PHOENIX
ARIZONA

Latitude: 33.5
Longitude: 112.1
Legal: 105
Magnetic Var/Decl:

City id	Country, State, City			Hemi-sphere	Latitude +n -s	Long +w -e	Mag dec/var	Time ref	Long corr
PHX	USA	AZ	Phoenix	N +ve	33.5	112.2	10.8e	105	28.8
SDL	USA	AZ	Scottsdale	N +ve	33.6	111.9	10.8e	105	27.6

true bearing = magnetic + 10.8˚

Various sundials

The latitude for Phoenix was chosen as 33.5˚ N, and 112.2˚W +/- 0.1˚. The property was analyzed using Google, and the house parameters appeared to square with the true cardinal points. They were then measured with a Brunton compass, and considering the magnetic declination (variation), it also appeared to be aligned with the true cardinal points.

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	GENERIC EOT		
	5th	15th	25th
JAN	5.1	9.0	12.0
FEB	13.9	14.2	13.4
MAR	11.9	9.3	6.3
APR	2.8	0.0	-2.3
MAY	-3.6	-4.0	-3.5
JUN	-2.0	-0.1	2.0
JLY	3.9	5.3	5.9
AUG	5.4	3.8	1.4
SEP	-2.2	-5.8	-9.4
OCT	-12.7	-15.1	-16.5
NOV	-16.5	-15.1	-12.5
DEC	-8.8	-4.5	0.2

Julian Day:	172	for mm and dd:	6 21
EOT mm.m:	01.1	EOT (Sun is slow)	
Long.Corr mm.m:	28.4	lat:	33.50
Net.Corr mm.m:	029.5	lng:	112.10
Declination:	23.5	ref:	105.0

Sunrise/set & Alt/Azi uncorrected

Rise hhmm: 0453 Set: 1907 Add this corr to sunrise/set etc

correction is mm.m + 29.5

Hours below are from local solar noon:

HH:	5	Alt:	1.2	Azi:	-62.4	h-dial angle:	-64.1	v-dial:	-72.2
HH:	6	Alt:	12.7	Azi:	-70.1	h-dial angle:	90.0	v-dial:	90.0
HH:	7	Alt:	24.7	Azi:	-77.2	h-dial angle:	64.1	v-dial:	72.2
HH:	8	Alt:	37.0	Azi:	-84.3	h-dial angle:	43.7	v-dial:	55.3
HH:	9	Alt:	49.5	Azi:	87.7	h-dial angle:	28.9	v-dial:	39.8
HH:	10	Alt:	61.9	Azi:	76.9	h-dial angle:	17.7	v-dial:	25.7
HH:	11	Alt:	73.5	Azi:	56.5	h-dial angle:	8.4	v-dial:	12.6
HH:	12	Alt:	80.0	Azi:	0.0	h-dial angle:	0.0	v-dial:	0.0

Julian Day:	356	for mm and dd:	12 22
EOT mm.m:	-01.2	EOT (Sun is fast)	
Long.Corr mm.m:	28.4	lat:	33.50
Net.Corr mm.m:	027.2	lng:	112.10
Declination:	-23.4	ref:	105.0

Sunrise/set & Alt/Azi uncorrected

Rise hhmm: 0707 Set: 1653 Add this corr to sunrise/set etc

correction is mm.m + 27.2

Hours beloware from local solar noon:

HH:	5	Alt:	-24.7	Azi:	77.3	h-dial angle:	-64.1	v-dial:	-72.2
HH:	6	Alt:	-12.7	Azi:	70.1	h-dial angle:	90.0	v-dial:	90.0
HH:	7	Alt:	-1.2	Azi:	62.4	h-dial angle:	64.1	v-dial:	72.2
HH:	8	Alt:	9.4	Azi:	53.7	h-dial angle:	43.7	v-dial:	55.3
HH:	9	Alt:	18.8	Azi:	43.3	h-dial angle:	28.9	v-dial:	39.8
HH:	10	Alt:	26.3	Azi:	30.8	h-dial angle:	17.7	v-dial:	25.7
HH:	11	Alt:	31.3	Azi:	16.1	h-dial angle:	8.4	v-dial:	12.6
HH:	12	Alt:	33.1	Azi:	0.0	h-dial angle:	0.0	v-dial:	0.0

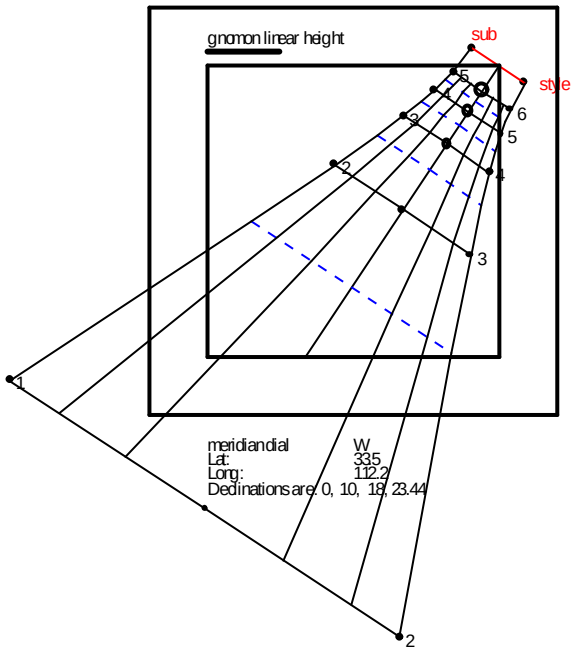
LAT	LONG	ref:long
33.50	112.20	105
location name or data		

NOTE: Tables are based on the LAT, LONG and time
zone reference in the boxes to the left. EOT is used.

Summer time is not considered. EOT is mm.mm

				LEGAL TIME		Daylight	Sunrise	Noon
Date	Julian	decl	eot m.mm	rise h.hh	set h.hh	duration	azimuth	altitude
1/5	5	-22.7	5.1	7.64	17.49	9.86	62.4	33.8
1/15	15	-21.3	9.0	7.63	17.63	10.01	64.2	35.2
1/25	25	-19.2	12.0	7.57	17.79	10.23	66.8	37.3
2/5	36	-16.2	13.9	7.45	17.97	10.52	70.5	40.3
2/15	46	-13.0	14.2	7.30	18.13	10.83	74.4	43.5
2/25	56	-9.4	13.4	7.12	18.28	11.16	78.7	47.1
3/5	64	-6.3	11.9	6.96	18.40	11.44	82.4	50.2
3/15	74	-2.4	9.3	6.74	18.53	11.78	87.1	54.1
3/25	84	1.5	6.3	6.52	18.65	12.13	91.8	58.0
4/5	95	5.8	2.8	6.27	18.78	12.51	96.9	62.3
4/15	105	9.5	0.0	6.06	18.90	12.85	101.4	66.0
4/25	115	12.9	-2.3	5.86	19.02	13.16	105.6	69.4
5/5	125	16.0	-3.6	5.69	19.15	13.46	109.3	72.5
5/15	135	18.7	-4.0	5.55	19.27	13.72	112.6	75.2
5/25	145	20.8	-3.5	5.45	19.39	13.94	115.2	77.3
6/5	156	22.5	-2.0	5.39	19.51	14.12	117.3	79.0
6/15	166	23.3	-0.1	5.37	19.58	14.21	118.3	79.8
6/25	176	23.4	2.0	5.40	19.62	14.22	118.5	79.9
7/5	186	22.9	3.9	5.46	19.63	14.16	117.8	79.4
7/15	196	21.7	5.3	5.55	19.58	14.03	116.3	78.2
7/25	206	19.8	5.9	5.66	19.50	13.84	114.0	76.3
8/5	217	17.2	5.4	5.78	19.36	13.58	110.8	73.7
8/15	227	14.3	3.8	5.90	19.19	13.30	107.2	70.8
8/25	237	11.0	1.4	6.01	19.00	12.99	103.3	67.5
9/5	248	7.1	-2.2	6.13	18.76	12.63	98.5	63.6
9/15	258	3.3	-5.8	6.24	18.53	12.30	94.0	59.8
9/25	268	-0.5	-9.4	6.35	18.30	11.95	89.4	56.0
10/5	278	-4.4	-12.7	6.46	18.07	11.61	84.7	52.1
10/15	288	-8.2	-15.1	6.59	17.86	11.27	80.1	48.3
10/25	298	-11.8	-16.5	6.74	17.67	10.94	75.8	44.7
11/5	309	-15.5	-16.5	6.91	17.50	10.59	71.4	41.0
11/15	319	-18.3	-15.1	7.07	17.38	10.31	67.9	38.2
11/25	329	-20.6	-12.5	7.23	17.31	10.08	65.0	35.9
12/5	339	-22.3	-8.8	7.38	17.28	9.90	63.0	34.2
12/15	349	-23.2	-4.5	7.51	17.31	9.80	61.8	33.3
12/25	359	-23.4	0.2	7.59	17.37	9.78	61.6	33.1
3/20	79	-0.5	7.9	6.63	18.59	11.96	89.4	56.0
6/21	172	23.5	1.1	5.39	19.61	14.22	118.5	80.0
9/22	265	0.6	-8.4	6.31	18.37	12.06	90.8	57.1
12/21	355	-23.4	-1.7	7.56	17.34	9.78	61.5	33.1

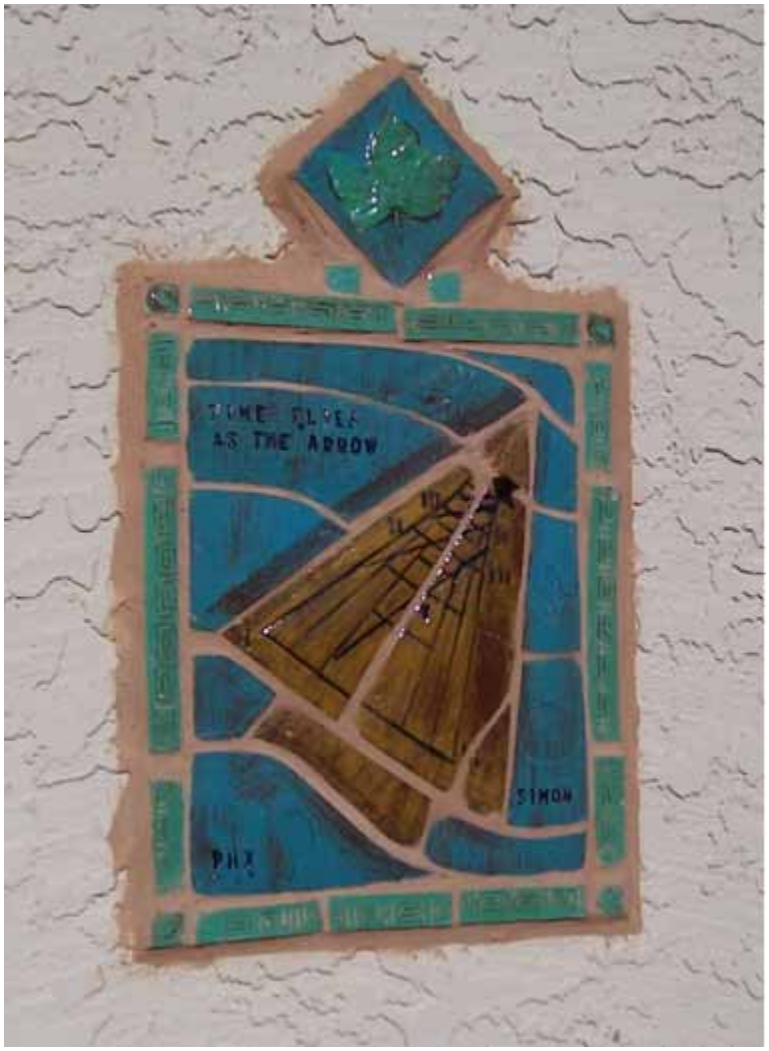
MERIDIAN TRUE WEST FACING DIAL



The first dial made was a true west facing meridian dial.

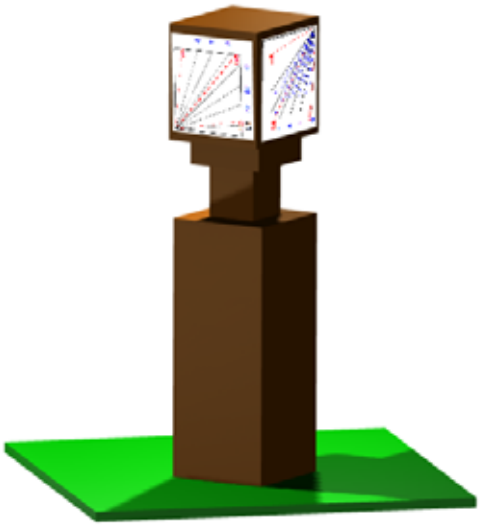
This picture was taken immediately after the grout was applied to the ceramic tiles, which were affixed to the wall with Versabond.

Some of the roughness of the final grout will disappear when the grout has dried, and with other touchup work.

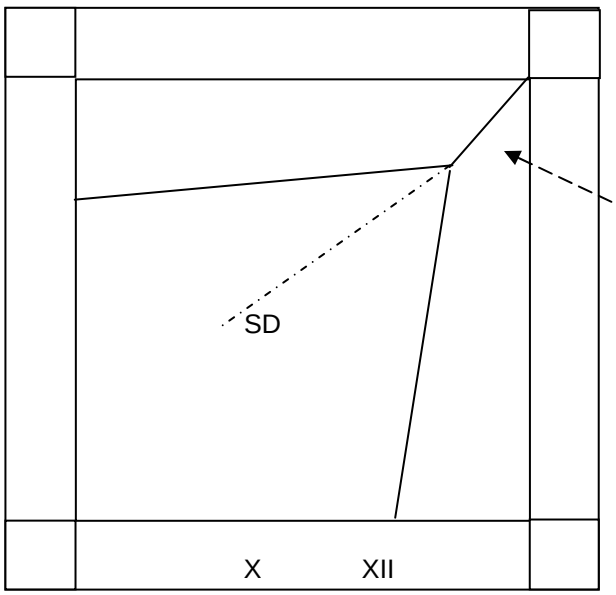


PILLAR CUBE DIAL 45 degree declining

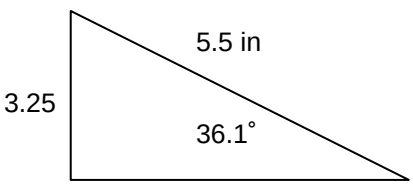
45 degrees offset from the cardinal points



