ILLUSTRATING MORE SHADOWS

THIS BOOK FOCUSES ON OUTSIDE GARDEN DIALS OF GLASS, CLAY, AND COMMON BUILDING MATERIALS. A MORE IN DEPTH VIEW OF LESS COMMON DIAL FEATURES SUCH AS THE INCLINED DECLINER AND CALENDAR OR DECLINATION CURVES, THIS BOOK USES EMPIRICAL, GEOMETRIC, TRIGONOMETRIC, CAD (COMPUTER AIDED DESIGN) BOTH 2D AND 3D, SPREADSHEET, PROCEDURAL PROGRAMMING, TABULAR METHODS, AND OTHER TECHNIQUES.

SIMON WHEATON-SMITH

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NOTE: The use of CAD for drafting, techniques for programming CAD, and 3d CAD methods for plate design are extensively discussed using TurboCAD and DeltaCAD, as appropriate, in many examples.

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A WALK AROUND THE GARDEN


a sundial garden

Where I live there are a fair number of sundials. In no particular order, they are summarized below. There are a number of ways of telling the time from the sun.

One such method is to use the sun's azimuth, which means how far east or west of the north south line the sun is. This is highly latitude dependent. The azimuth for any given hour varies dramatically from winter to summer. Below is an azimuth dial.


azimuth dial


analemmatic azimuth dial

One dial that incorporates azimuth and is sometimes found in public recreation areas is the analemmatic dial. The one to the left is 16 feet east to west, made in less than a couple of hours, and great for recreation centers for children during school breaks. The photo is taken from the west north west to the east south east.

Another method of determining the time from the sun is to use the sun's altitude, or how high up in the sky the sun is, just like the mariner's sextant. This is latitude dependent. The altitude for any given hour varies dramatically from winter to summer. To the right is an altitude dial.


altitude dial

The third method is to use the angle that the sun makes around the earth's rotational axis, the sun's hour angle. This is always assumed to be 15 degrees an hour and is latitude independent. What makes dials that use the hour angle latitude dependent is the display of data on the face of the dial, or dial plate, or surface which has, among other things, the marks telling the time, or the hour lines.

. . . more follows

Declination lines for the horizontal using trigonometry (continued)

Using the sun's altitude and azimuth, certain standard declinations, and a unit style linear length

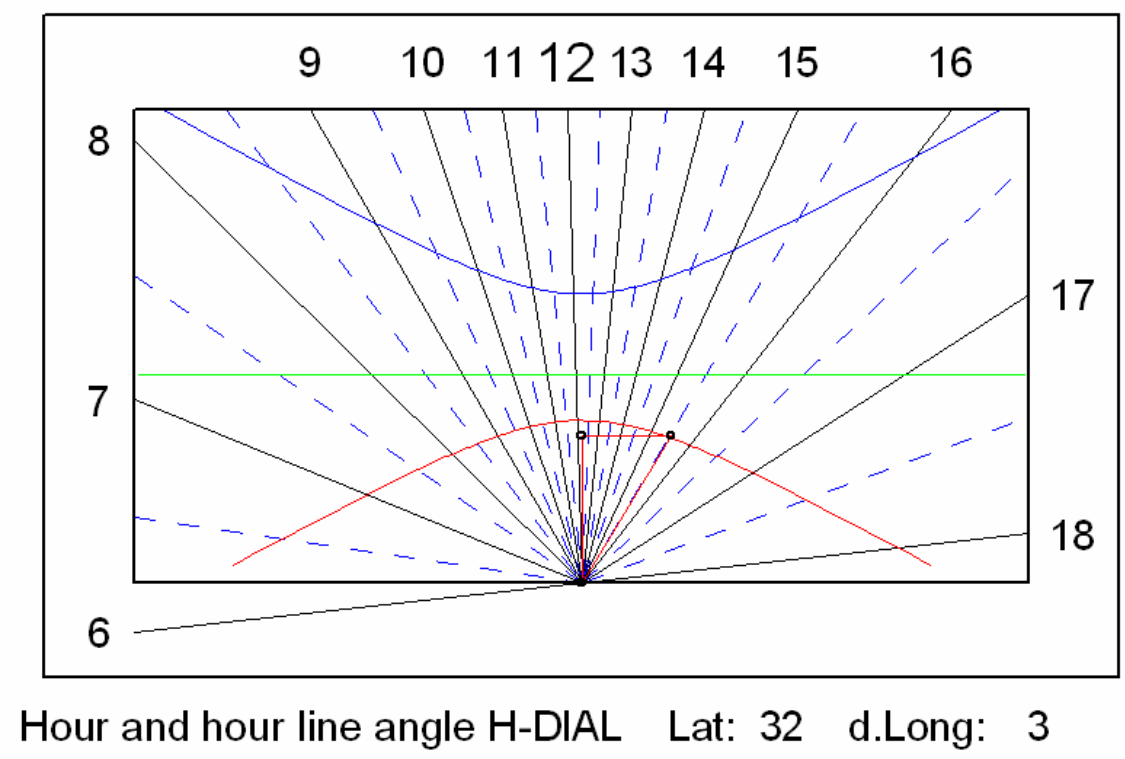
Given a style's linear length, how far along an hour line from the dial center is the declination point on a horizontal dial (with certain standard declinations)

