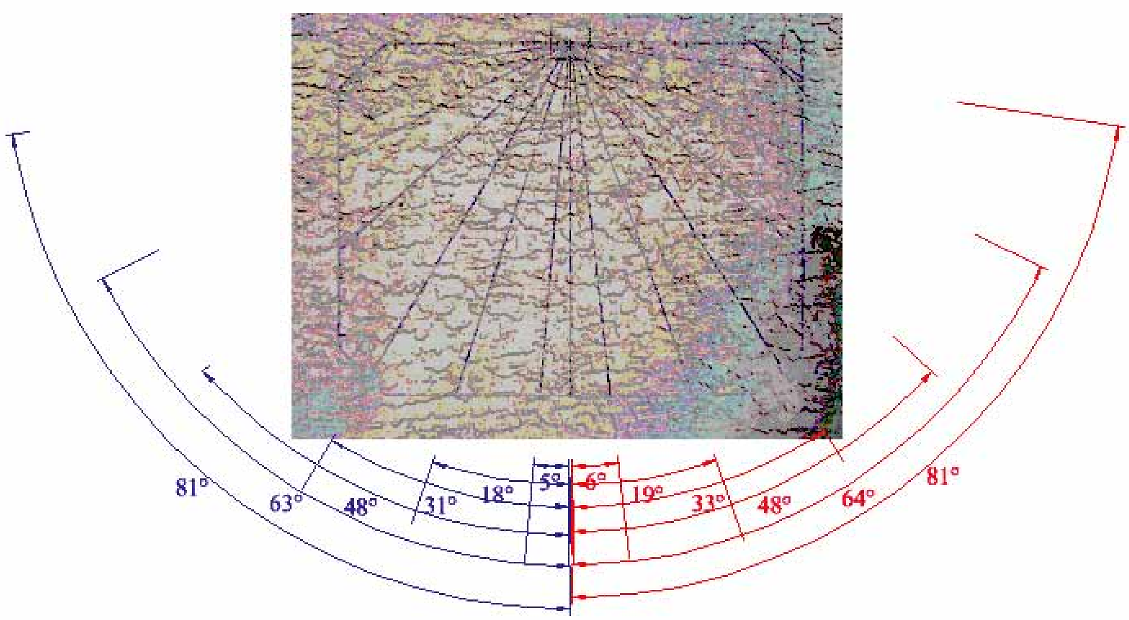
Vertical hour line angles with long corr	
am	pm
5.93	-5.93
12.25	0.33
18.71	6.60
25.35	12.94
32.24	19.40
39.43	26.07
46.97	32.99
54.87	40.22
63.13	47.79
71.72	55.74
80.55	64.04
89.52	72.65
-81.50	81.50