1 inch border

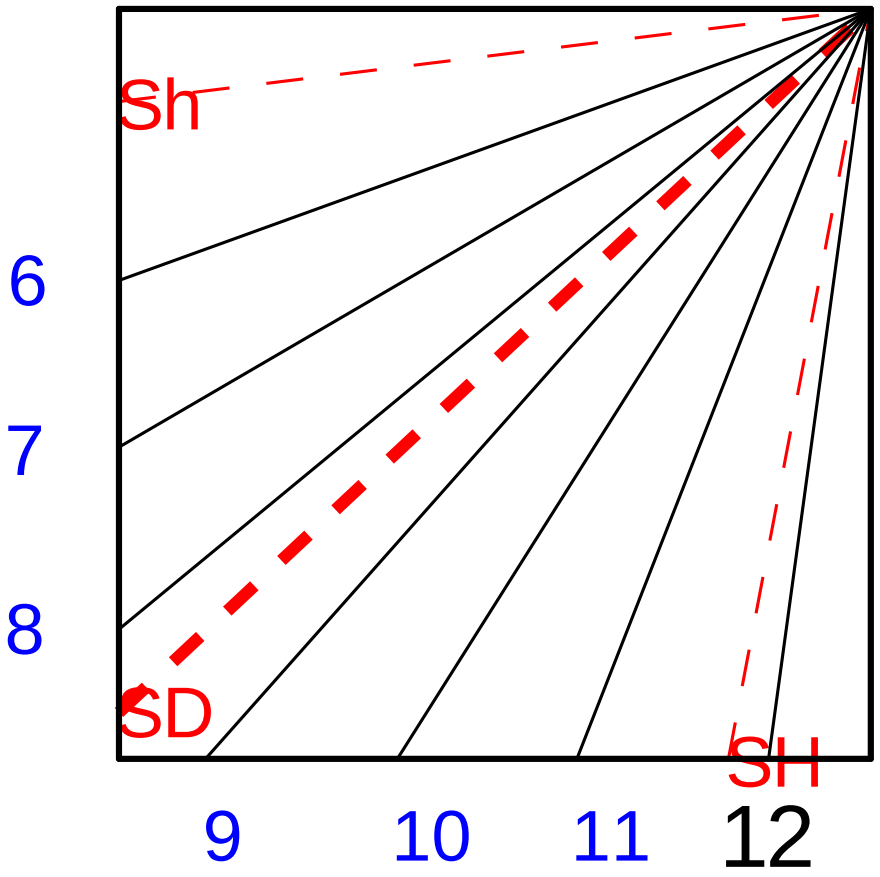


Roman numbers
on horizontal and
not vertical border



PHOENIX

S 45 E vertical decliner



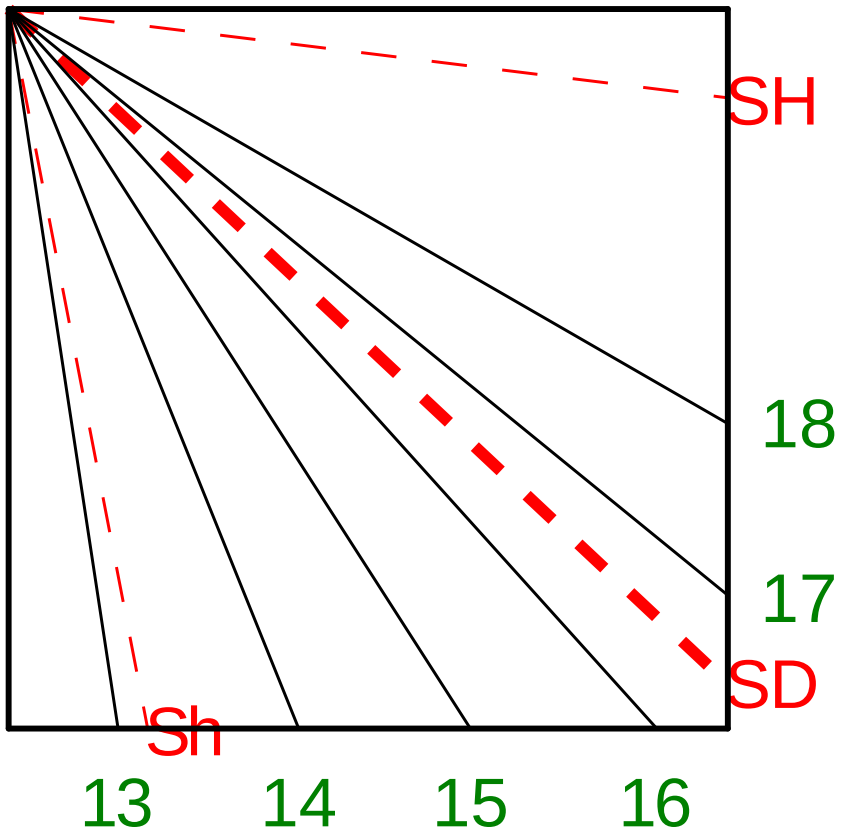
Hour and hour line angle VERTICAL DECLINER DL= 53.9

6	7	8	9	10	11	12	13	14	15	16	17	18
-70.2	-59.7	-50.5	-41.6	-32.2	-21.4	-07.9	09.9	32.8	58.0	80.0	-83.0	-70.2

Lat: 33.5 Long: 112.2 Dec: 45 SE /*
SD: -46.9 SH: 36.1

PHOENIX

S 45 W vertical decliner

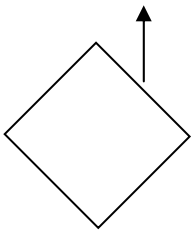


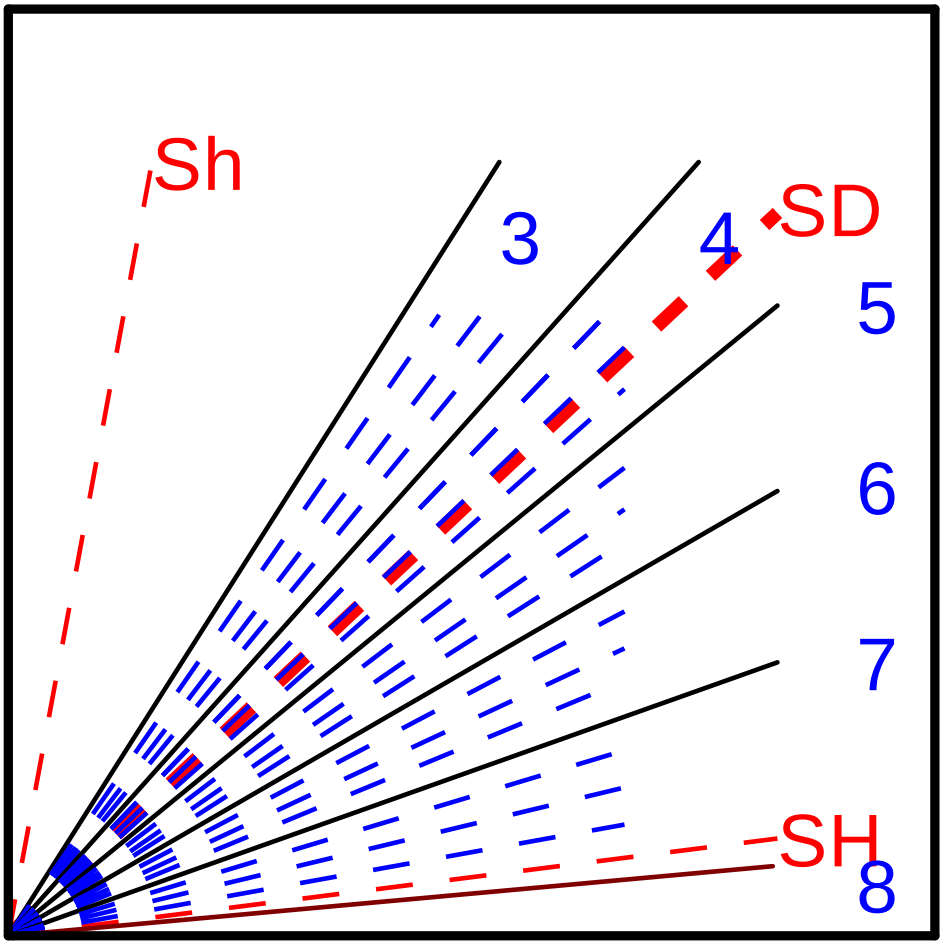
Hour and hour line angle VERTICAL DECLINER DL= -68.3

6	7	8	9	10	11	12	13	14	15	16	17	18
60.1	70.6	83.6	-79.3	-57.0	-31.8	-09.1	08.5	21.9	32.6	42.0	50.9	60.1

Lat: 33.5 Long: 112.2 Dec: -45 SW *\
SD: 46.9 SH: 36.1

PHOENIX
S 135 E vertical decliner



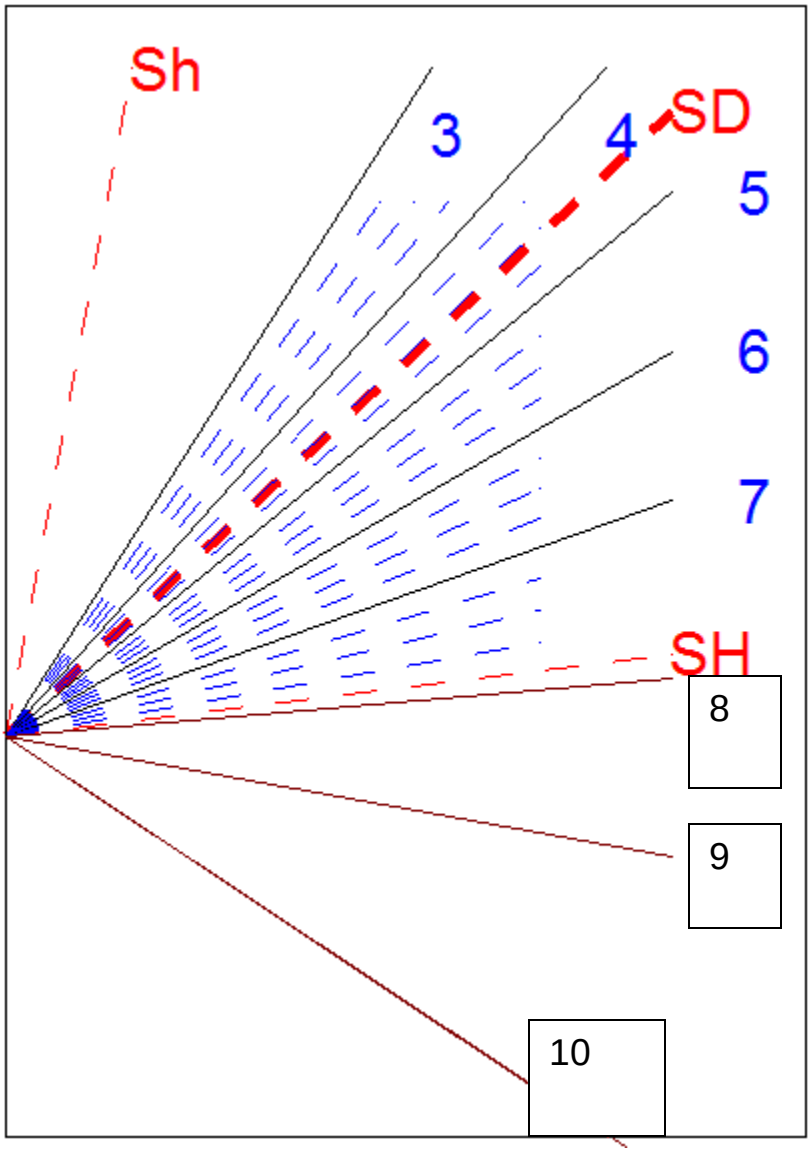


POLAR VERTICAL DECLINER Hour:Hourline angle

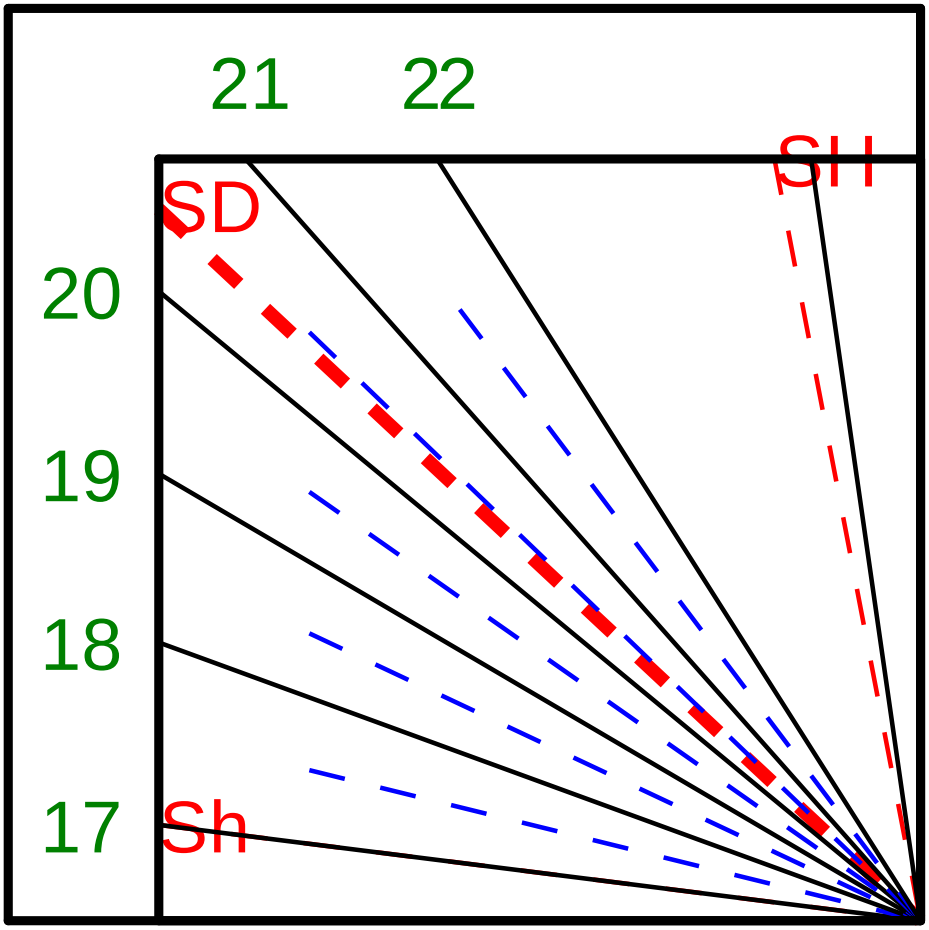
3	4	5	6	7	8		17	18	19	20	21	22
-32.6	-42.0	-50.9	-60.1	-70.6	-83.6		-50.9	-60.1	-70.6	-83.6	79.3	57.0
											10.7	33.0
57.4	48.0	39.1	29.9	19.4	06.4		39.1	29.9	19.4	06.4		

Lat: 33.5 Long: 112.2 Dec: 135 NE *
SD: 46.9 SH: -36.1

S 135 E or N 45 E but with more hours



PHOENIX
S 135 W vertical decliner

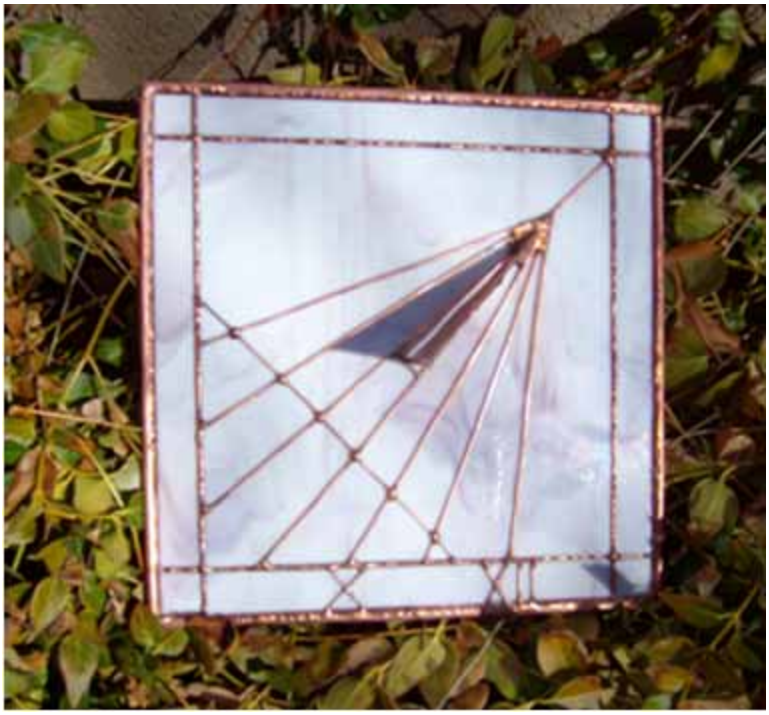


POLAR VERTICAL DECLINER Hour:Hourline angle

3	4	5	6	7	8	17	18	19	20	21	22
-58.0	-80.0	83.0	70.2	59.7	50.5	83.0	70.2	59.7	50.5	41.6	32.2
		07.0	19.8	30.3	39.5	07.0	19.8	30.3	39.5	48.4	57.8
32.0	10.0										

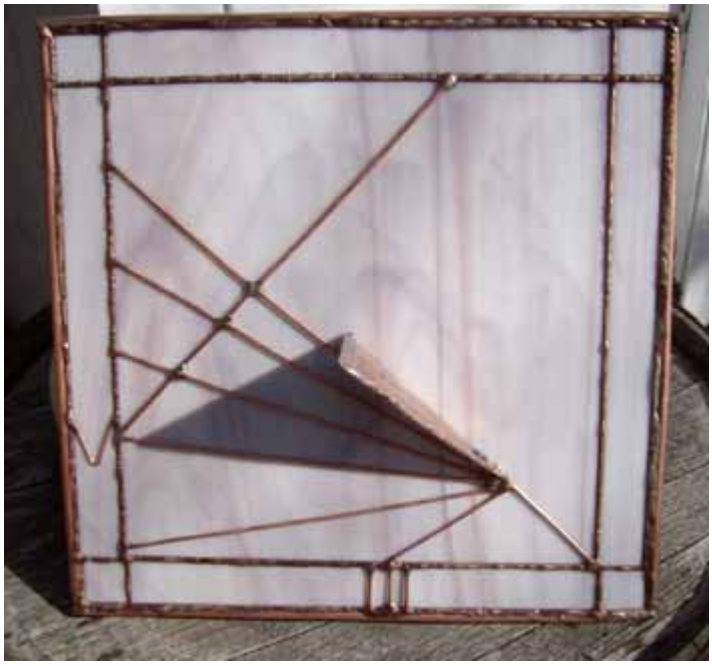
Lat: 33.5 Long: 112.2 Dec: -135 NW */
SD: -46.9 SH: -36.1