This is a simple conversion from the style's length and latitude, to a gnomon height. The tables for this method are in appendix **A4.6** for latitudes 0 to 65 for declinations of +23.5, 0, and – 23.5

Procedural code compared to spreadsheet methods – horizontal dial

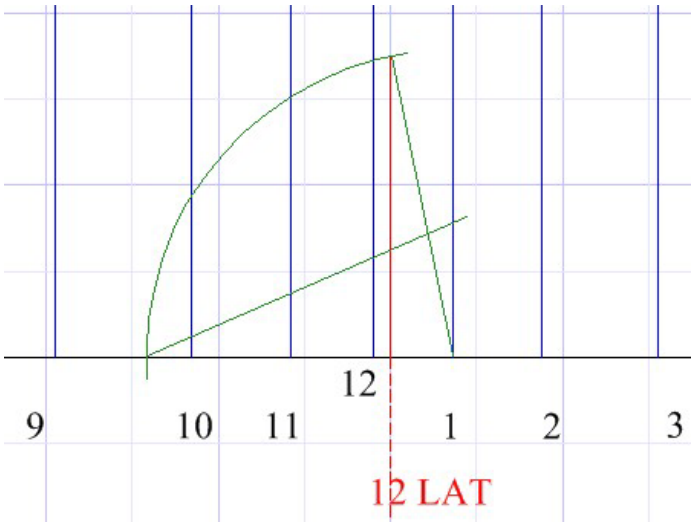
Using the sun's altitude and azimuth, certain standard declinations, and a unit style linear length ~ derived from the nodus to dial plate linear distance

The formulae developed and used have been based on simple trigonometry and used as is or in spreadsheets. Such formulae can also be used in repetitive loops as in simple programming. While this book uses TurboCAD throughout, there is another CAD package called DeltaCAD which, while limited to 2d drafting, does provide an adaptation of the BASIC language integrated into their graphics system. Below is a picture captured using DeltaCAD, and the code, which is available on the CD accompanying this book as well as on this book's web site, has some points worth noting. Some of the key parts of the code are extracted and explained on the next page.



. . . more follows

The geometric methods which used CAD as a drafting tool, agreed with the spreadsheet on hour distances. A benefit of CAD is that the final drawing may be printed and used as a template for the actual dial.



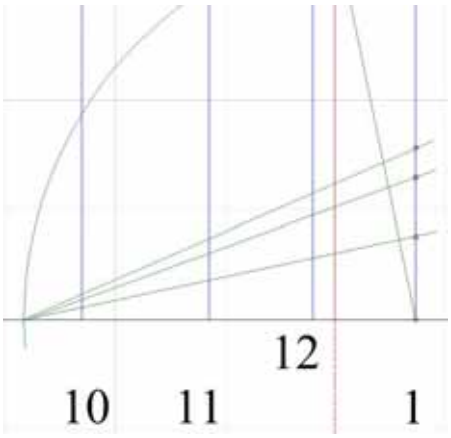
An hour line is selected, in this case 1 pm legal time.