These have longitude correction

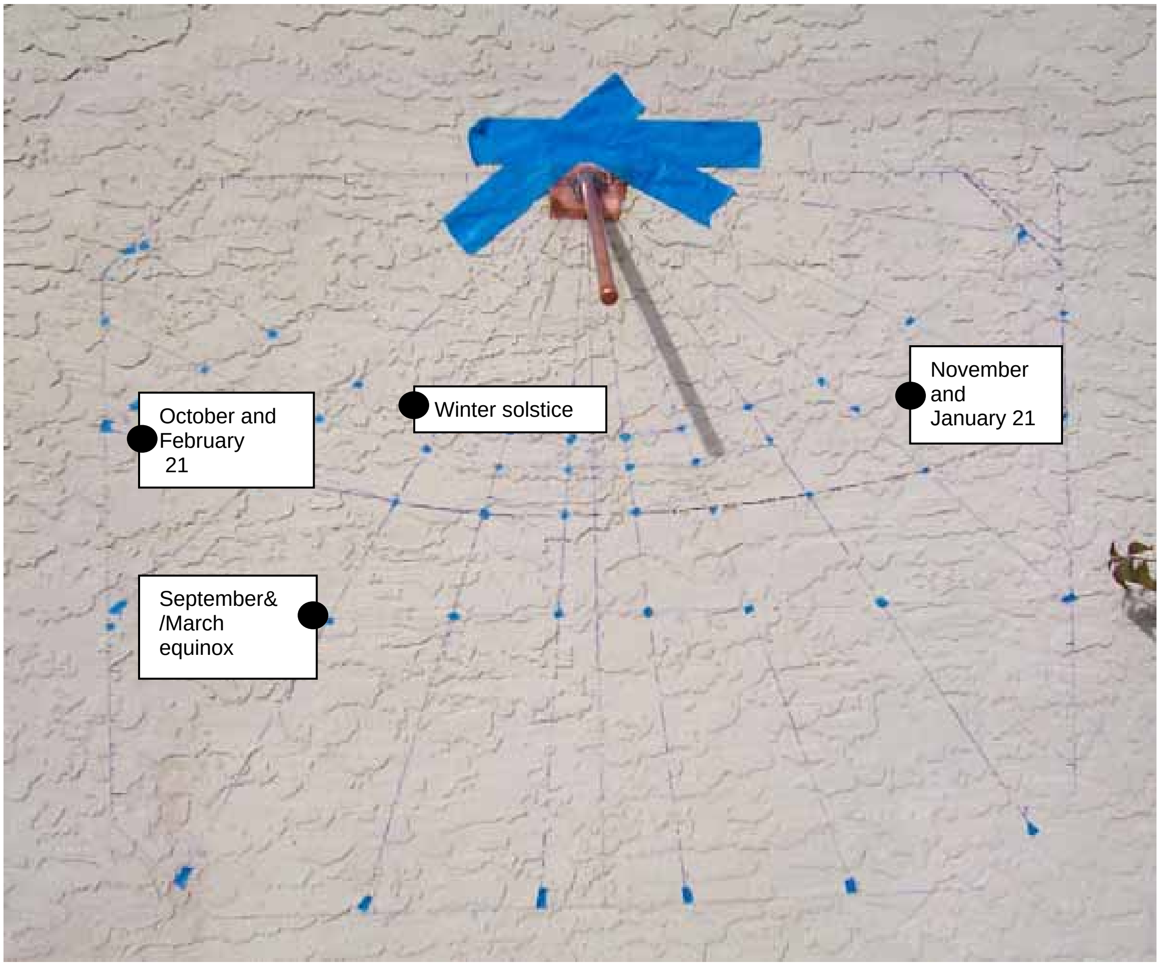
A close up of the dial plate has dial center with one inch markers on the horizontal going through dial center. This is to facilitate calendar (declination) curve drawing. The hour lines were drawn with a simple protractor, and marked on the wall.



The angles were measured in TurboCAD and found to be within a degree of predicted.



After the hour lines were marked, using X,Y coordinate pairs for where the declination (calendar) curves intersect hour lines, they were transposed to the dial plate on the wall.