S45E dial plate



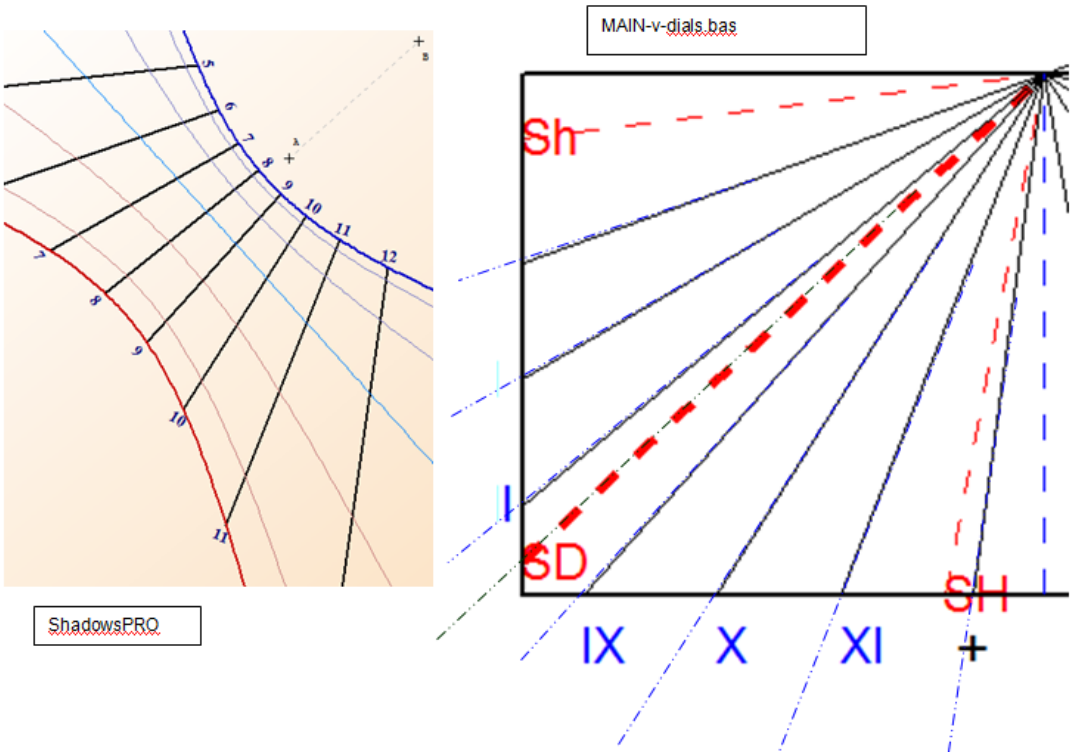
N45E dial plate

N45W dial plate



The dial in place **after stucco applied**

After installation, the S 45 E dial plate, while accurate at 7 and 8 am, was off for some hours.



First, the DeltaCAD macro was compared to ShadowsPRO, and it matched. A good sign. Then the printed dial plate was slid between the filigree dial plate hour lines and the glass backing. For some reason, the 11 and 12 hours were off, in other words, I screwed up when I transposed the hour lines to copper wire filigree on the glass backing.

Since the dial plate was already set, a heavier duty solder iron was used, the equinox line segments removed, the hour lines reset, and new equinox wire inserted. The dial plate re-cleaned, and copper patina applied.

The actual shadows were marked, then the wires were unsoldered and reset.

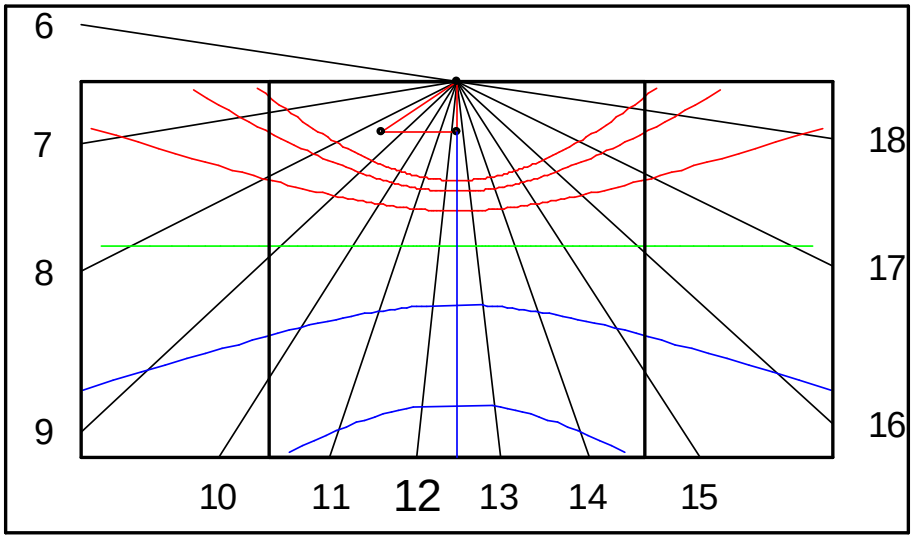
Because the hour lines were a filigree as opposed to cut into the glass, this was easy to do. And, the DeltaCAD dial plate was slid in behind the hour lines, and they matched.

The problem was the original transposition from the DeltaCAD drawing to the bare glass.

TRUE SOUTH FACING DIAL

The next dial plate needed was a true south facing dial. The dial plate was built with the DeltaCAD macro for vertical dials, available free on the web site:-

www.illustratingshadows.com

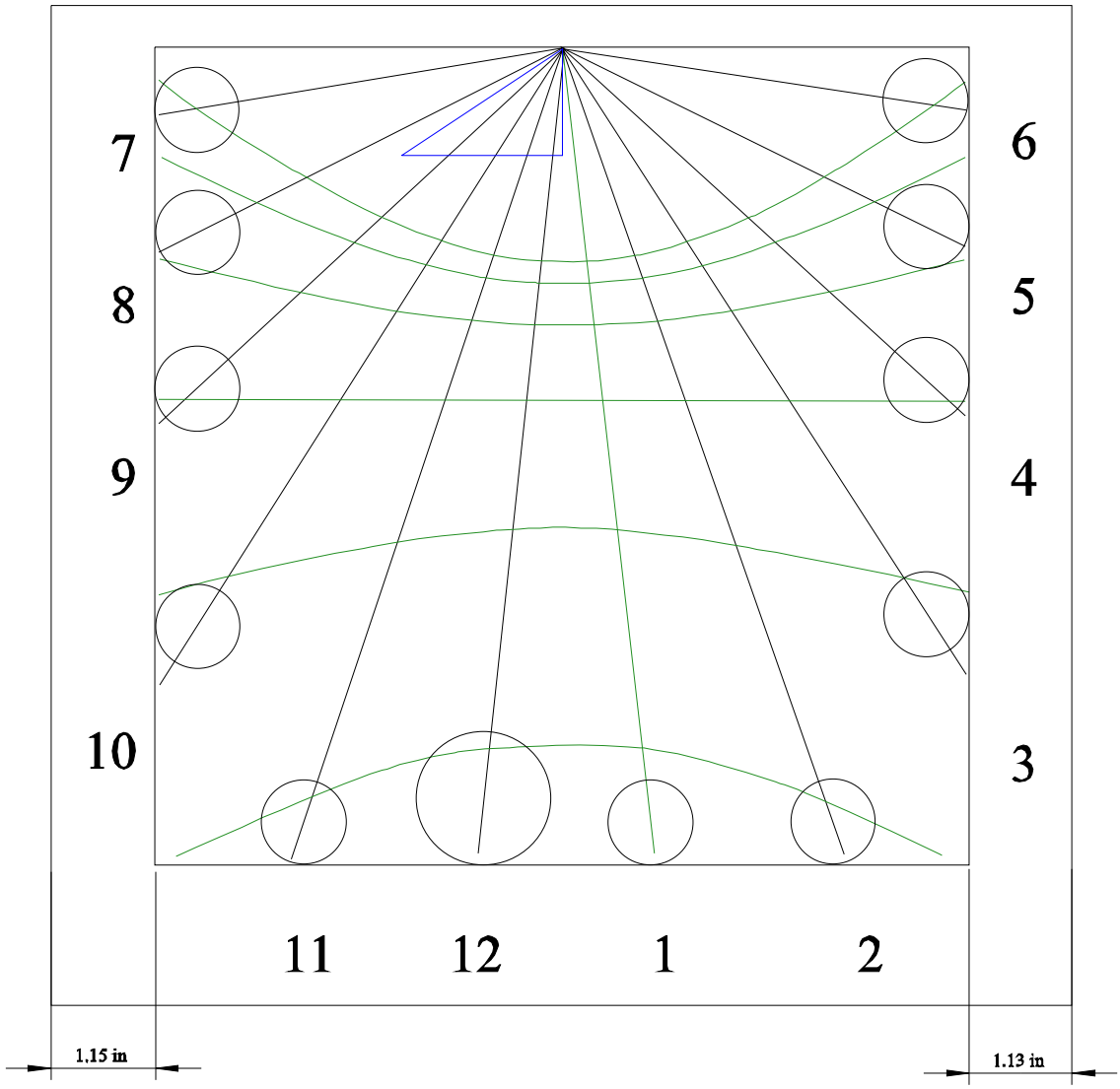


v-dial and calendar using gnomon linear height

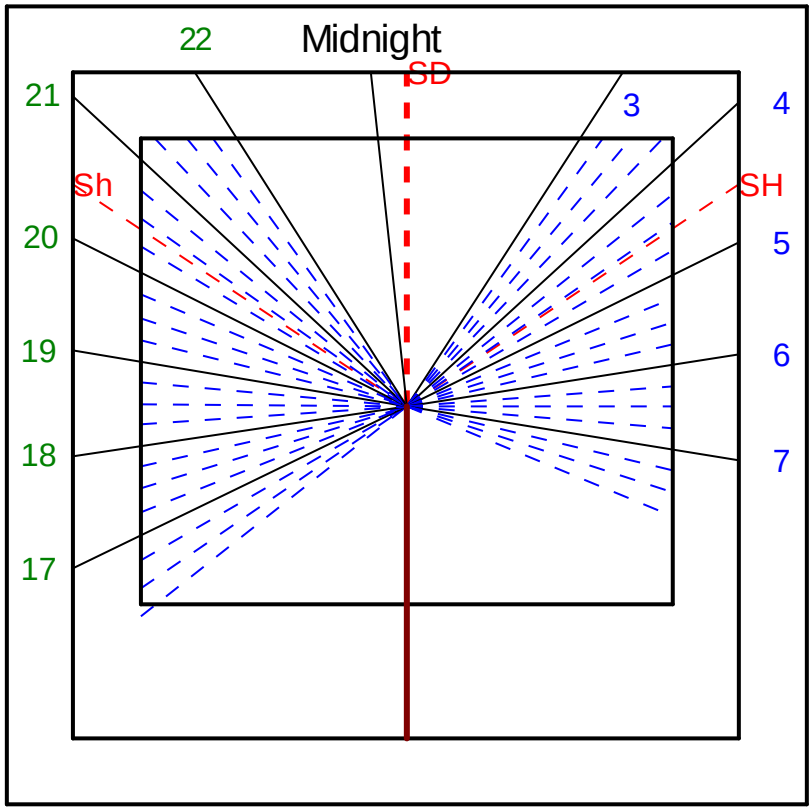
Lat: 33.5 d.Long: -07.2

18	17	16	15	14	13	12	11	10	9	8	7	6
-81.4	-63.9	-47.7	-32.9	-19.3	-06.5	06.0	18.8	32.3	47.1	63.2	80.7	-81.4

Hours above horizontal use the 90 reference line below horizontal.
Declinations used are: 0, 10, 18, 23.44


7
6
8
5
9
4
10
3
11
12
1
2
1.15 in
1.13 in

TRUE NORTH FACING DIAL

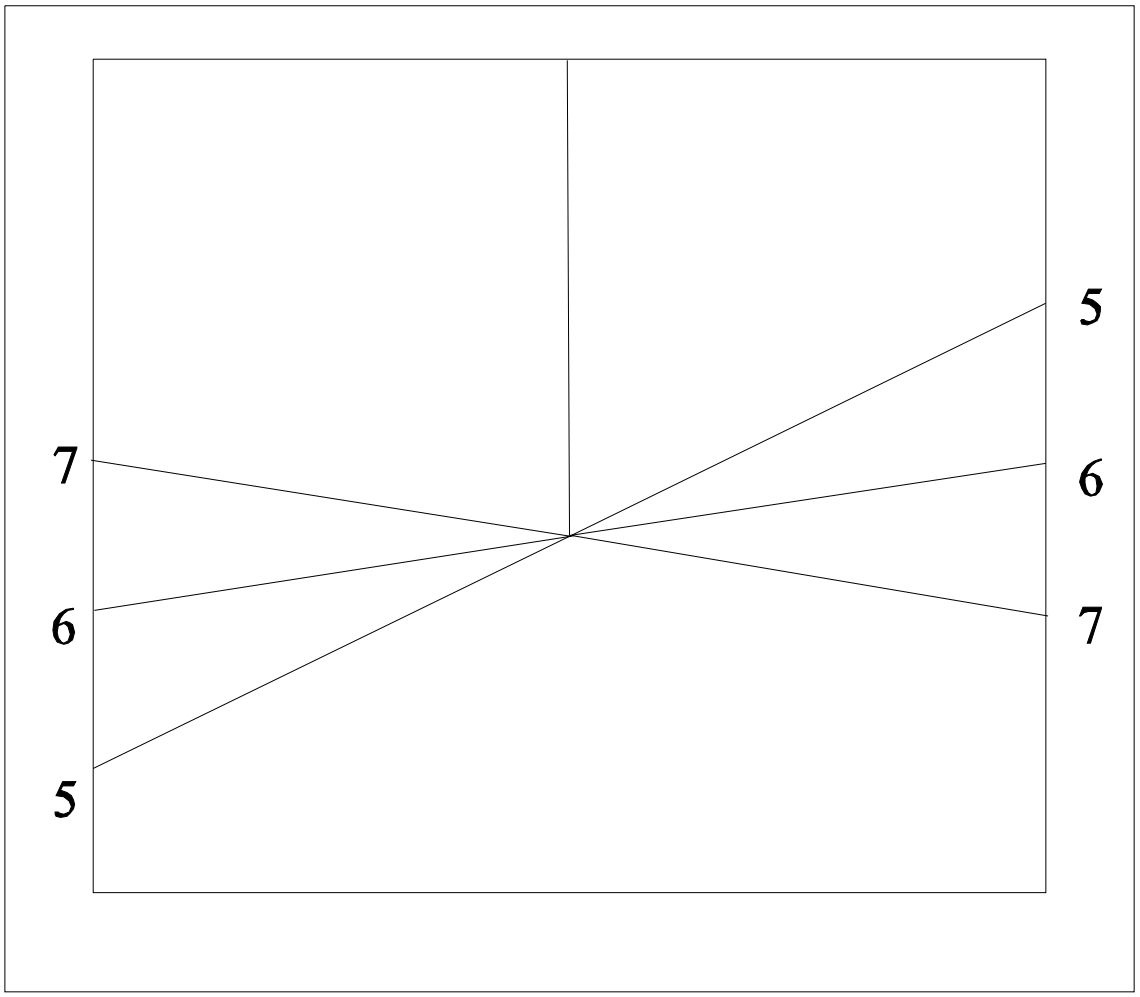


POLAR VERTICAL DECLINER Hour:Hourline angle

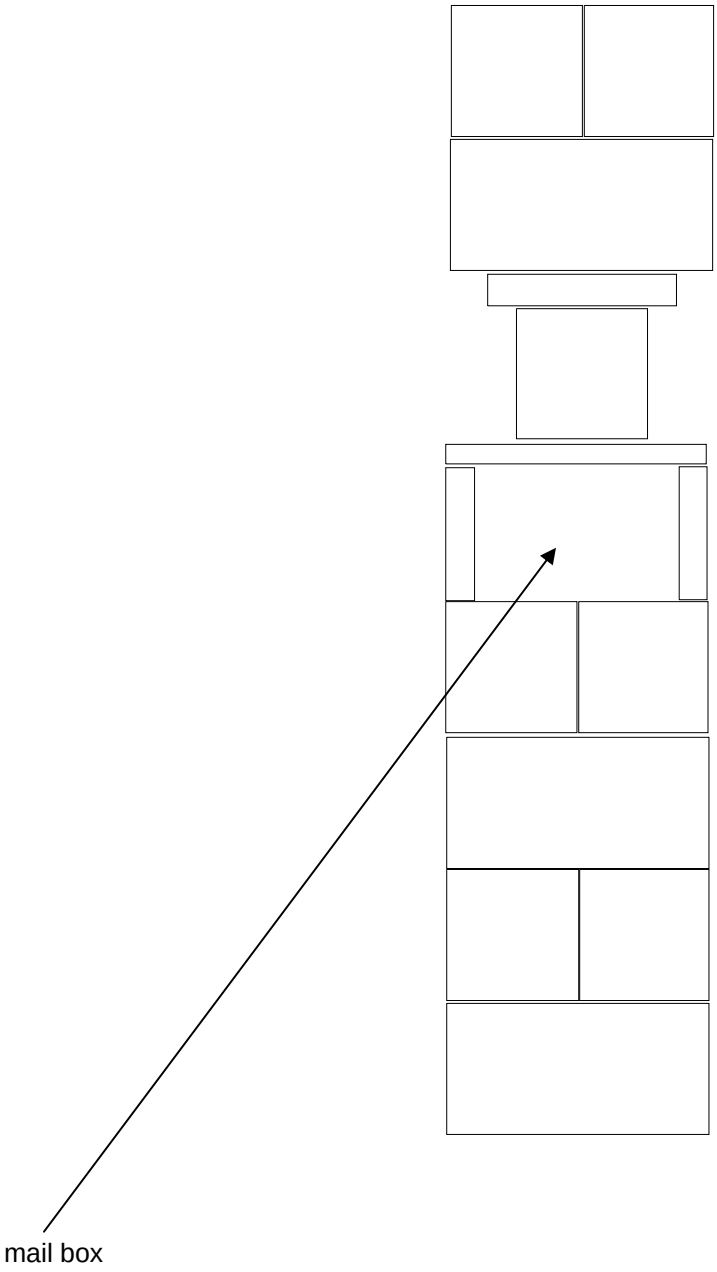
3	4	5	6	7	8	17	18	19	20	21	22
-32.9	-47.7	-63.9	-81.4	80.7	63.2	-63.9	-81.4	80.7	63.2	47.1	32.3
				09.3	26.8			09.3	26.8	42.9	57.7
57.1	42.3	26.1	08.6			26.1	08.6				

