

The Sundial Primer - "Dialling Guides"

Double Gnomon Polar Sundial

The purpose of the "Dialling Guides" is to provide an easy method for laying out the hour lines for a number of double gnomon polar sundials located at any latitude in either the Northern or Southern Hemispheres. The double gnomon polar sundial was described in the instructions for the "Dialling Guides" for a classic single gnomon polar sundial. The double gnomon polar sundials described there can be designed using the templates provided as their hour lines will lie only on the dial plate. Note that some common details that were discussed in the previous instructions may not be repeated here in the same detail.

The double gnomon polar sundial presented here is special in a couple of ways. The first is the sundial hour lines are carried up the side of the two gnomons and therefore allows the sundial to show the time from 6 a.m. to 6 p.m.. The second is, due to the specific relative dimensions of the dial plate width to the gnomon height, there are a number of hour lines that come into alignment. Before discussing the "Dialling Guides", here are some details regarding this unique polar sundial. Figure 1 shows a double gnomon polar sundial with a dial plate width " W " and gnomons with heights half the dial plate width or " $W/2$ ". The time telling shadow is cast upon the dial plate by the inside edges of the gnomons. These edges are the styles. This is illustrated in Figure 1 for the right gnomon at 15 minute intervals. Notice how the shadow moves up the left gnomon. Each full hour line is displaced by 15° . It should be noted that any double gnomon polar sundial can have its hour lines carried up the gnomons regardless of whether the hour lines align or not.

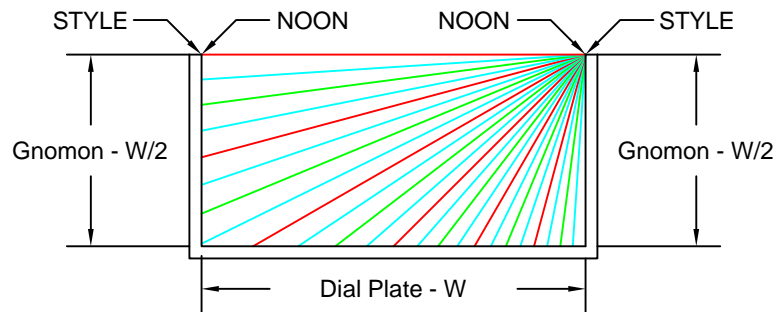


Figure 1

In Figure 2 the hour lines from the second gnomon are introduced. The shadow will shift from one gnomon to the other at solar noon. The direction of the shift depends upon whether the sundial is in the Northern or Southern Hemisphere. Notice that the morning and afternoon hour lines coincide at the three points marked "X". The times of coincidence are 8 a.m. / 1 p.m., 9 a.m. / 3 p.m. and 11 a.m. / 4 p.m.

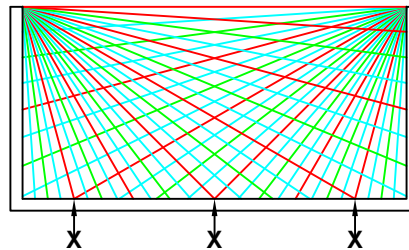


Figure 2

To lay out the hour lines on a sheet of paper fold down the two gnomons bringing their hour lines with them. This is shown in Figure 3. It is not difficult to lay out this sundial graphically. But why bother when you have a "Dialling Guide".