A line is drawn from the base to the top of the style.

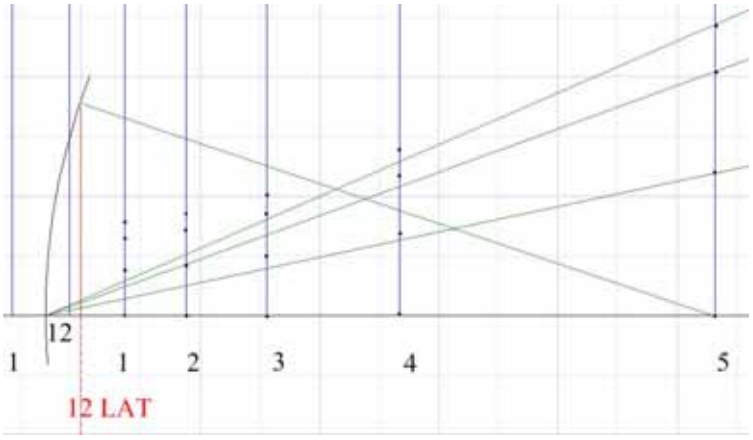
That line is rotated, an arc was used, down to the dial plate.

From where that arc intercepted the dial plate, a line was drawn at the declination, 23.5 in this case, and where that line intersected the original hour line, there is the point for that calendar line for that declination.

To the right is a close-up of the above, except that lines have been drawn for 12 and 20 degrees, and for completeness the 0 degree equinox has a circle on it, albeit somewhat superfluous.



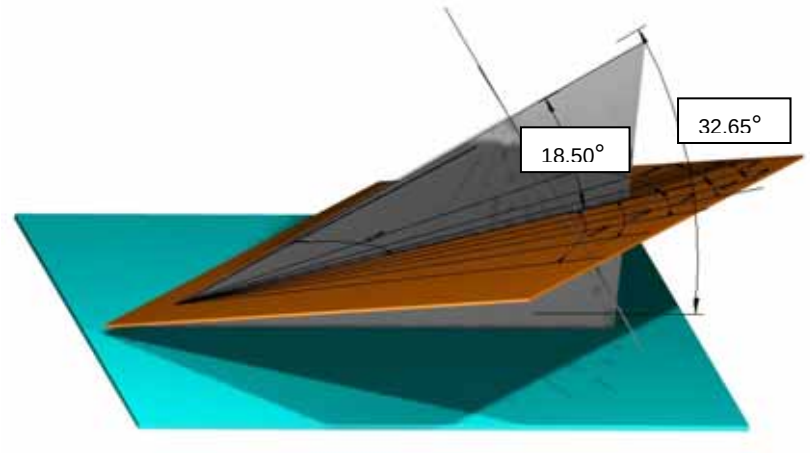
The CAD system used was TurboCAD whose deluxe version is available for around $100, and also provides 3d modeling. This system allows lines to be grouped, and this facilitates the rest of the calendar lines because once those declination lines have been drawn, their base can be moved and calendar points drawn quickly, it saves re measuring those calendar based declination angles.



The results of shifting the group of declination angles is shown to the left.

. . . more follows

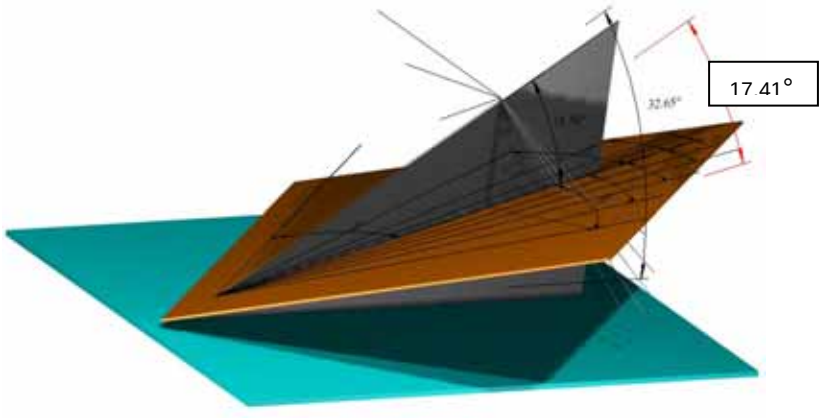
The final verification is for the style distance and height, SD and SH. In this case the CAD method measured from noon.