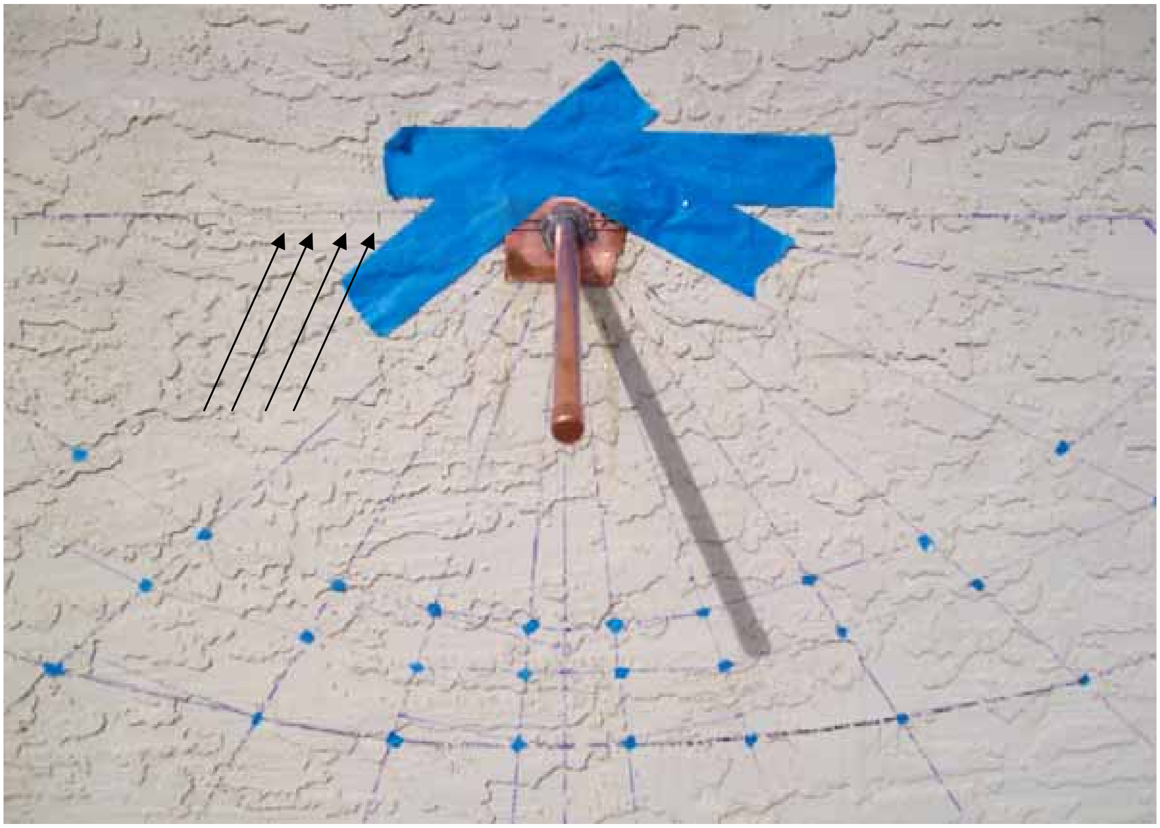


The gnomon was tacked with an epoxy, it will later be secured with Versabond which will also hold a terra cotta sun depiction.

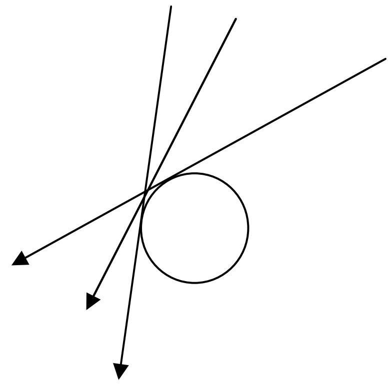
The gnomon is not offset as the picture might suggest, the apparent offset is caused by the camera angle.

The nodus is correctly showing the declination line.

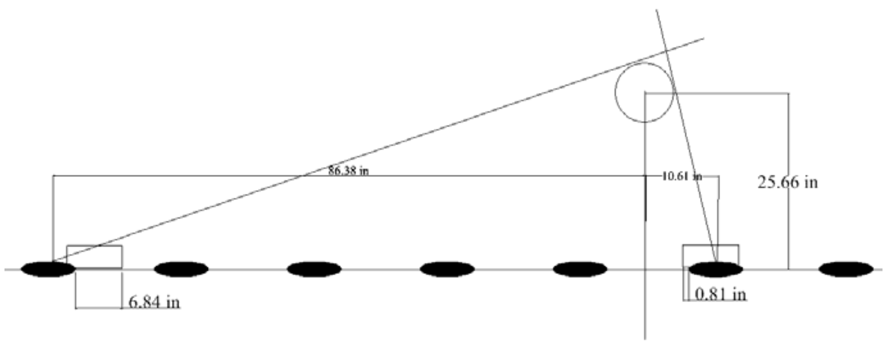
This close up shows the one inch markers on the top of the dial plate boundary. The other edges were also so marked. This made simple the use of X,Y pairs for things such as the calendar curve and hour line intersections.



The planned gnomon was simple copper pipe. However, the shadow edge creates problems, since (1) the style is variable based on the sun's hour angle, (2) the dial center also varies with the sun's hour angle, and (3) the entire mess is convoluted because this was not a painted dial (where the hour lines were usable as is) but raised since the hour lines (and calendar or declination corves) were to made from tiles, thus raising the actual dial plate about 1/3 of an inch away from the vertical wall.



Further, the hour lines were to be marked with tile strips about ¼ inch thick. And that creates a parallax error because they stand out from the original dial plate.

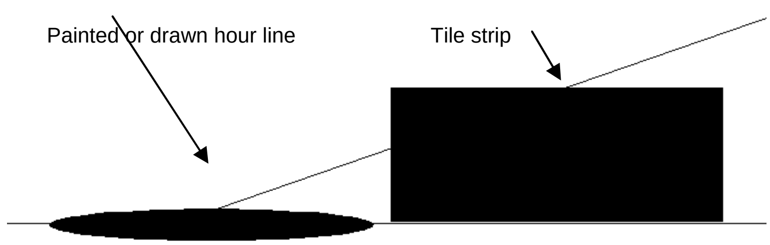


The parallax error is smaller for hours close to noon local apparent time (LAT), but increases as the hours increase from noon LAT, as shown above. In essence, there is no change to the hour line angles, the actual dial plate is lifted up from the dial plate depicted on the wall, and the dial center moves down the style, all by the height of the tile strips AND by the fact the style is a tube and not a thin gnomon.

The correction can be done (1) mathematically, (2) empirically by using the EOT and measuring the shadow, or (3) by projecting a line, perpendicular to the style, to the painted or otherwise marked hour line, and inserting the tile strip such as shown below:

The tile strip is offset so the projecting line meets the center of the painted hour line, and the center of the tile strip.