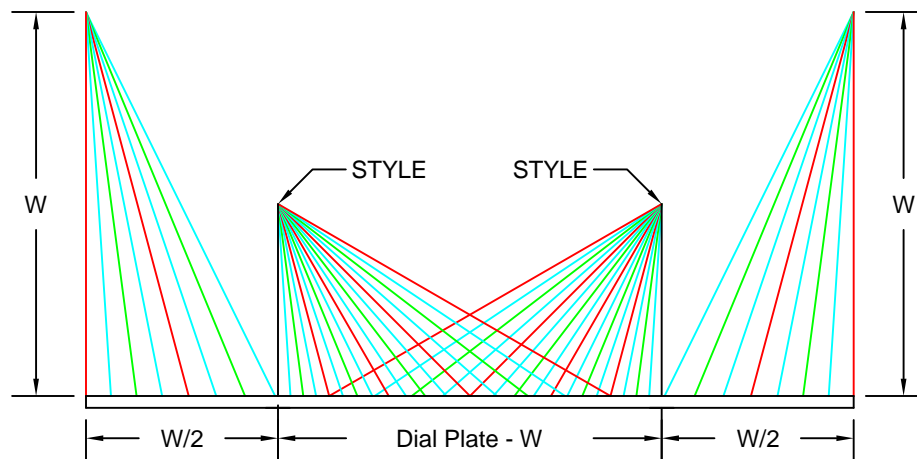


Figure 3

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The "Dialling Guides" are very easy to use and will help you lay out a variety of these special double gnomon polar sundials. They come in two sizes if printed out at full scale. One set can be printed on 8-1/2" by 11" paper and the other on 11" by 17" paper. The scaling is in inches and will help in determining the required size of the dial plate. The "Dialling Guides" can be printed to any size but then the scaling in inches is no longer valid. This gives you the flexibility to create any size of "Dialling Guide" you need to meet your requirements. The following summarizes the double gnomon polar sundial "Dialling Guides" available:

1. Sizes: 2 to 6 inches in 1/4 inch increments; Time Range: 6 a.m. to 6 p.m.; Time Increment: 10 minutes
2. Sizes: 2 to 6 inches in 1/4 inch increments; Time Range: 6 a.m. to 6 p.m.; Time Increment: 15 minutes
3. Sizes: 6 to 10 inches in 1/4 inch increments; Time Range: 6 a.m. to 6 p.m.; Time Increment: 10 minutes
4. Sizes: 6 to 15 inches in 1/4 inch increments; Time Range: 6 a.m. to 6 p.m.; Time Increment: 5 minutes

There are "Dialling Guides" where the templates for some sundial sizes are repeated between the two paper formats. Also some of the "Dialling Guides" have the dial plate and gnomon separated as this allows a wider range of sizes to be provided. This just gives you more options in selecting the "Dialling Guide" you need for your design.

It is interesting to note that the time range on the dial plate for any of these sundials is approximately 4:14 a.m. to 7:46 p.m. All other times after 6 a.m. and before 6 p.m. appear on the two gnomons. Also the gnomon height is always half the dial plate width.

First determine the size of polar sundial you wish to create. The size indicated on the "Dialling Guides" is the dial plate width between the inside surfaces of the two gnomons. The gnomon thickness does not need to be taken into consideration for this sundial. Select the appropriate "Dialling Guide" based on the desired time range and increment. Once you have the "Dialling Guide" you need it requires a little preparation before it can be used. For example, let's say we want to make a double gnomon polar sundial with a dial plate width of 5 inches with 15 minute time increments. Figure 4 shows the "Dialling Guide" that will be used.

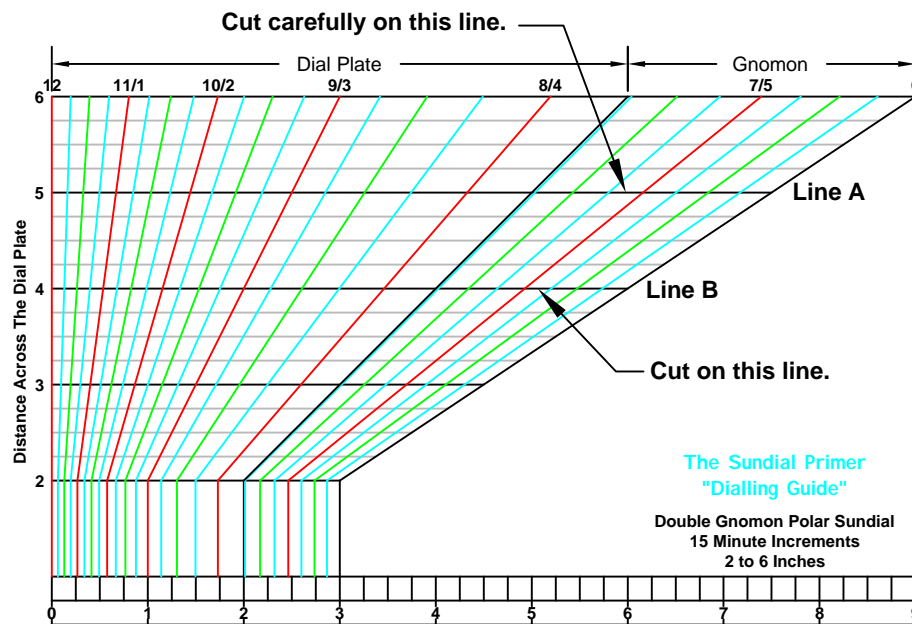


Figure 4

This "Dialling Guide" provides the layout of the hour lines for 21 double gnomon polar sundials. Line "A" contains the required information for the hour lines of a 5 inch double gnomon polar sundial. Extend this line to the right and cut carefully on the line. Extend and cut along line "B". This is done only to make the Guide easier to handle and line "B" can be any line you choose. All the margin information is lost when you cut out the Guide so write the numbers at each of the hour lines. It's just that easy!