Lat: 33.5 Long: 112.2 Dec: 180 N /\

SD: 00.0 SH: -56.5

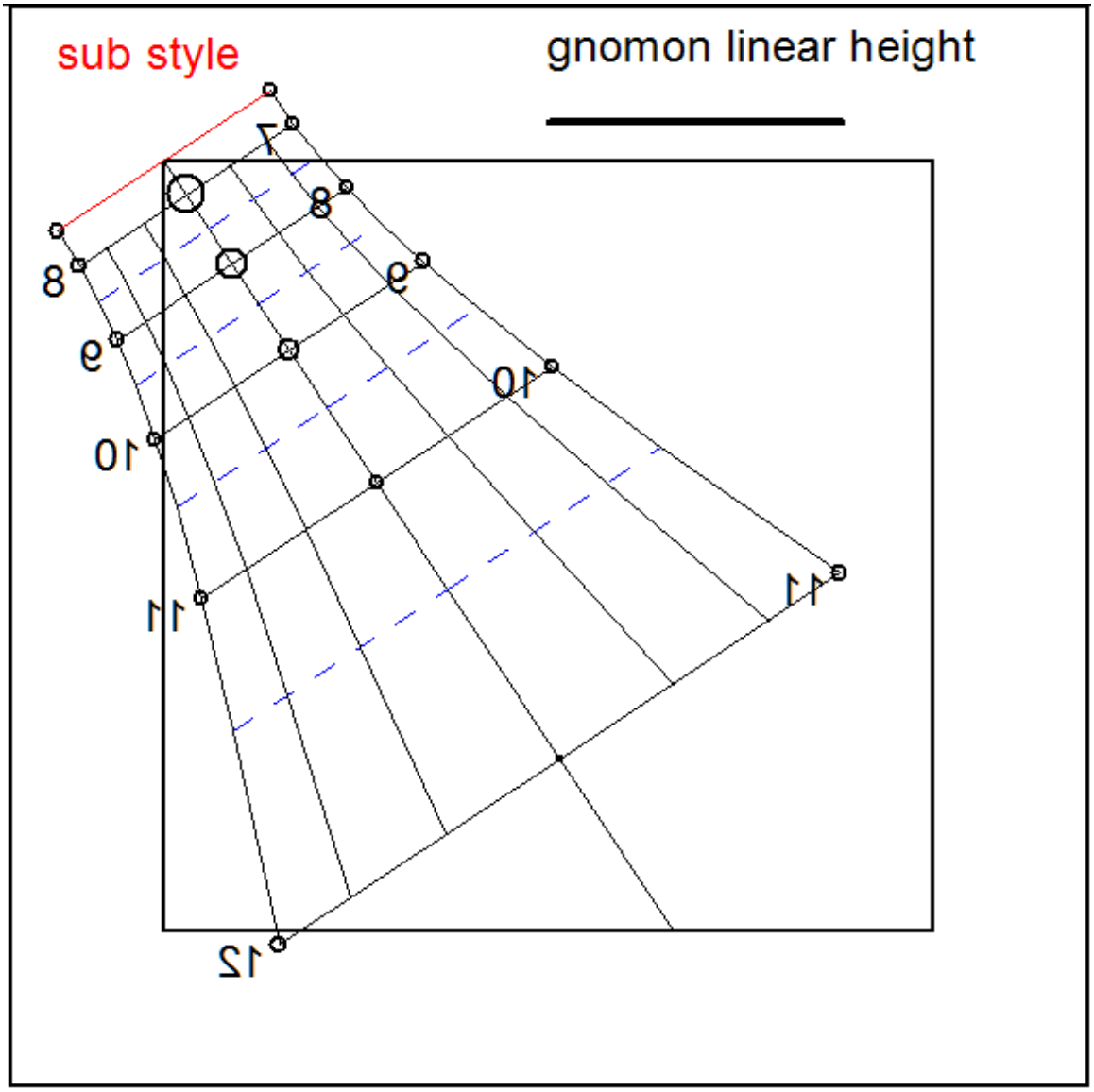

7
6
5
5
6
7

PILLAR CUBE DIAL NSEW ~ not declining

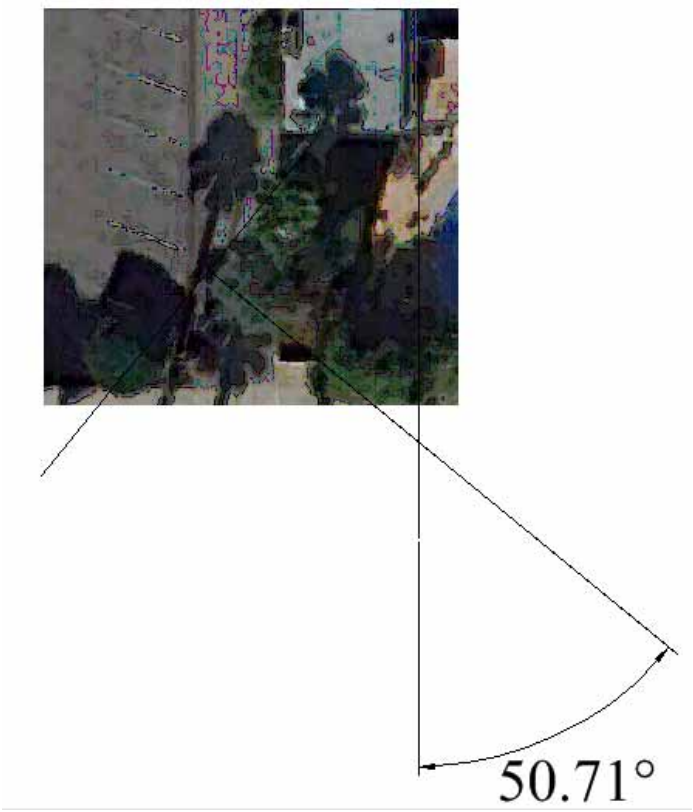


12	8*8*16	1 sack concrete
1	8*8*8	1 sac mortar
1	12*4*12	1 box stucco powder
6	2*8*16	some versabond

East facing plates



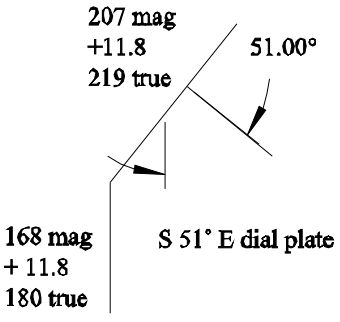
PHOENIX, S 51 E decliner



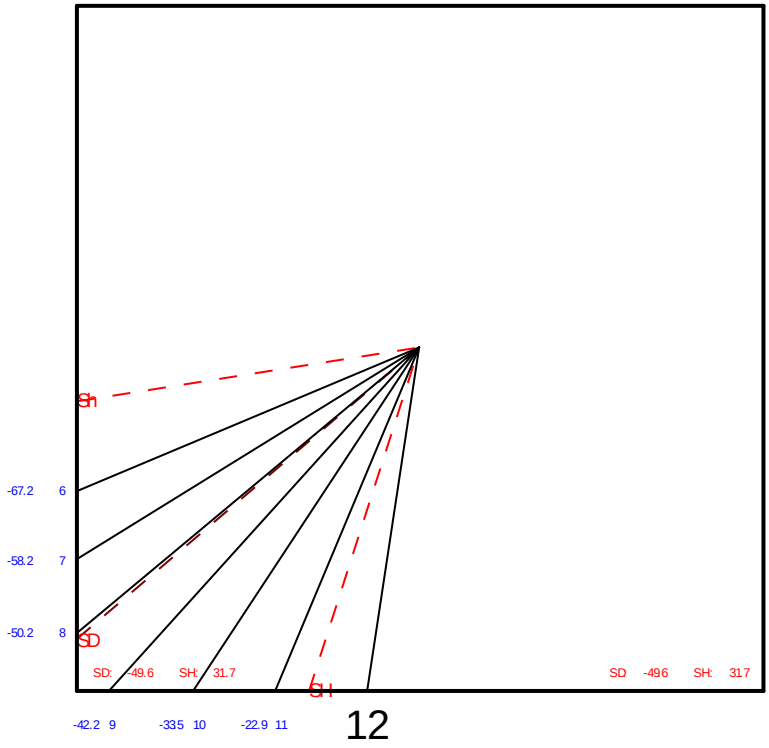
A wall was angled from the meridian. Google showed it to be S 51˚ E

A Brunton compass showed the magnetic wall alignment to be 207 degrees.
Add the easterly declination/variation to get 219 degrees true.
And 219 – 90 is 129 degrees, and that from 180 gives us 51 degrees. The wall facing SE is thus:-

S 51˚ E



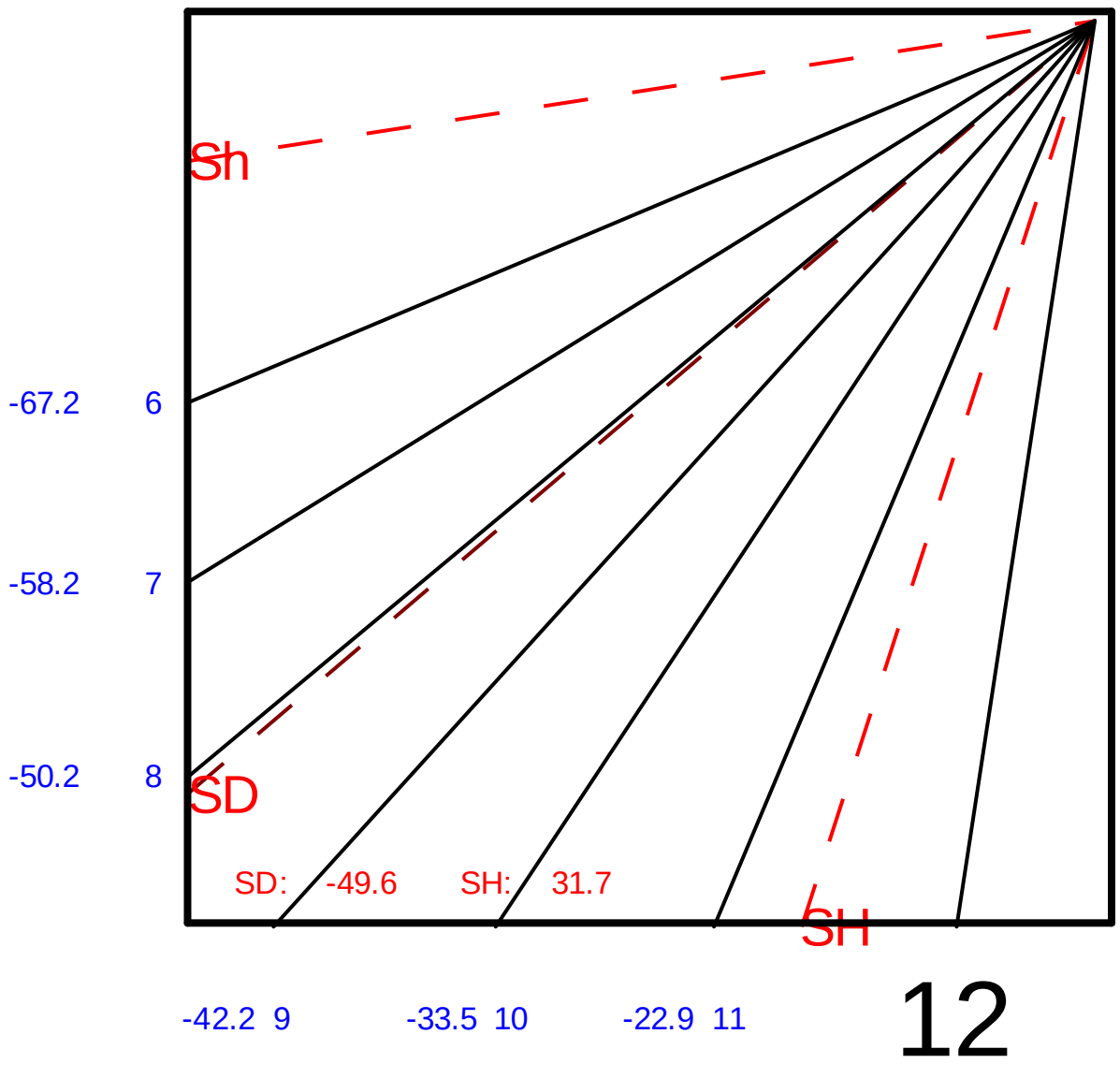
While meridian dials are a natural for an arrow shape, being in the southwest, the desire was to have this S 51 E dial plate also look like an arrow.