In this case, I chose the empirical approach.



A sun ornament was slid over the gnomon, through its mouth, and affixed to the wall with Versabond. The borders were similarly affixed to the wall.

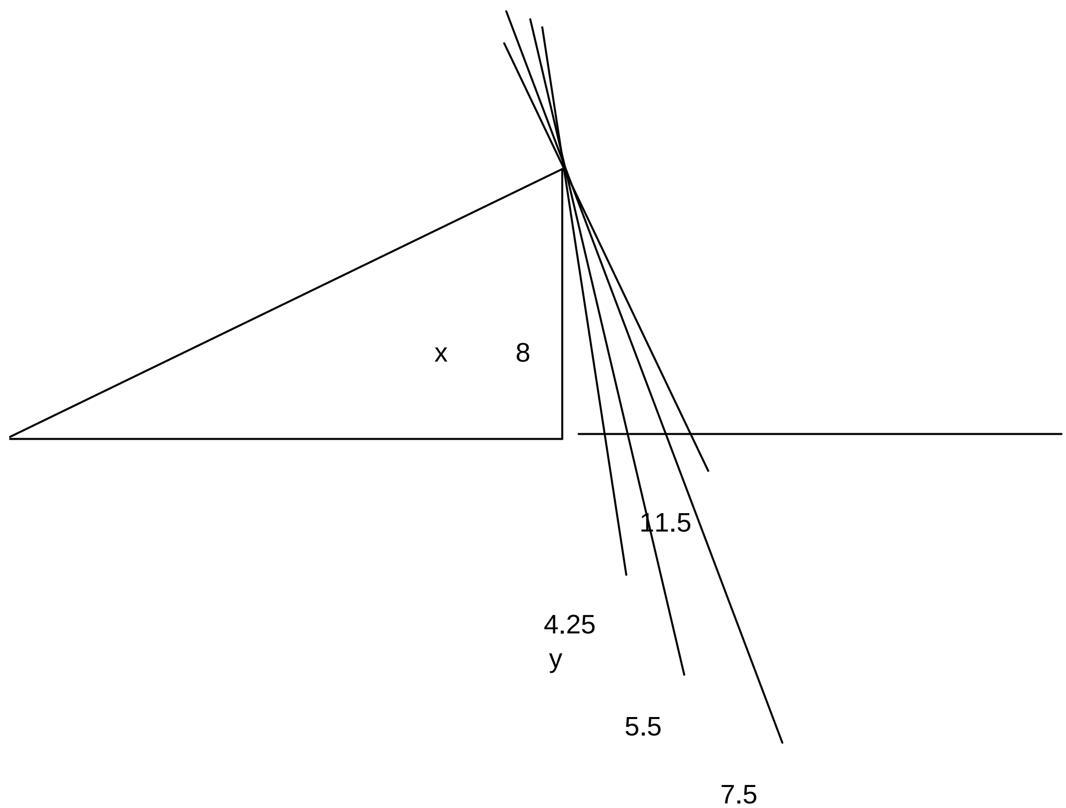
Some 4” corner tiles were added, and some 2” tiles were used to emphasize the equinox line.

Then the hour lines were completed. The equation of time was: sun fast, EOT = - 11.38 (mm.mm), so at the hour, minus 11.38 minutes (11 minutes 23 seconds), the shadow should be on the hour line. This is the empirical approach.

Then gaps in the tile were filled with a sanded grout, and gaps between hour lines had just a thin layer “painted” on rather than fully built up.

Some after the fact calculations for adding declination curves below the dial   May 31, 2012