Figure 5 shows the "Dialling Guide" ready for use. The points "X" and "Y" will be used later to help in laying out the hour lines.

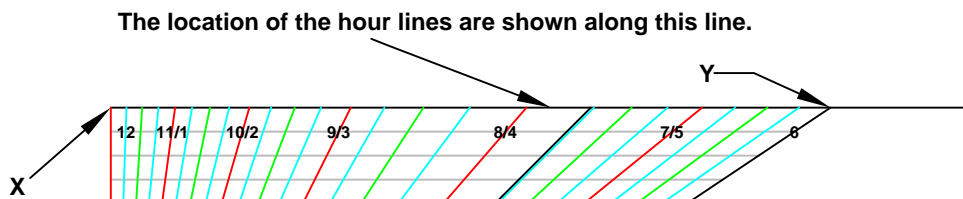


Figure 5

The Sundial Primer - "Dialling Guides"

Double Gnomon Polar Sundial

The size of the dial plate and gnomons must be determined. To lay out the hour lines for this sundial the dial plate width must be 5 inches. The gnomon for a polar sundial can be rectangular and attached directly to the dial plate. For it to be secure it must have some thickness to accept fasteners. Assume a thickness of 1/4 inch. Figure 6 shows two possible methods of combining the dial plate and gnomons to create the sundial. It can be seen that each method affects the width of the dial plate and the height of the gnomon. However, in both cases the total dial width is "W + 2T" or 5.5 inches, with the left and right dial plate widths equal to 5 and 5.5 inches respectively.

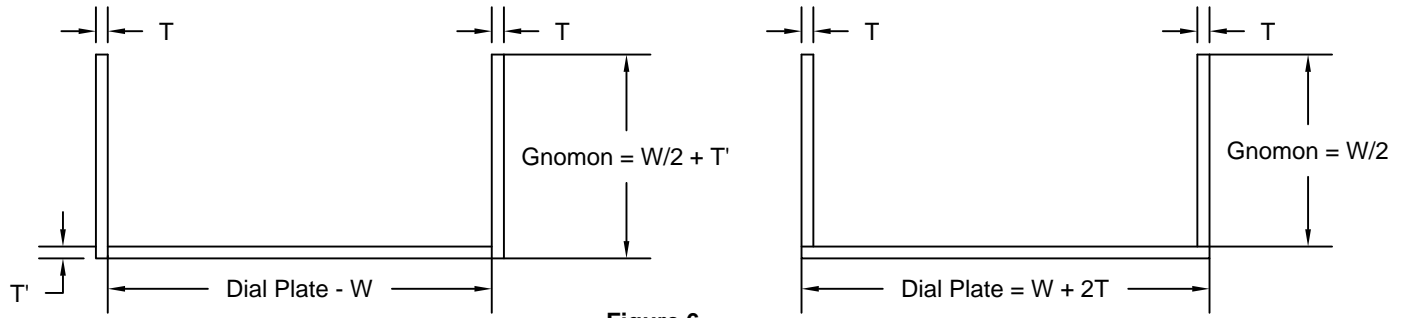


Figure 6

Now for the length. The selection of the length requires some consideration to ensure that the shadow from either gnomon will always indicate the time on any day of the year. For now let the hour lines lie between two lines spaced apart a distance equal to the height of the gnomon or in this case 2.5 inches. Add 1/2 inch to the top and the bottom. The selection of the dial plate length is discussed later. Using the layout on the left of Figure 6 the dial plate width is 5 inches. With a dial plate thickness "T" of 1/4 inch, the gnomons are 2.75 inches high and 3.5 inches long. The final size of the dial plate is 5 inches wide and 3.5 inches long as shown in Figure 7. A 1/4 inch gnomon is positioned at either end of the dial plate as shown.