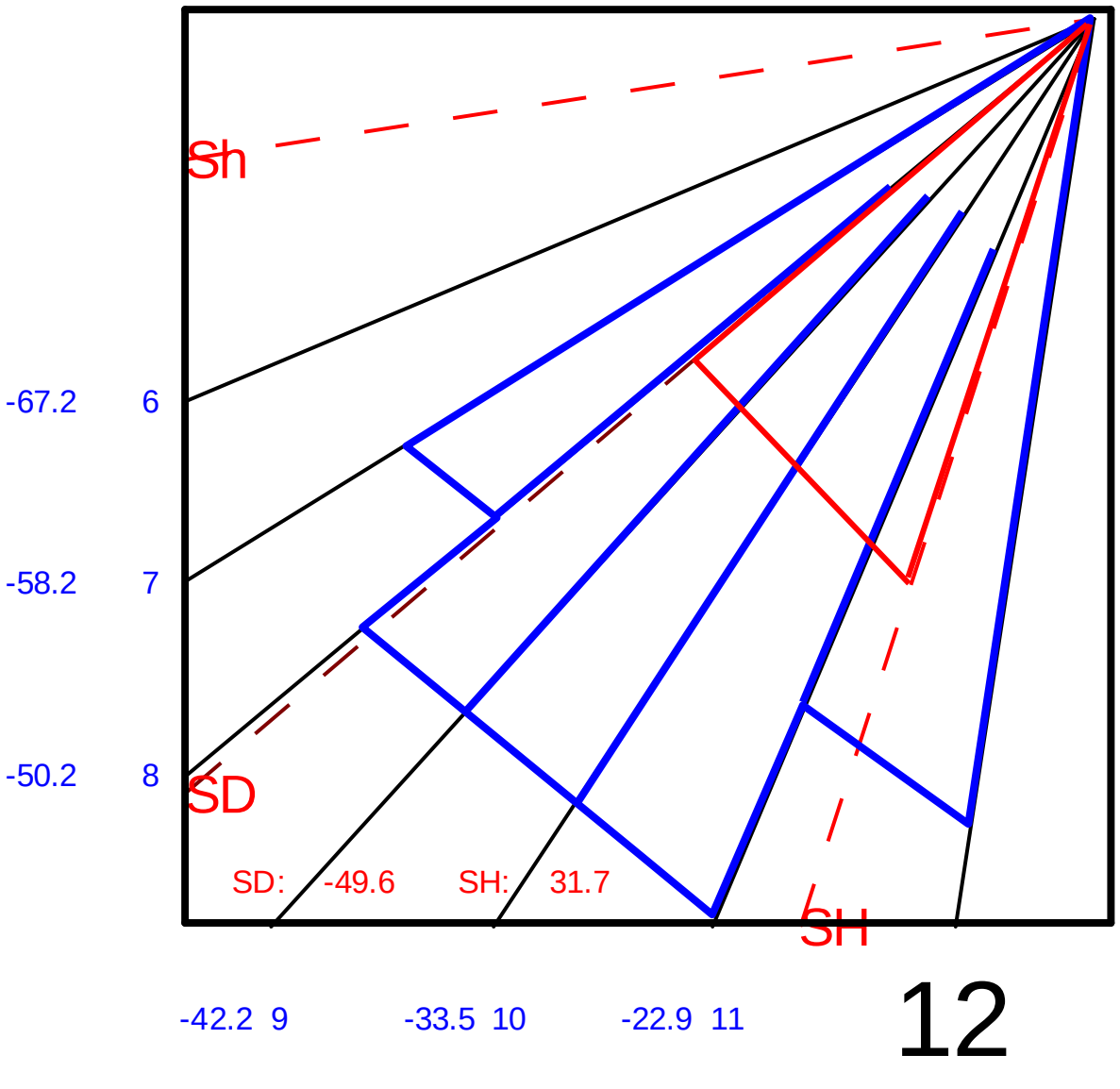


Hour and hour line angle VERTICAL DECLINER

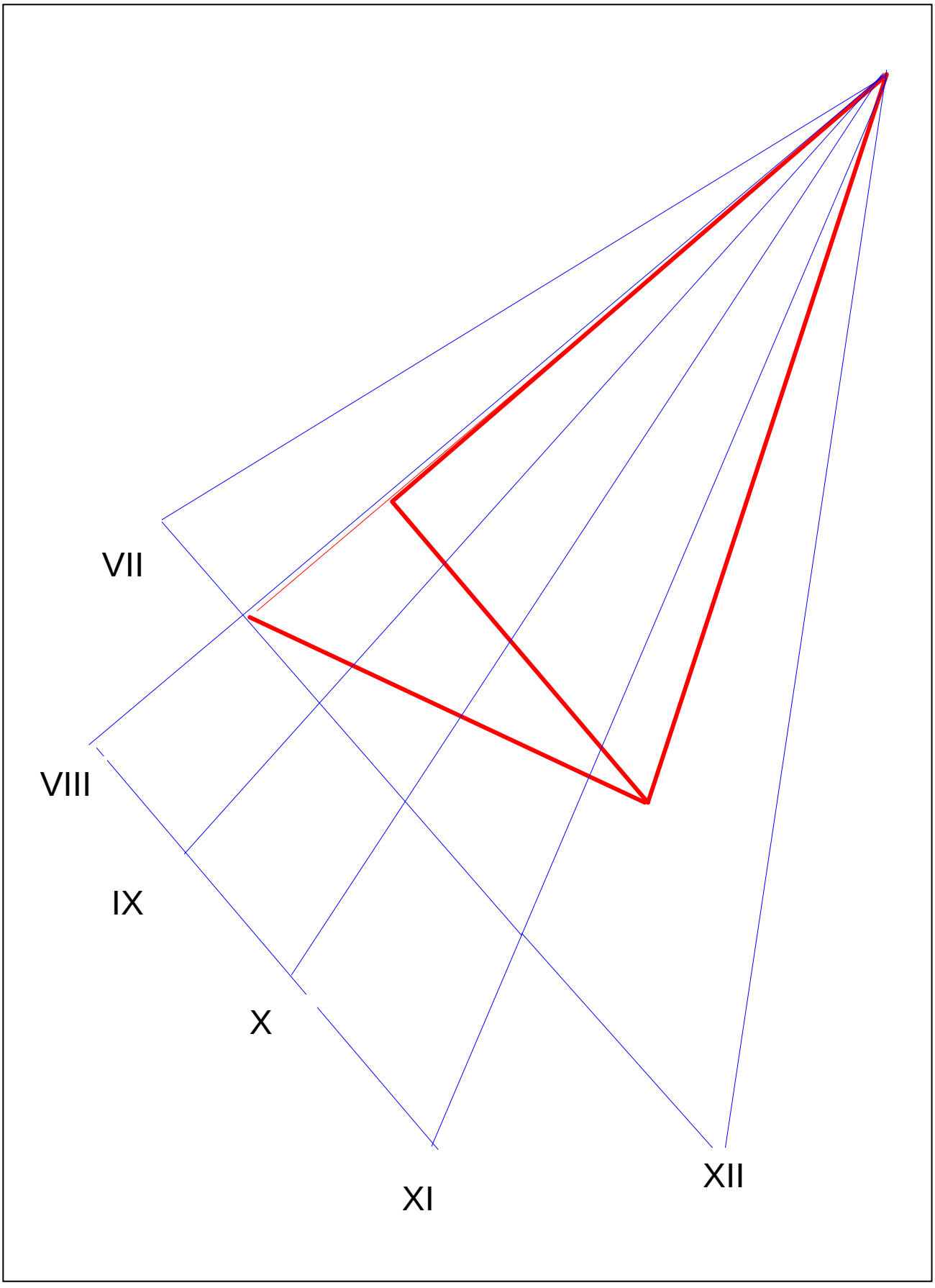
6	7	8	9	10	11	12
-67.2	-58.2	-50.2	-42.2	-33.5	-22.9	-08.6

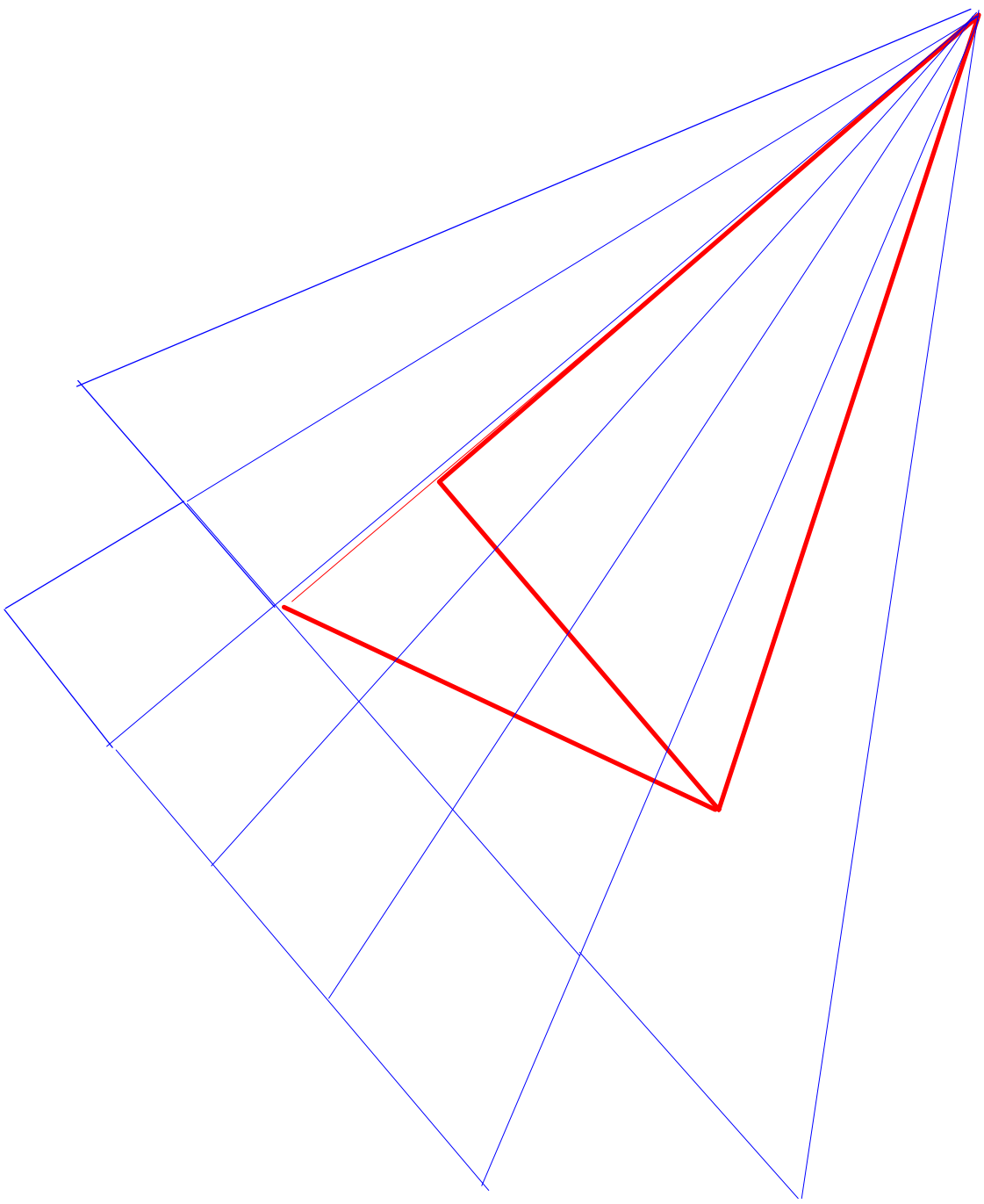
Lat: 33.5 Long: 112.1 Dec: 51.0 SE /*
SD: -49.6 SH: 31.7


Sh
-67.2 6
-58.2 7
-50.2 8
SD
SD: -49.6 SH: 31.7
SH
-42.2 9
-33.5 10
-22.9 11
12



the above looks nicer but the next page has the equinox line as well

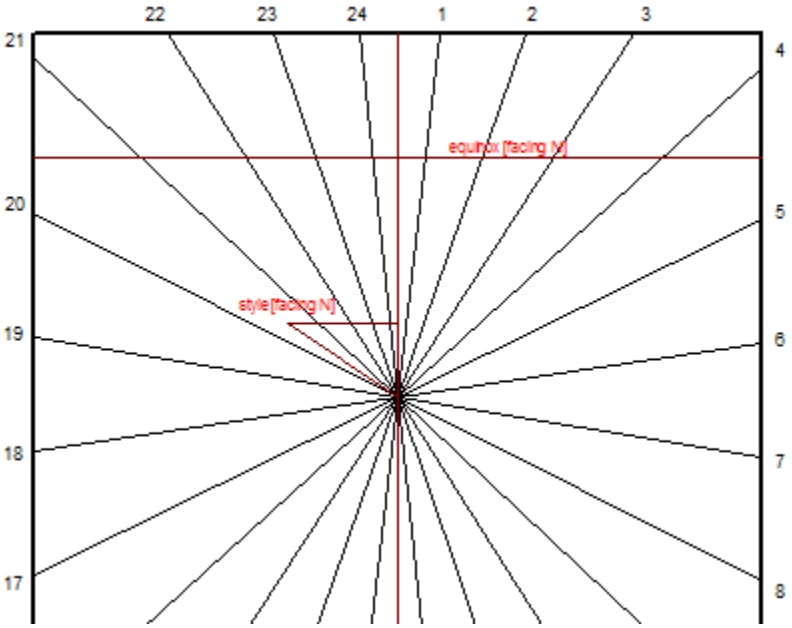

VII
VIII
IX
X
XI
XII



same as previous page but one extra early hour to see if it looked better


PHX
IX
X
XI
XII

PHOENIX, north (true) facing dial



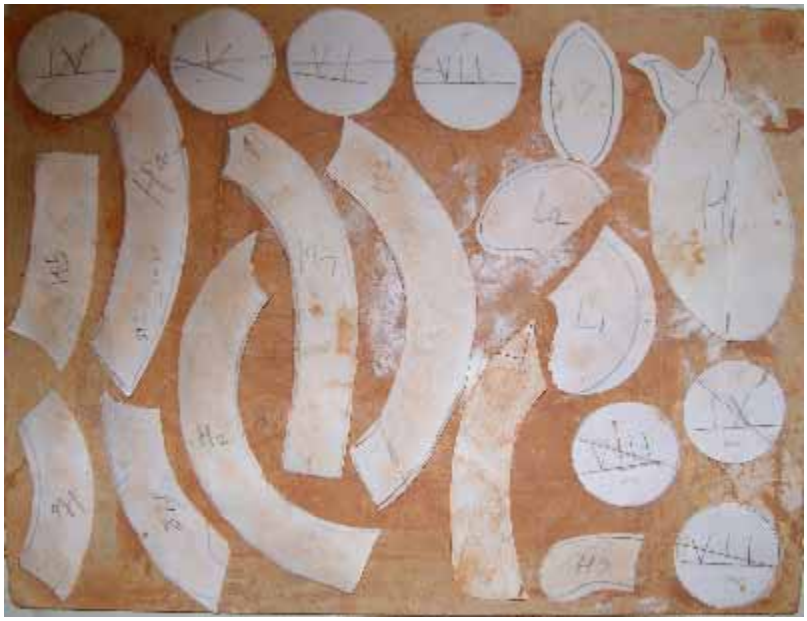
hour line angle V-DIAL

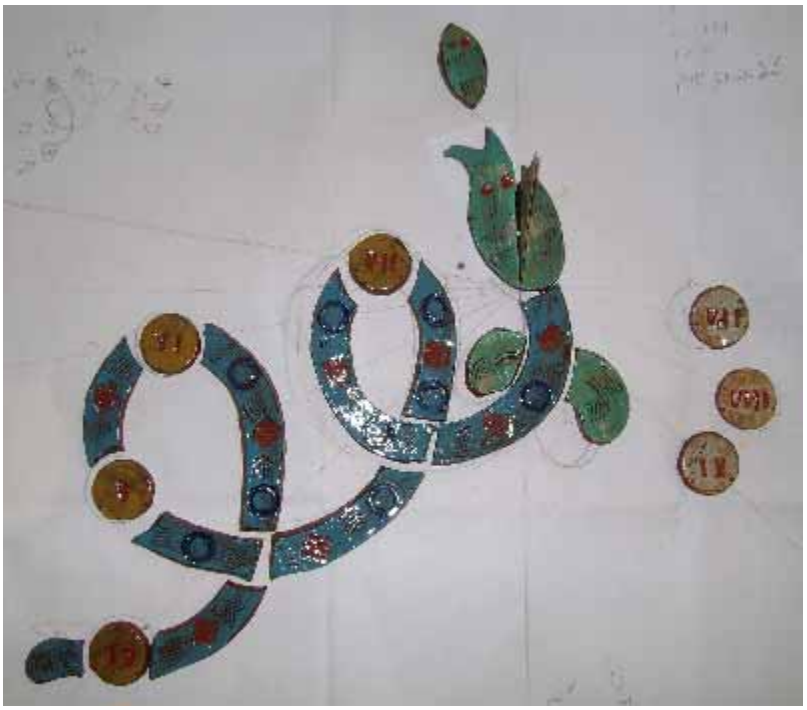
Lat: 33.5

Long: 112.1

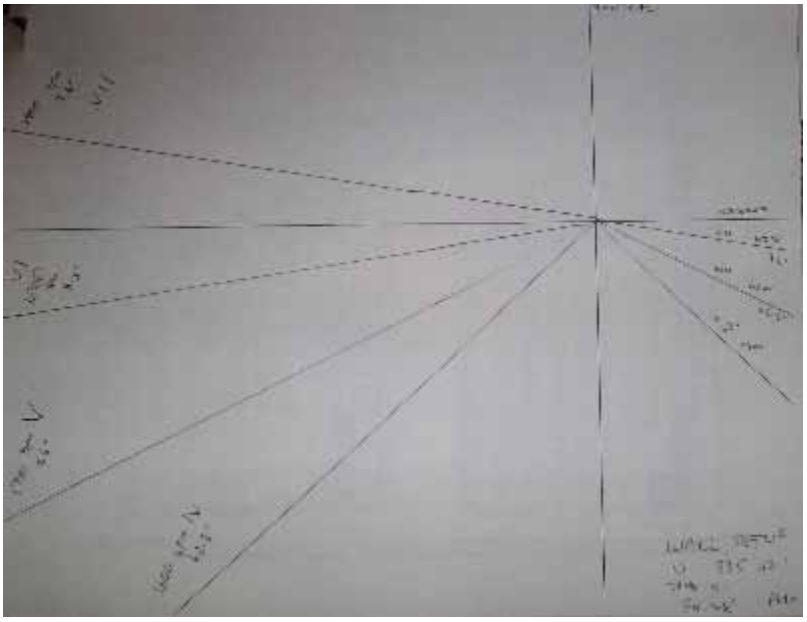
6	7	8	9	10
05.53	06.53	07.53	08.53	09.53
81.5	-80.6	-63.1	-47.0	-32.2

16	17	18	19
15.53	16.53	17.53	18.53
47.8	64.0	81.5	-80.6





This design document shows the final fired ceramic elements.