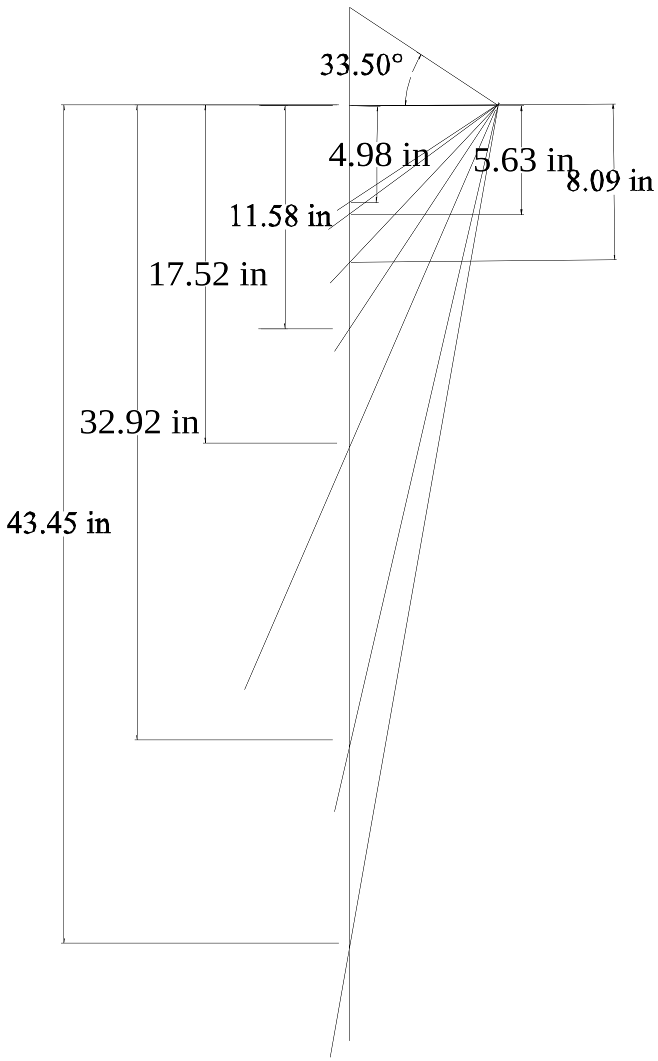
	C	D	E	F	G	H	I	J	K	L	M
3	dist to dec curve, lat=33.5, vertical dial										
4					winter						summer
5	dec				**23.5**	20	10	0	-10	-20	-23.5
6	angle (90-lat)-dec		=(90-E11)-G5		**33**	36.5	46.5	56.5	66.5	76.5	80
7	rad(lat-dec)		=RADIANS(G6)		**0.576**	0.637	0.812	0.986	1.161	1.335	1.396
8	tan(rad(lat-dec))		=C11*TAN(G7)		**5.20**	5.92	8.43	12.09	18.40	33.32	45.37
9											
10	glh		lat								
11	8		33.5								
12											
13											

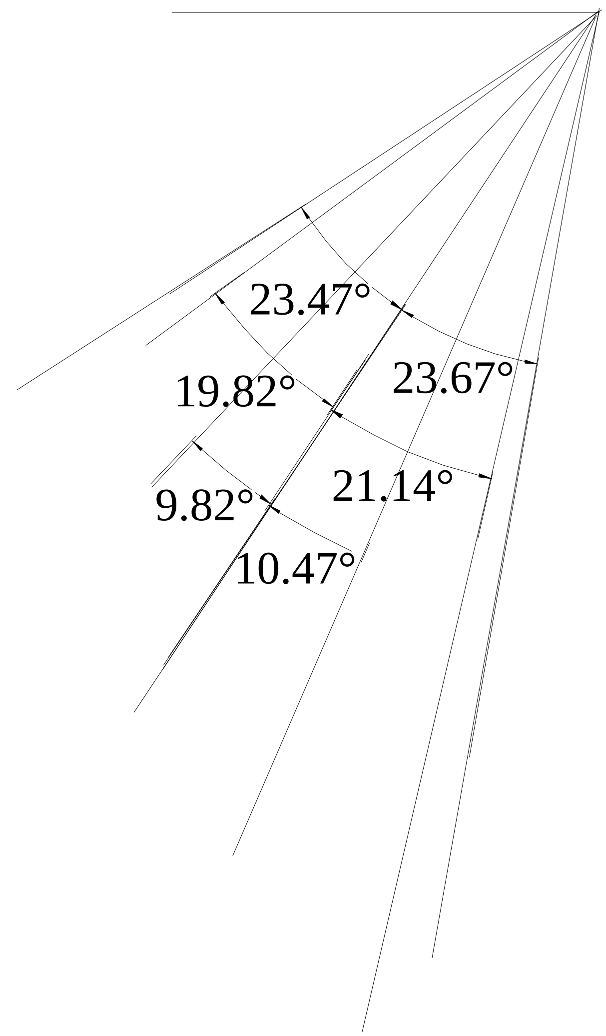


NOTE: standard declinations for the months vary:-

GOOD DECLINATIONS TO USE FOR REASONABLE SYMMETRY FOR THE AMBIGUOUS MONTHS			
23.50	**20**	**10**	0
	or 19 or 18	or 11 or 12	
Jun, Dec	Jan, May	Feb, Apr	Mar, Sep
	Jly, Nov	Aug, Oct	

Using Turbocad:





THE END