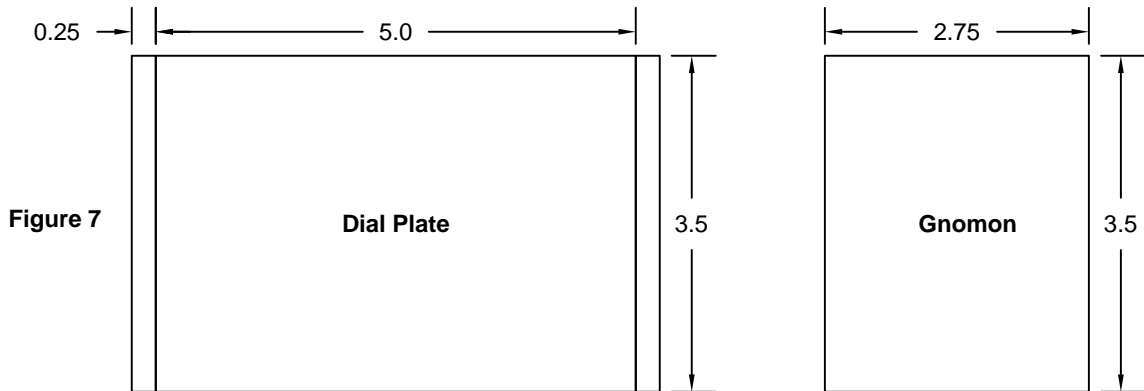


Figure 7

Draw a horizontal line across the centre of the dial plate. Draw the parallel lines "AB" above and "CD" below this horizontal centre line at a distance of 1.25 inches. Draw a line "EF" across the length of the gnomon, parallel to the base and 1/4 inch above. Figure 8 illustrates the above discussion.

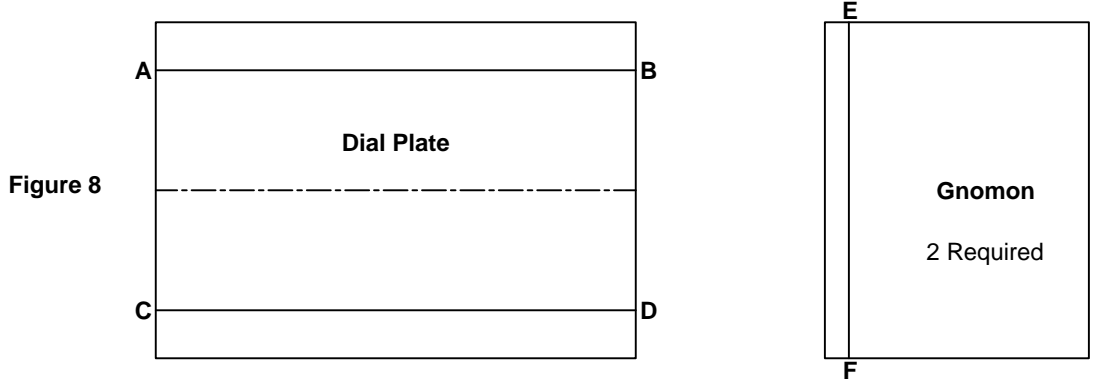


Figure 8

The dial plate and gnomons are now ready to have the hour lines marked. This step is carried out the same way whether you are designing a double gnomon polar sundial for the Northern or Southern Hemisphere. The "Dialling Guide" shown in Figure 5 will be used. Marking the points for the hour lines on the dial plate is a four step process as shown in Figure 9. The 12 (noon) hour line must always lie against the inside surface of one of the gnomons and the point "X" placed in the positions shown. After all the desired hour lines are marked the points can be joined to create a series of vertical lines as shown in Figure 10. These are the hour lines for the dial plate. The hour lines for the gnomons are now marked as shown using the point "Y". All that is left is to label the hour lines.