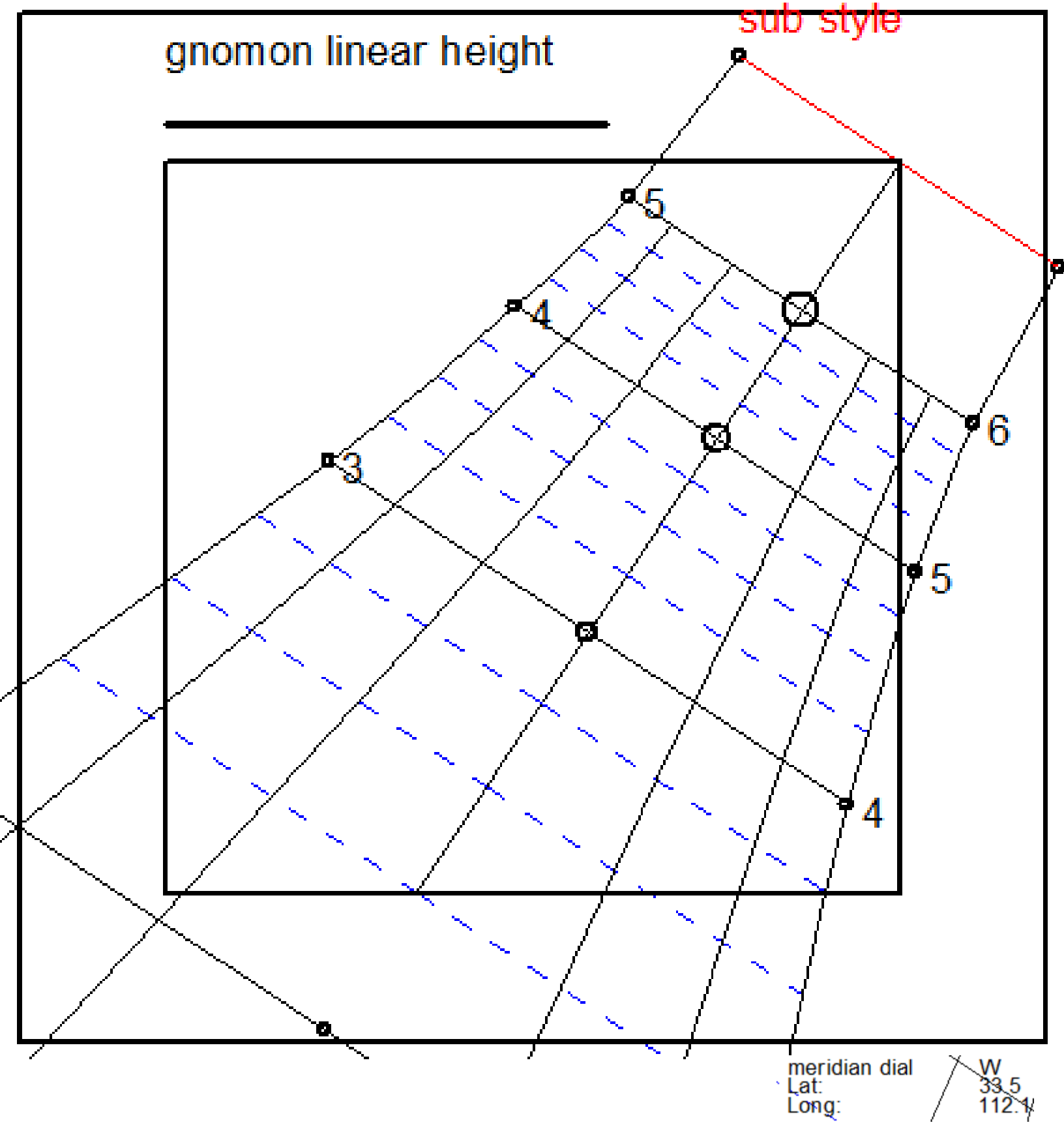


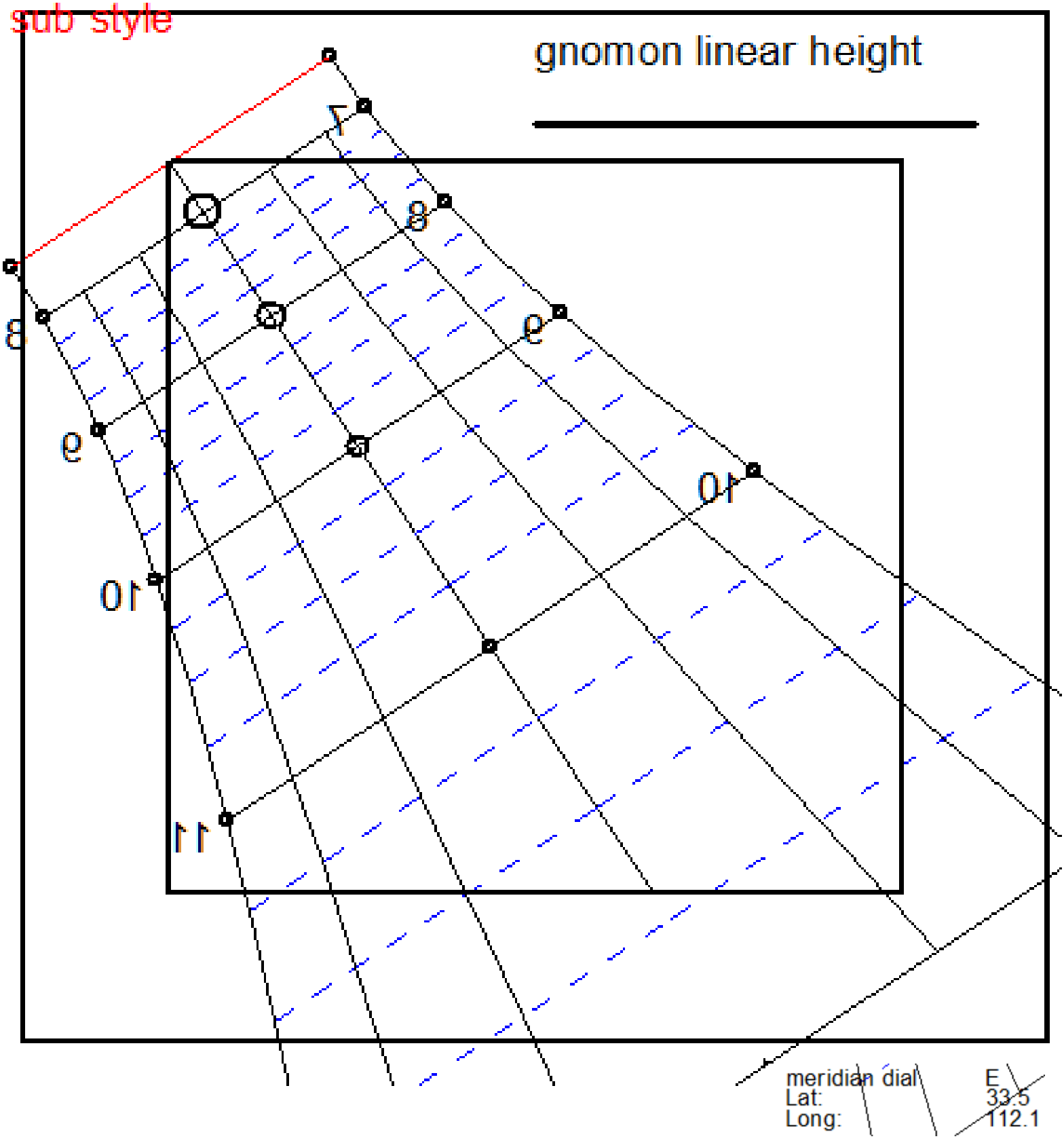
This template from the design document above, allows the hour lines to be drafted onto the final vertical true north facing wall.

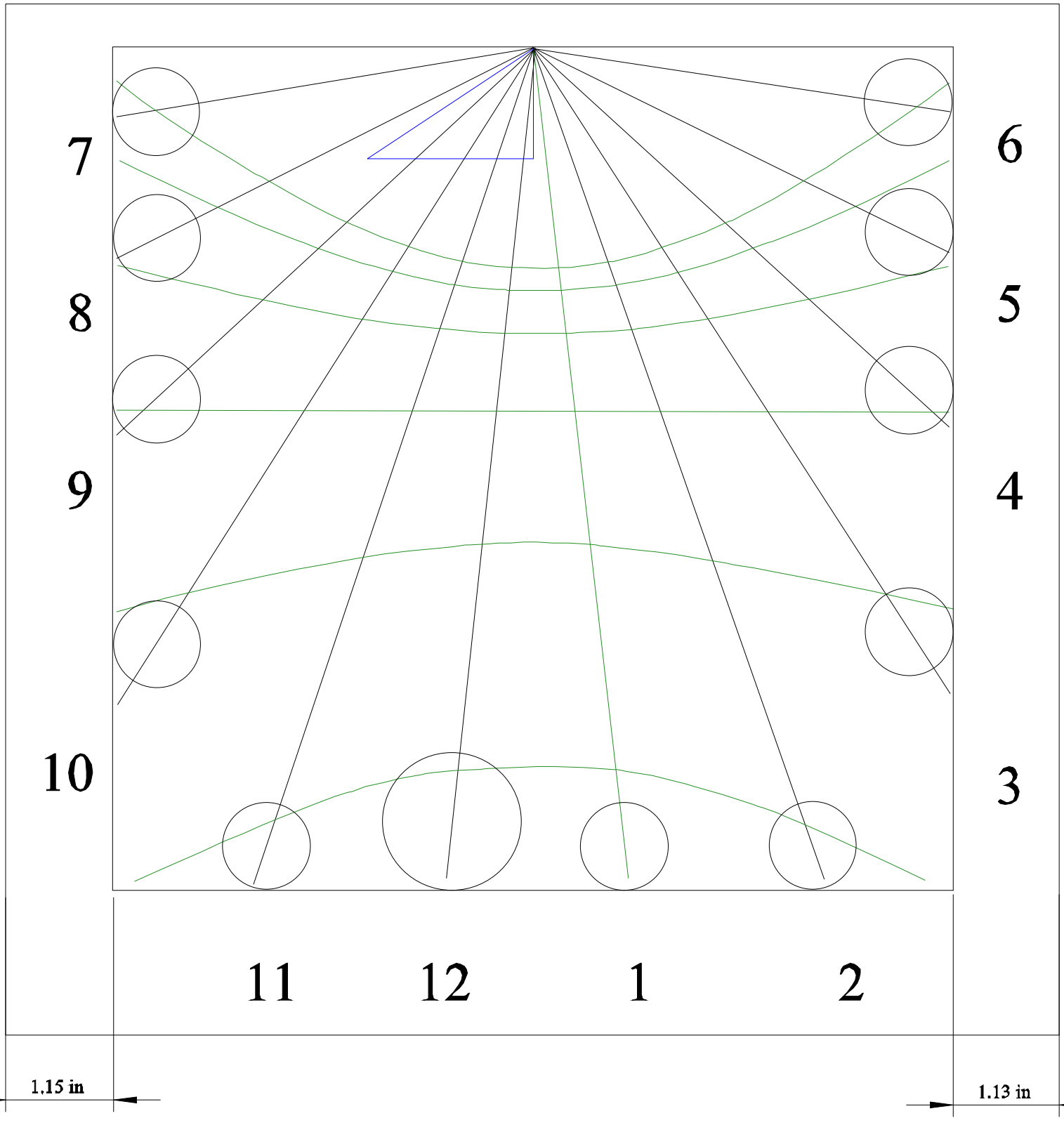
This was taken at 6:40 in the afternoon, and while muted by trees between the dial and the sun, the shadow was distinct.

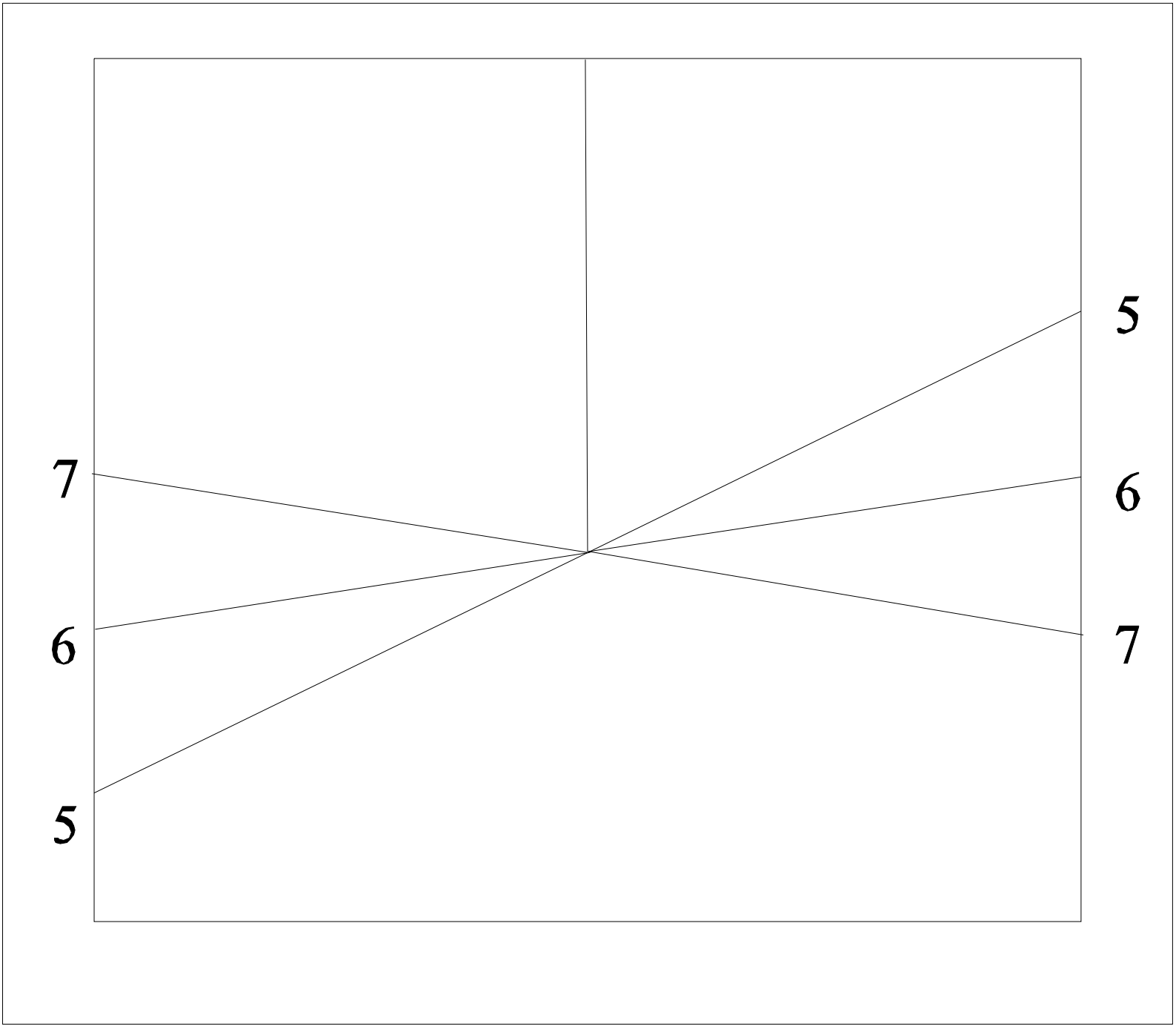
A second skink dial was made for elsewhere on the property.