The CAD provided		The spreadsheet deduced		
SD	4.56	SD	4.55	SD being from noon
SH	18.50	SH	17.76	

Why was the style height off? Because it was the SH for a vertical gnomon whereas we need the SH for a gnomon adjusted by the style distance. The technique to measure the SD for the adjusted gnomon was simple. The workplane was set to the dial plate, a cube placed on it, and that cube rotated to parallel the style distance line. Then the work plane was switched to the vertical surface, so angular measures would truly measure the gnomon perpendicular to the surface rather then the gnomon that was vertical to the horizon. The angle was then measured properly, and found to be:

The CAD provided		The spreadsheet deduced		
SD	4.56	SD	4.55	SD being from noon
SH	17.41	SH	17.76	

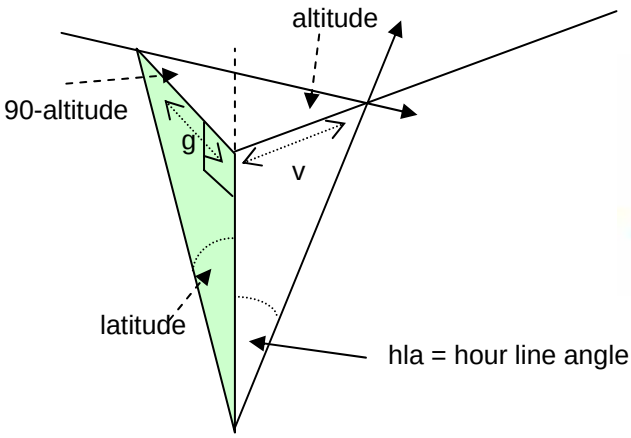


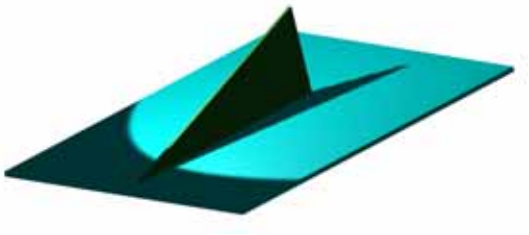
. . . more follows

Declination lines for the horizontal using trigonometry.

Using the sun's altitude (with certain standard declinations)

How far from the nodus base (nodus dropped perpendicular to dial plate) on a horizontal or flat dial is the declination point?





tan (alt) = gnomon linear height / distance from gnomon base = g / v
thus v = g / tan(alt) or v = g * cot(alt)
or in spreadsheet (Excel) terms which has the formula for altitude and
where the declination is a fixed number such as 23.5, 0, or –23.5, or some other value

=gnomonlinearheight /
(TAN(ASIN(SIN(RADIANS(decl)) *SIN(RADIANS(lat))+COS(RADIANS(decl)) *
COS(RADIANS(lat)) * COS(RADIANS(15*(12-hh)))))))

This method works for all angles, and assumes a known perpendicular distance from the nodus to the dial plate. Thus this works for all style heights (latitudes including 0).

The tables for this method are **A4.4** for latitudes 0 to 65 for declinations of 23.5, 0, and – 23.5

The azimuth may be used as a vector from the nodus base, or using the law of sines, a distance from dial center along the hour line may be derived. However, using the azimuth fails when the azimuth is 0, fails at the equator, and requires the dial center to be accessible. This is often not true for great decliners. For this reason, the azimuth method is less common, but covered in a few pages.