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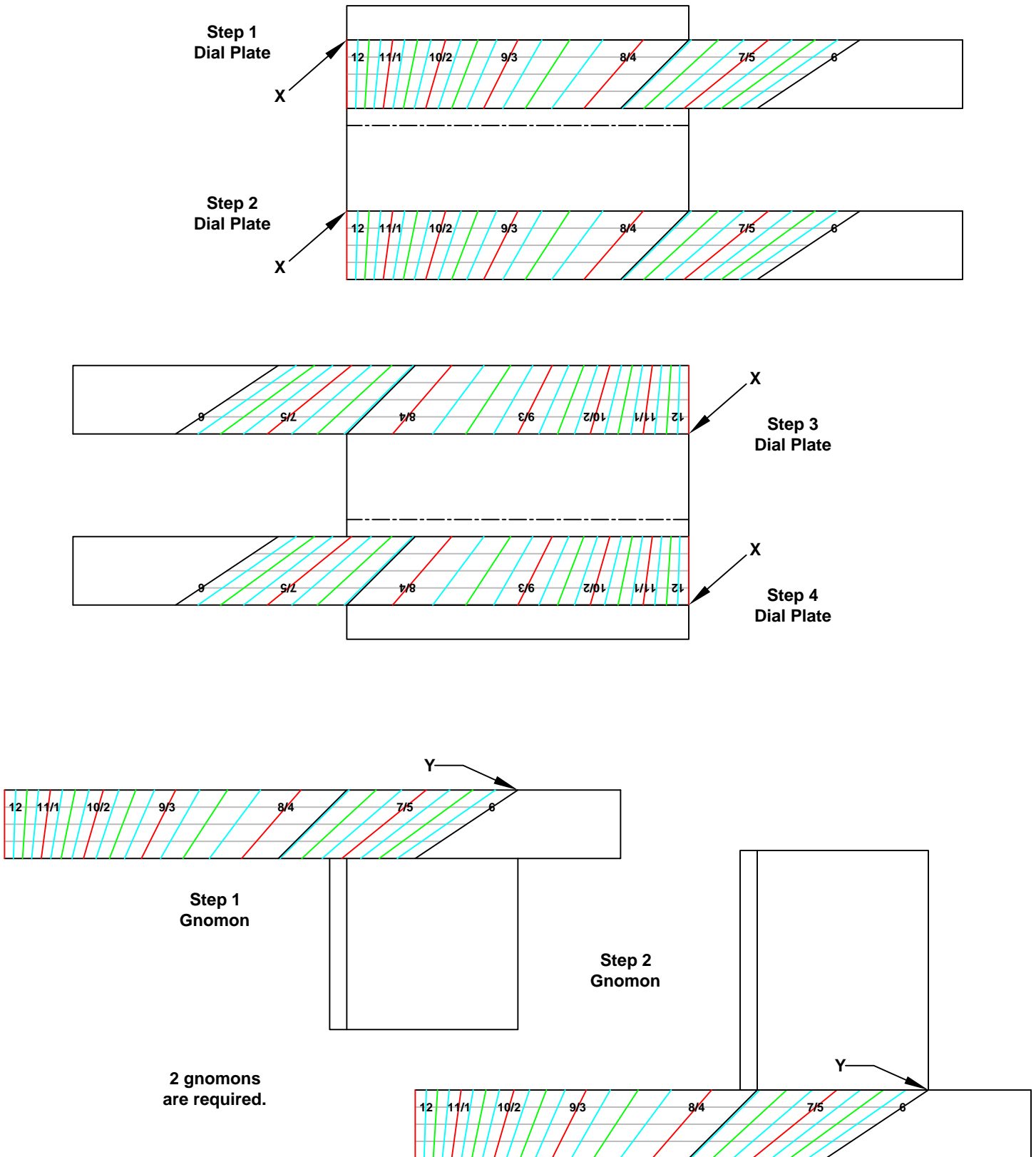


Figure 9

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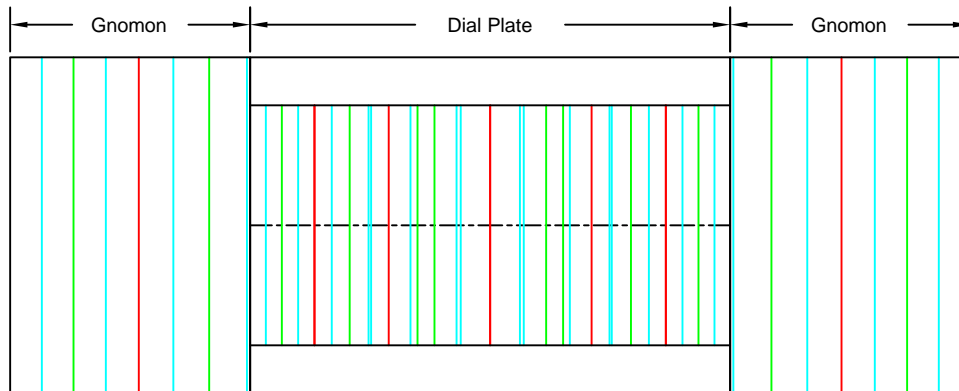


Figure 10

OUCH! What's wrong with this picture? The hour lines on a double gnomon polar sundial all fall within the same area of the dial plate. As a result, displaying hour lines at even 15 minute intervals results in a sundial that is not very user friendly. Perhaps a large dial plate, different hour line lengths, reducing the time interval to 30 minutes or any combination of these may result in a useable sundial. You can give it a try.

There is an alternative that will result in a fine sundial. The solution is to stack the morning and afternoon hour lines, one above the other, on the dial plate. This uses the same layout procedure shown in Figure 9 except that the morning and afternoon hour lines are placed in two different areas on the dial plate. The gnomons do not change. This layout is illustrated in Figure 11. In this layout each dial plate length is maintained at the gnomon height of 2.5 inches and the additional 1/2 inch is added to the top and bottom for a total dial plate length of 6 inches.