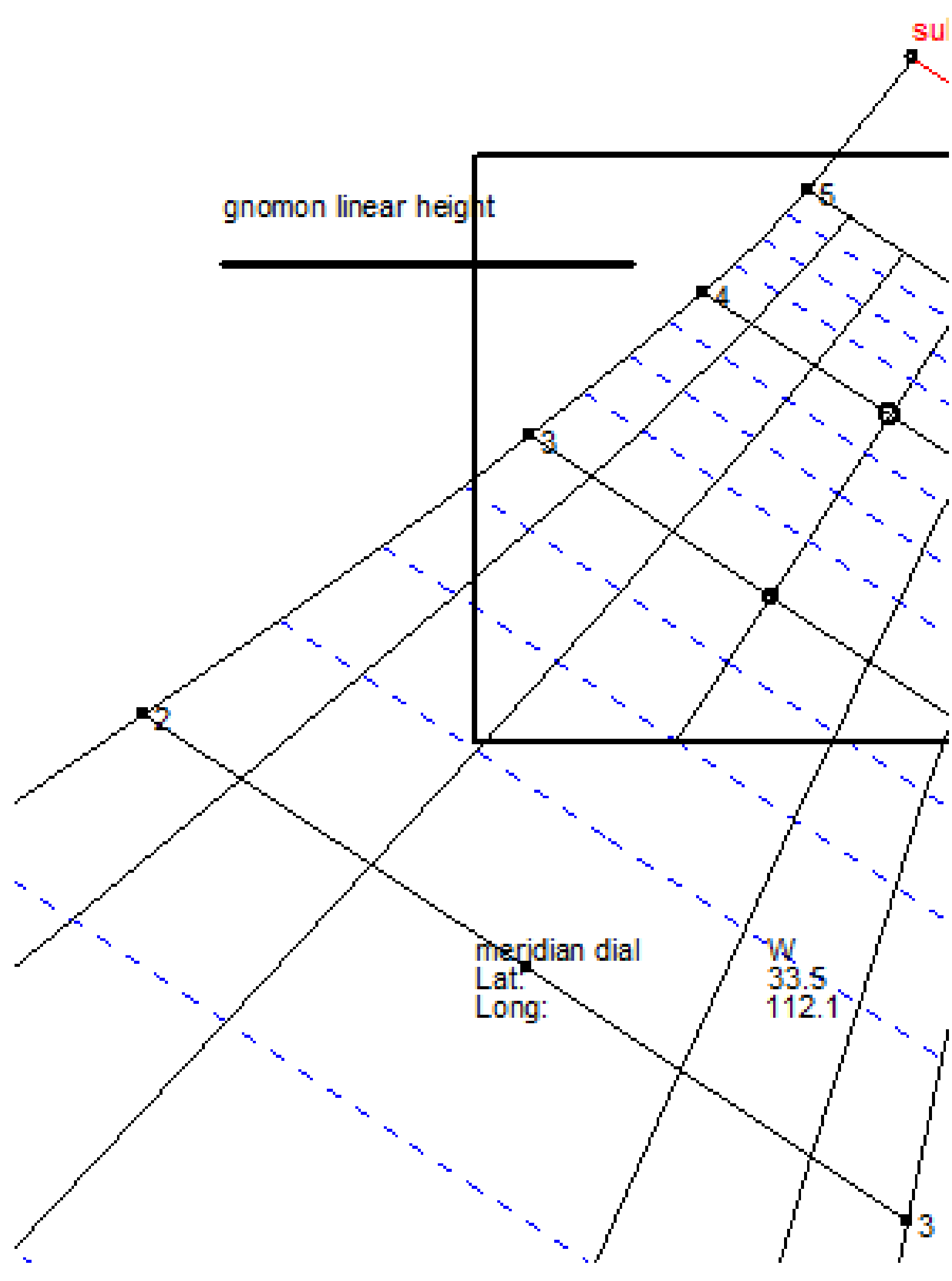
A COLUMN DIAL ~ TRUE CARDINAL POINTS



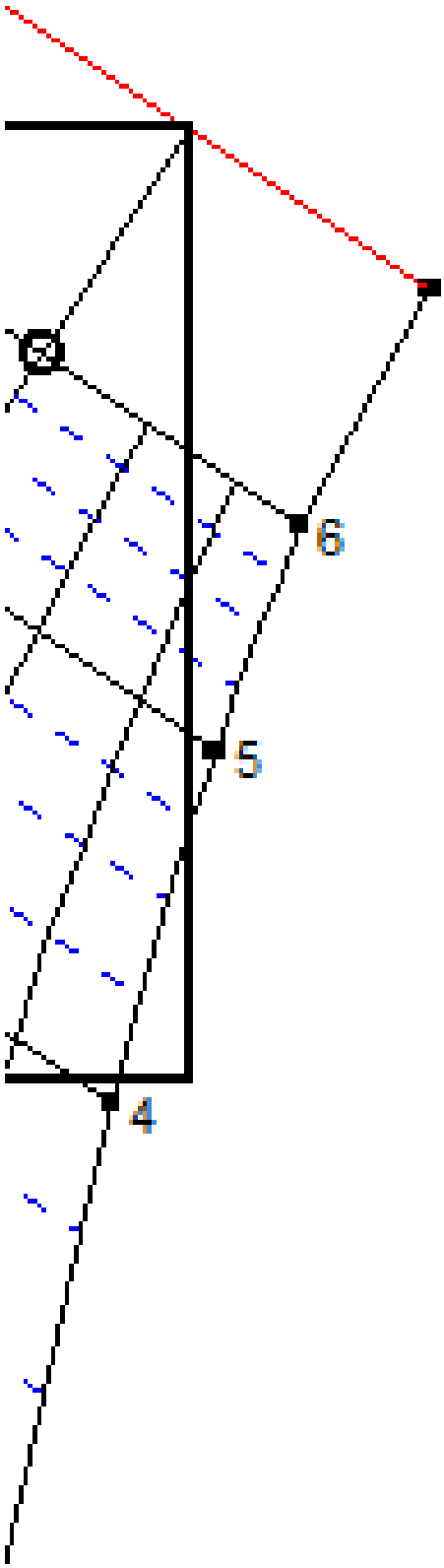

sub style
gnomon linear height
7
8
9
10
11
meridian dial
Lat:
Long:
E
33.5
112.1

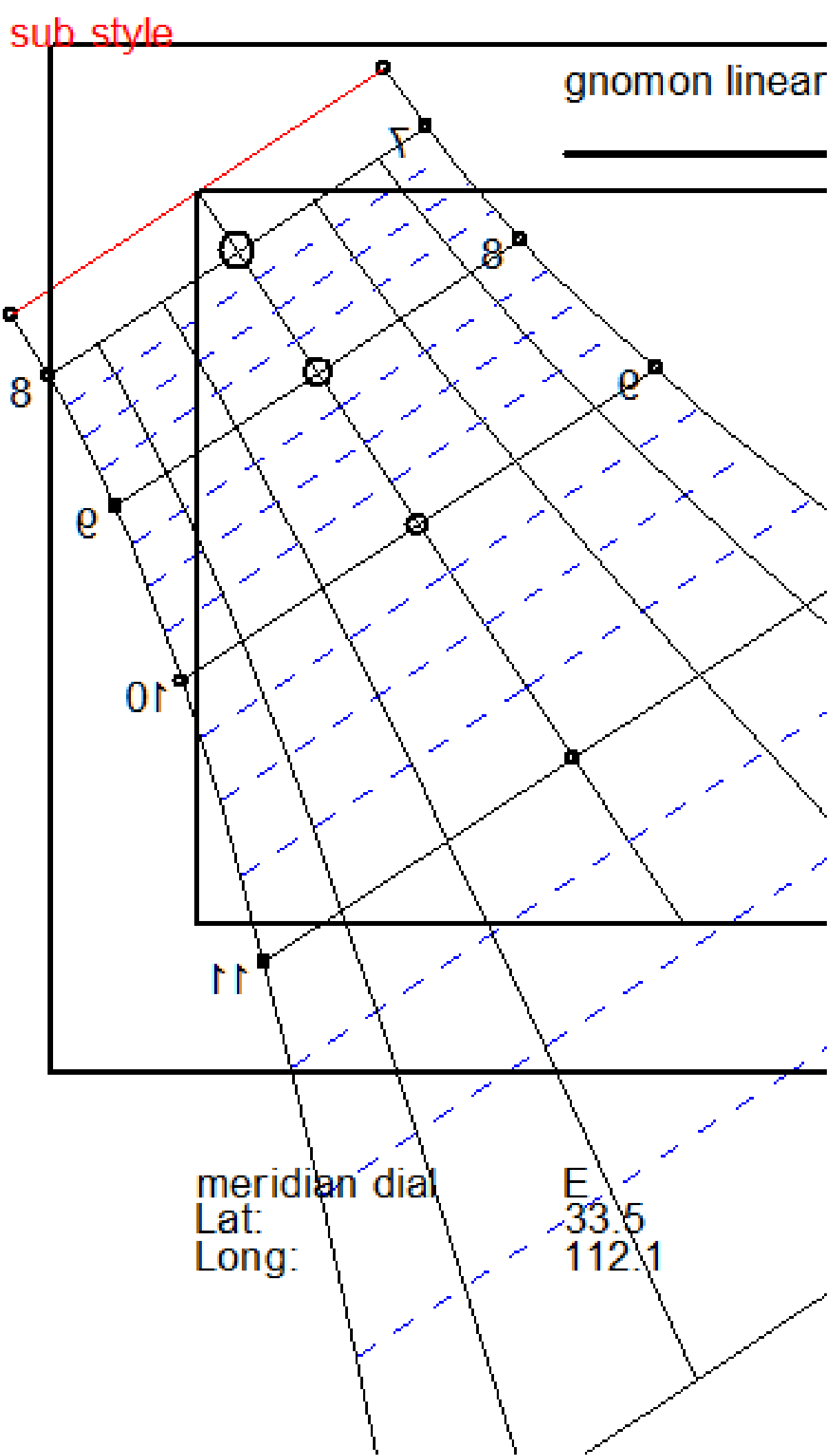

7
6
8
5
9
4
10
3
11
12
1
2
1.15 in
1.13 in

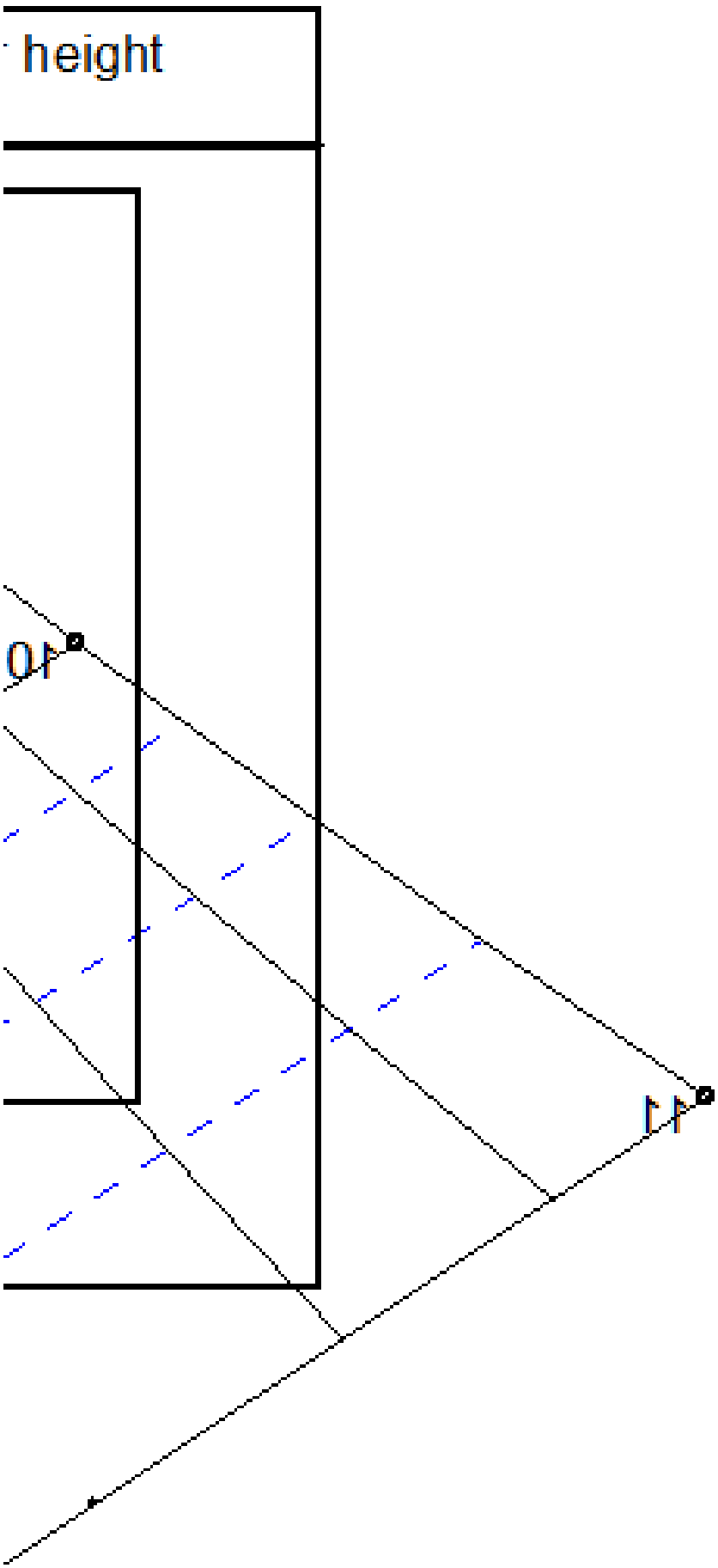

7
6
5
5
6
7

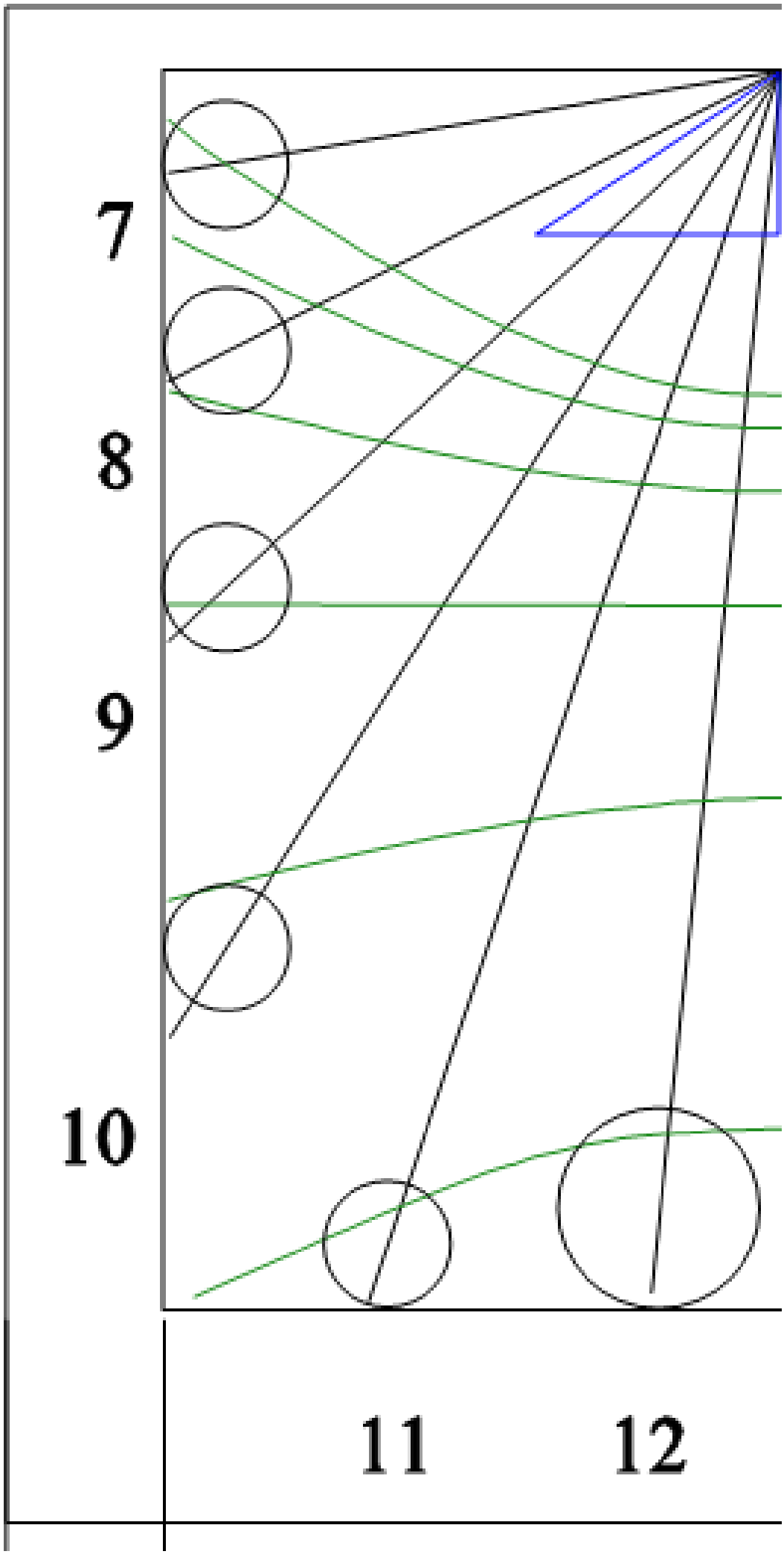

su
gnomon linear height
5
4
3
2
meridian dial
Lat:
Long:
W
33.5
112.1
3

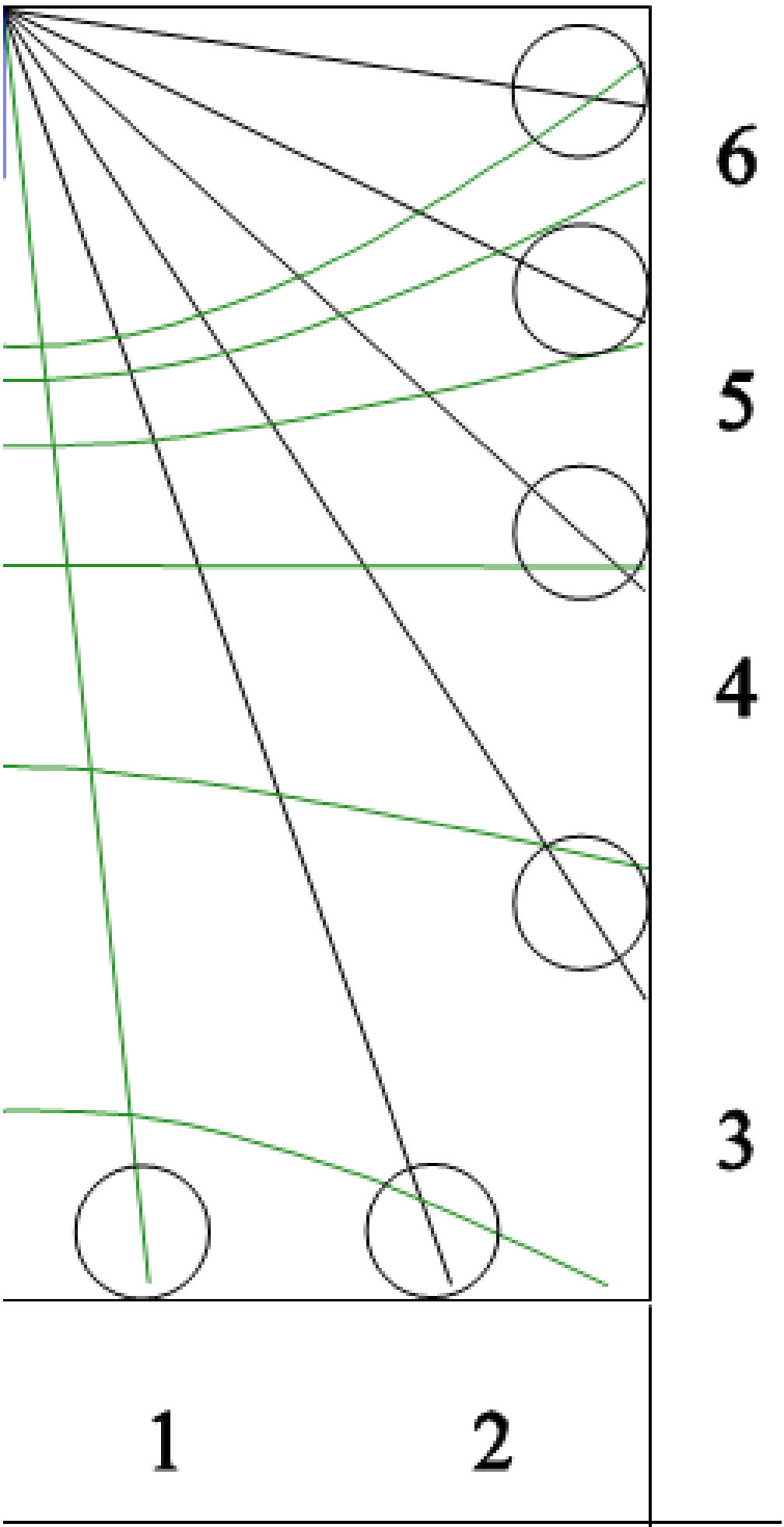
b style




sub style
gnomon linear
7
8
8
9
9
10
11
meridian dial
Lat:
Long:
E
33.5
112.1


height


7
8
9
10
11
12


6
5
4
3
1
2

The original clay used was Terra Red cone 5 clay. However that clay was no longer in stock, so Redstone cone 5 clay, WC420 was used instead.

The shrinkage was substantially different from the Terra Red, so all the slips had to be remade.

The west and the south dial plates

The south and the east plates

The north and east dial plates

The east plate

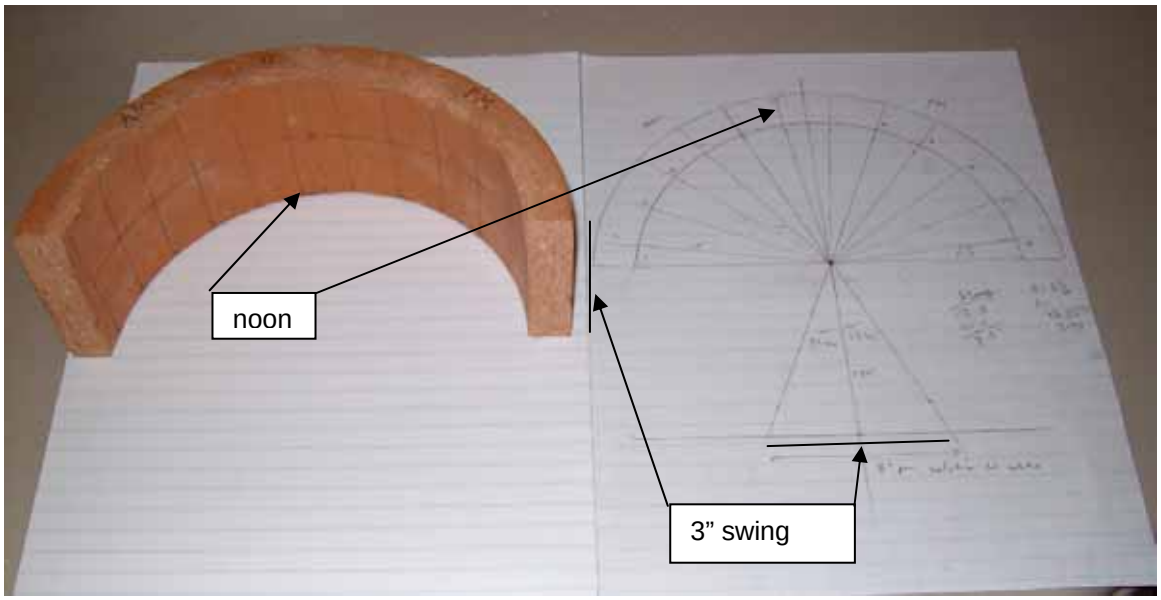
The west plate

The south plate

The north plate

A PHOENIX ARMILARY DIAL

Lat 33.5 and longitude 112.2 with a legal meridian of 105:-



The hour lines (AM right in the above, PM left) were rotated 7.2 degrees, and the span of the nodus for a style to plate radius of 3.37 inches was about 3”, so the armillary was cut from a clay pipe with enough width to handle the solstice to solstice swing, because the style would have a nodus.

I accidentally engraved the 9 am numeral on the 8am hour lien, luckily this was the first engraving. So, I had to offset all the other hours also. Lopsided, but it will work, and be an interesting change for an armillary dial.

The dial plate tacked to a base and to some small rocks, using Versabond.

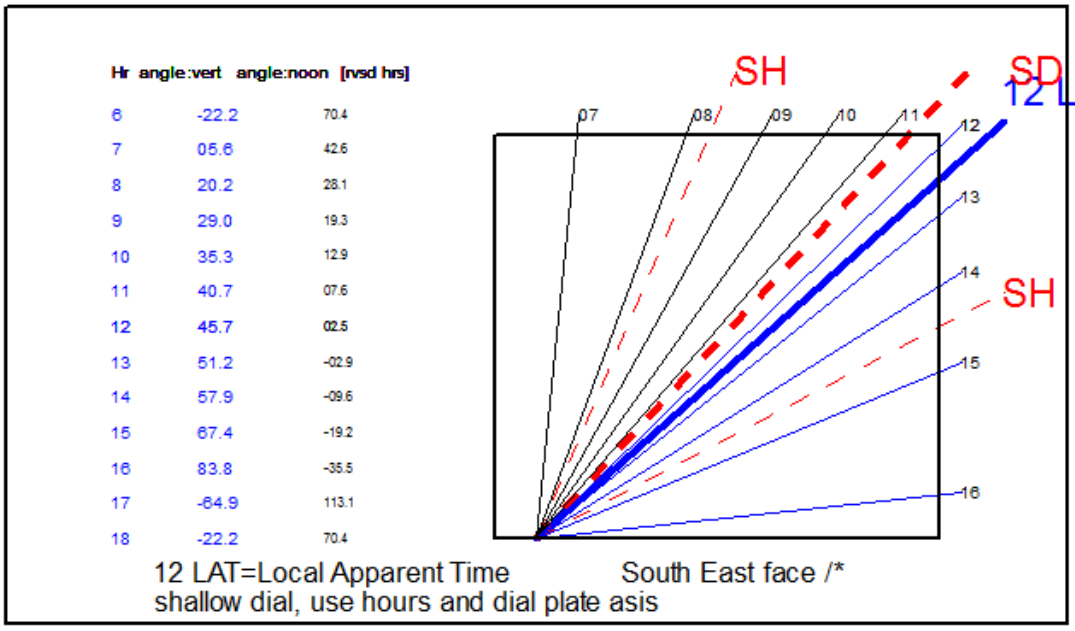
The dial protected with masking tape before mortar was applied. Mortar was used rather than sanded grout, this was to generate a coarser finish.

The final dial in use.

AN INCLINED DECLINER

Declining: S 51 E
Inclining: 20
Latitude: 33.5
Longitude: 112.2
Legal meridian: 105

Many programs exist to aid with dial plate design or drafting. Below is the Illustrating Shadows DeltaCAD macro for inclined decliners. The figures closely match the next page which is the Illustrating Shadows main spreadsheet's inclined decliner worksheet. Both DeltaCAD and the spreadsheet have graphical depictions.

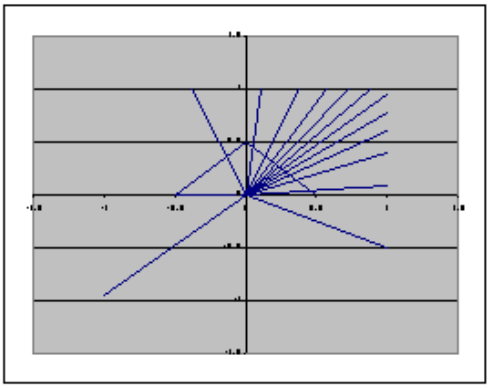


Inclined Decliner dial. Check hour naming if inc/dec angles excessive.

Lat:	33.5	Long:	112.2	RefLong:	105
Inc:	20	Dec:	50		
12 LAT:v:	48.2	12 LAT:h:	41.8	Noon:v:	45.7
SDv:	42.7	SDn:	-05.5	SH:	-19.6

INCLINED DECLINER spreadsheet Back to table of contents Refer to **ILLUSTRATING TIME'S SHADOW**

Declination [+SW -SE]	-51	< 90	**SOUTHEAST**
Inc fr horiz	20.00	< lat	**SHALLOW**
(reclined from vertical)	70.00		
Lat	33.50		
Long	112.20		
Legal	105		