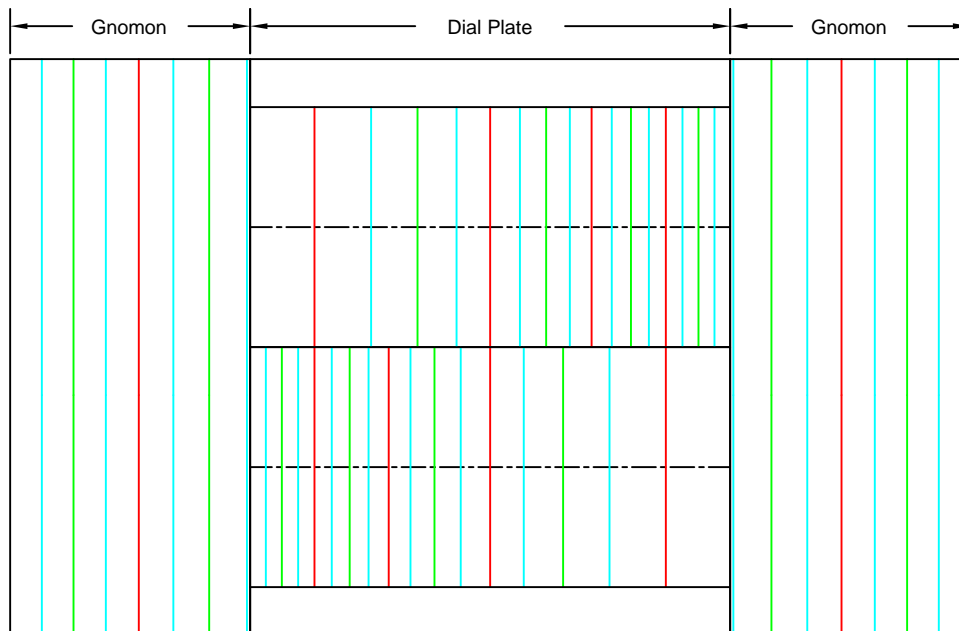


Figure 11

This is a much better layout and makes dial quite easy to read. Notice the three morning and afternoon hour lines that line up with each other.

The hour lines are numbered as shown in Figure 12 for the Northern and Southern Hemispheres. The 9 a.m. and 3 p.m. hour lines for a polar sundial are located at a distance from the gnomon equal to the height of the gnomon. As a result these hour lines are located at the centre of the dial plate and coincide with each other.

The hour lines and numbering can be designed to suit your needs. The gnomon can be a simple rectangle in shape.

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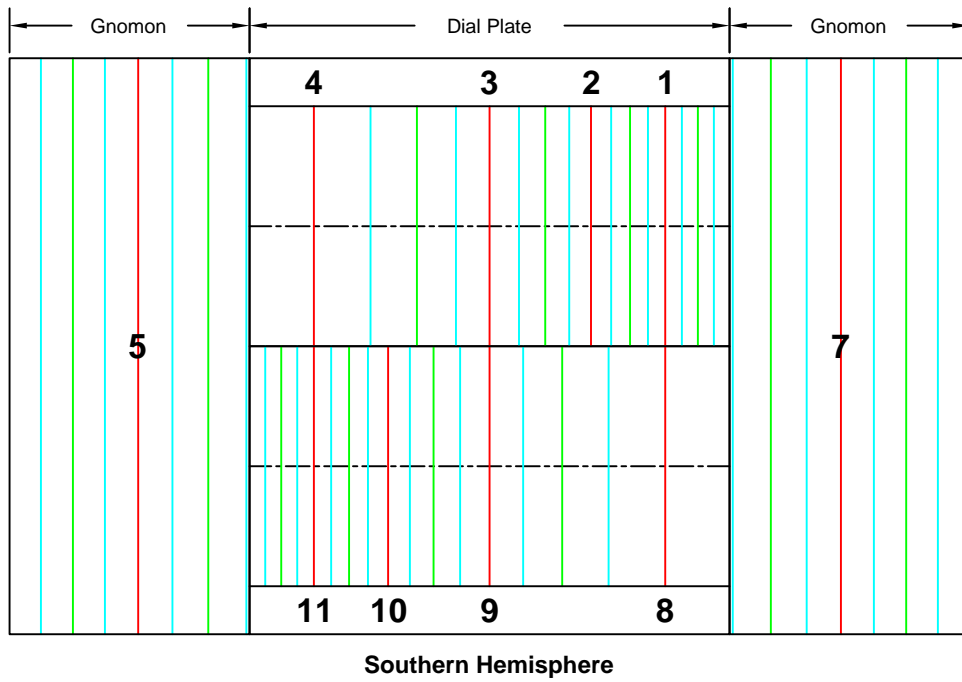
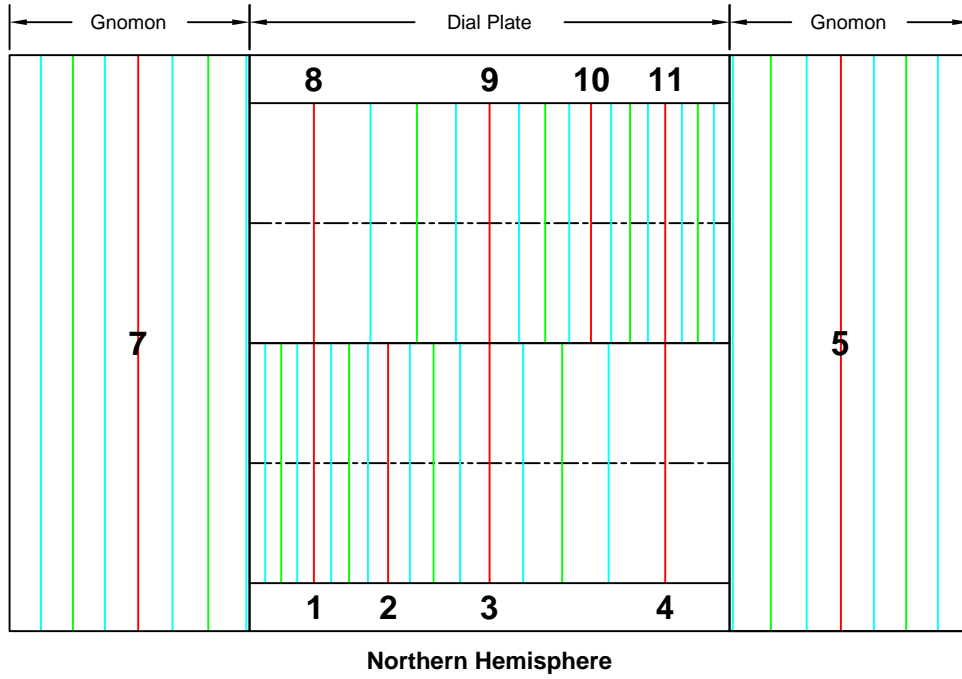


Figure 12

7 The Sundial Primer - "Dialling Guides" Double Gnomon Polar Sundial

created by
Carl Sabanski

Let's return to the determination of the length of the dial plate required to ensure that the gnomon's shadow will indicate the time throughout the year. This must be done on the solstices as was discussed in the instructions for the classic single gnomon polar sundial. You should get them and read that section. To illustrate this point Figure 13 will be used. This figure is a modified Figure 10 with only the afternoon hours shown. The length of the shadow casting gnomon, located on the left, has been reduced to the length of the hour lines.