SDv	43.5	USE THIS	SDv = SD from VERTICAL
SH	-19.8	USE THIS	SH (regular style height)

HOUR LINE ANGLE FROM VERTICAL			angle from horizontal	angle from noon
HR		hr.ln.angl		
6	AM HOURS	-20.90	110.90	-70.15
7		6.52	83.48	-42.73
8		20.97	69.03	-28.28
9		29.80	60.20	-19.44
10		36.21	53.79	-13.04
11		41.57	48.43	-7.67
12		46.69	43.31	-2.56

USE THESE

HOUR LINE ANGLE FROM VERTICAL			angle from horizontal	angle from noon
HR		hr.ln.angl		
12	PM HOURS	46.69	136.69	-2.56
13		52.21	142.21	2.97
14		59.01	149.01	9.76
15		68.74	158.74	19.49
16		85.32	175.32	36.07
17		-63.10	26.90	-112.34
18		-20.90	69.10	-70.15

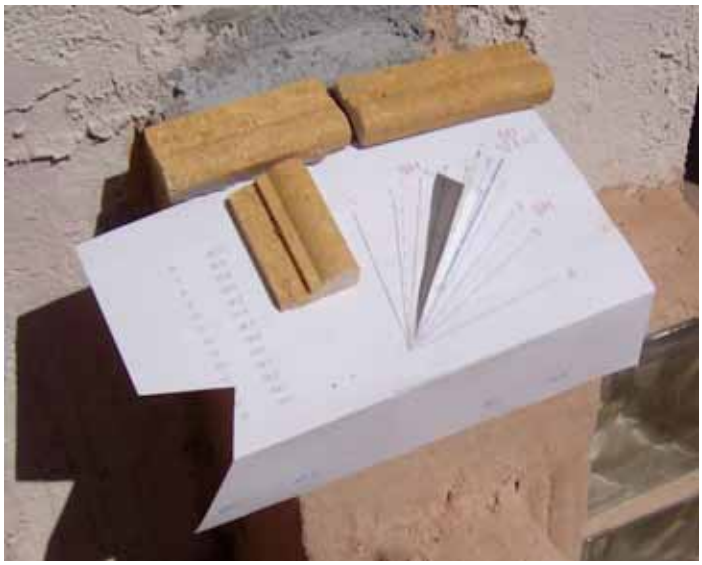
51.00 DeltaCAD decl angle

NOTE: Excel has SW as +ve DeltaCAD macro has SW as -ve and this is arbitrary, there is no good reason for it.

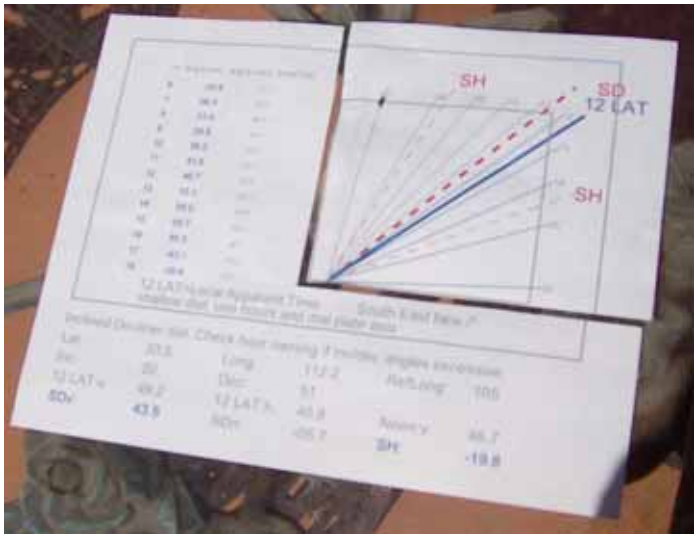
CAUTION: This spreadsheet requires intuitiveness. The formulae were based on the BSS formulae as well as on the work of others. The figures have been tested with other modes of construction, however, just because figures are given, it does not always mean that they are usable. Always make mockups before casting a final design. You may copy or distribute this spreadsheet provided credit is given to www.illustratingshadows.com

If you use the ShadowsPRO series of programs, which are very good, always remember that just because you entered a longitude for the dial location, it is NOT used unless you tell the drawing to consider the dial's longitude.

The first step was to make a simple cutout from the DeltaCAD program and verify a few of the hours.



Then another DeltaCAD print was cut out and used to transfer the hour lines and the sub style (SD) to the dial plate, in this case some Saltillo tile.

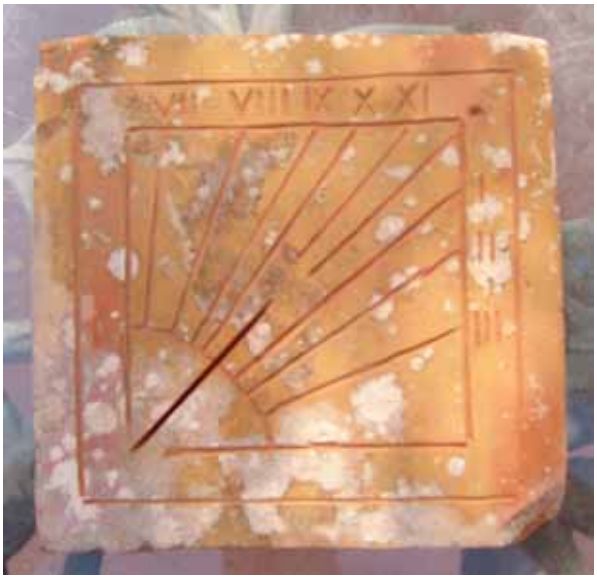


The dial plate has the hour lines and sub style transferred, carbon paper can be used, or the back of the DeltaCAD depiction can be marked with a pencil, and then the lines transferred.

The angles were verified with a protractor none the less.

A groove was cut with a diamond blade for the sub style, and a copper gnomon fashioned, and inserted to a good fit, and then compared with the original paper cutout dial plate.

Then a Dremel bit was used to inscribe the lines.



And a pencil used to highlight them, then the gnomon inserted with epoxy. Before the epoxy set, the dial plate was rotated and the hour lines ensured to align with the gnomon's style. Then the dial place was sited, and verified on one of the hours. Versabond Thin-set was used to seat the dial plate. Then a sanded grout (sandstone color) was used to complete the installation. That same sanded grout was used at the sub style where the gnomon was affixed to the dial plate, masking tape was used to limit the grout at the sub style area. Then the dial plate itself was sealed with a sealer.

The dial set on a column


VIII IX X XI