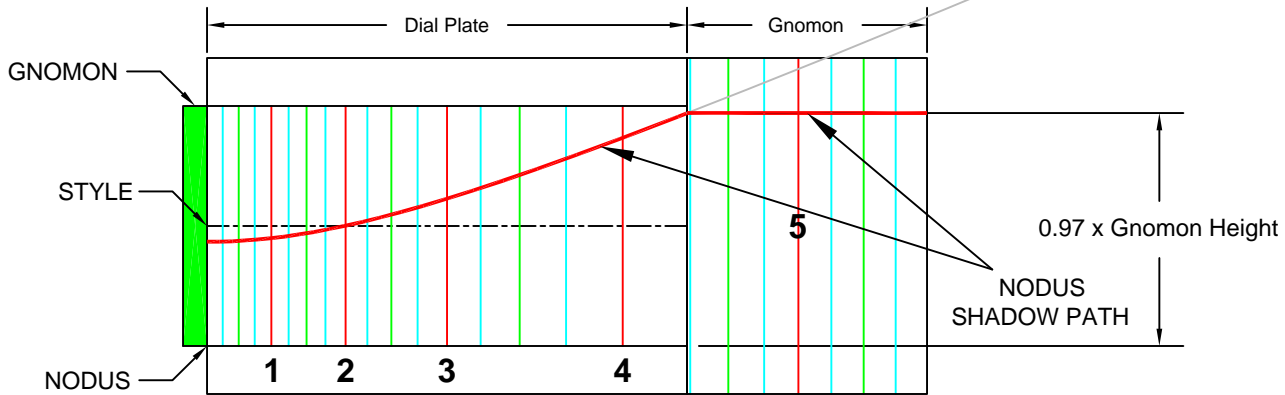


Figure 13

The solstice declination lines have been applied to the dial plate. They are relative to a nodus located at the bottom right corner of the left gnomon as shown in the figure. The shadow of the nodus will move off the left gnomon and on to the dial plate after solar noon (12:00 p.m.) and off the dial plate and on to the right gnomon after 4:14 p.m. The distance the shadow is up the 4:14 p.m. hour line before moving off the dial plate can be calculated to be "0.97 x Gnomon Height". For this example this distance would be:

$$d = 0.97 \times 2.5 = 2.43 \text{ inches} \quad \text{This same analysis can be done for the right gnomon and the morning hours.}$$

The shadow from the nodus travels up or down the gnomon in what appears to be almost a straight line. As I do not know how to calculate this I used a 3-dimensional CAD sundial and rendered shadows at various times as it travelled up the gnomon. It appeared to be a straight line and a straight line is illustrated in the figure. The selection of gnomon height as the minimum hour line length is adequate, however, a slightly longer length might be better. This is a simple calculation and no tables will be provided.

The polar sundial created using these "Dialling Guides" will indicate local apparent or solar time. To obtain clock time the sundial reading must be corrected for longitude and the Equation of Time. To help you with this check out the "Correct-A-Dial" at "The Sundial Primer".

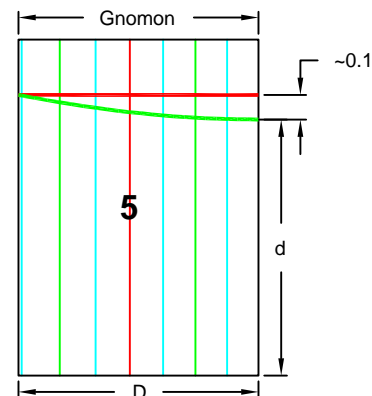
Mac Oglesby provided the following equation for the path of a declination line as it travels the gnomon. Mac also performed a number of simulations using his homemade heliodon and a model of the sundial, which demonstrated that the shadow of the nodus did move along a path as shown in the figure below. A heliodon is a device that can simulate the sun at any time and for any day of the year.

On the gnomon, the actual distance "d" along any hour line to a declination line for a particular day is given by:
 $d = H \times \tan(\text{DEC}) \times \tan(h') / \sin(h)$

where "H" is the height of the gnomon, "DEC" is the declination of the sun for any given day, "h" is the hour angle when the shadow of the nodus is at the foot of the gnomon and "h'" is the hour angle for the time of interest on the surface of the gnomon.

The declination line is at its extreme on the solstices and "DEC" equals 23.44°. The declination line moves on to the two gnomons at 7:46 a.m. and 4:14 p.m. and the hour angle "h" equal 63.435°. These values are used to calculate the values in the table below with a gnomon height "H" of 1 and hour lines spaced at 5 minute intervals. The actual declination line is shown in the figure and can be compared to the straight line that was assumed above.

Time	h	D	d	Time	h	D	d		
7:46	4:14	63.435	0.000	0.969	6:50	5:10	77.5	0.557	0.888
7:45	4:15	63.75	0.014	0.967	6:45	5:15	78.75	0.602	0.884
7:40	4:20	65	0.067	0.957	6:40	5:20	80	0.647	0.881
7:35	4:25	66.25	0.120	0.947	6:35	5:25	81.25	0.692	0.877
7:30	4:30	67.5	0.172	0.939	6:30	5:30	82.5	0.737	0.875
7:25	4:35	68.75	0.222	0.930	6:25	5:35	83.75	0.781	0.872
7:20	4:40	70	0.272	0.923	6:20	5:40	85	0.825	0.870
7:15	4:45	71.25	0.321	0.916	6:15	5:45	86.25	0.869	0.869
7:10	4:50	72.5	0.369	0.909	6:10	5:50	87.5	0.913	0.868
7:05	4:55	73.75	0.417	0.903	6:05	5:55	88.75	0.956	0.867
7:00	5:00	75	0.464	0.898	6:00	6:00	90	1.000	0.867
6:55	5:05	76.25	0.511	0.893					



Happy Dialling!