

1 The Sundial Primer - "Dialling Guides" Equatorial Ring Sundial

created by
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The purpose of the "Dialling Guides" is to provide an easy method for laying out the hour lines for a number of equatorial ring sundials located at any latitude in either the Northern or Southern Hemispheres. The equatorial ring sundial is a universal sundial and can be used anywhere in the world. All that is required is to tilt the sundial so the gnomon points to the celestial pole. Please go to "The Sundial Primer" and visit the "Equatorial Ring Sundial" page for more details.

The "Dialling Guides" are very easy to use and will help you lay out a variety of equatorial ring 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 hour ring. The "Dialling Guides" can be printed to any size but then the scaling in inches is no longer valid.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. There is another method of creating larger sundials that will be discussed later. The following summarizes the equatorial ring sundial "Dialling Guides" available:

1. Sizes: 4 to 10 inches in diameter in 1/4 inch increments; Time Range: as required; Time Increment: 10 minutes
2. Sizes: 4 to 10 inches in diameter in 1/4 inch increments; Time Range: as required; Time Increment: 15 minutes
3. Sizes: 10 to 18 inches in diameter in 1/4 inch increments; Time Range: as required; Time Increment: 5 minutes
4. Sizes: 20 to 36 inches in diameter in 1/2 inch increments; Time Range: as required; Time Increment: 5 minutes

Figure 1 illustrates a side view of an equatorial ring sundial with the parts labelled. This figure will aid in the following discussion.

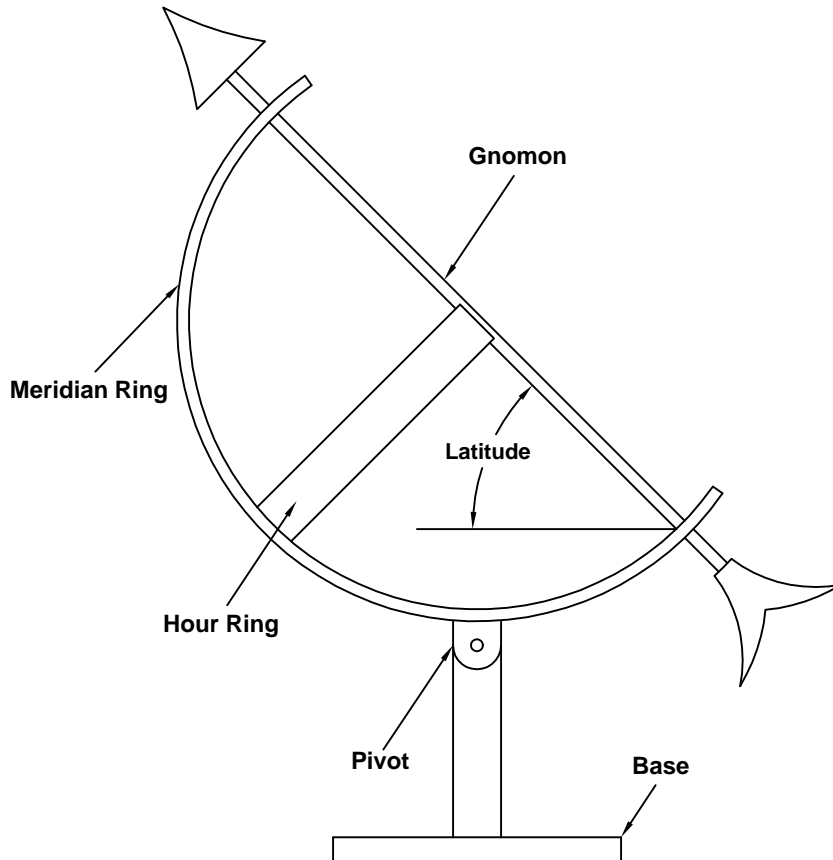


Figure 1

First determine the size of equatorial ring sundial you wish to create. The size indicated on the "Dialling Guides" is the inside diameter of the hour ring. The radius of the hour ring is shown in brackets. The diameter is incremented by either 1/4 or 1/2 inch depending upon the "Dialling Guide" used. Select the appropriate "Dialling Guide" based on the desired size and time increment. The time range will depend upon the latitude where the sundial will be located. Normally an equatorial ring sundial will have a time range from 6 a.m. to 6 p.m. but the sundial can indicate the time from sunrise to sunset. If you would like your sundial to have a range beyond 6 a.m. to 6 p.m. the width of the hour ring must be considered. This will be discussed later. 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 an equatorial ring sundial with a diameter "D" of 8 inches, time range of 6 a.m. to 6 p.m. and 15 minute time increments. Figure 2 shows the "Dialling Guide" that will be used.

This "Dialling Guide" provides the layout of the hour lines for 25 equatorial ring sundials. Line "A" contains the required information for the hour lines of an 8 inch diameter equatorial ring 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!

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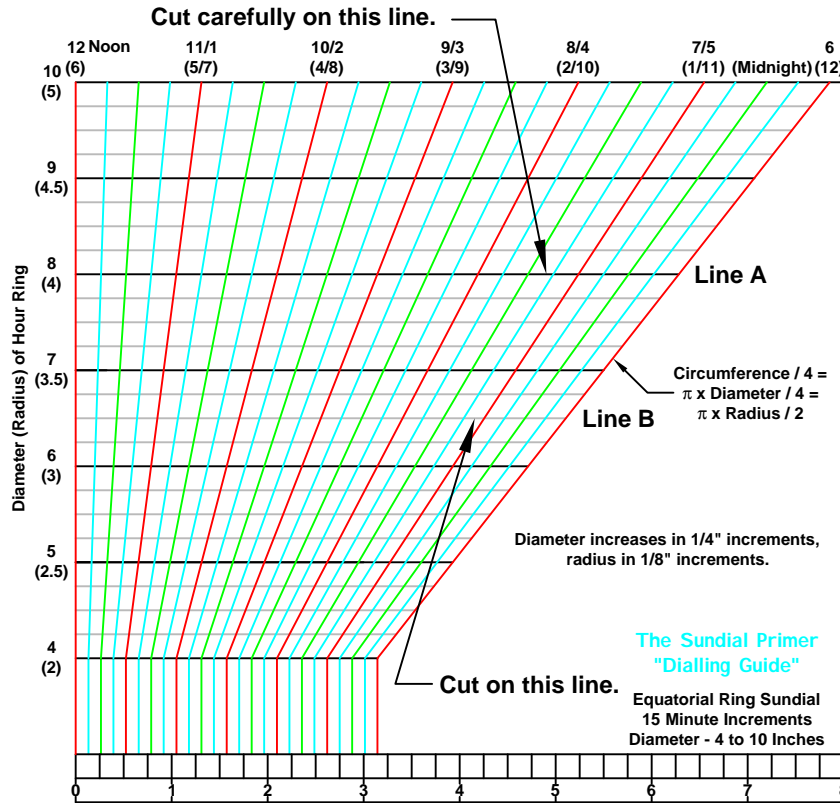


Figure 2

Figure 3 shows the "Dialling Guide" ready for use. The point "X" will be used later to help in laying out the hour lines.

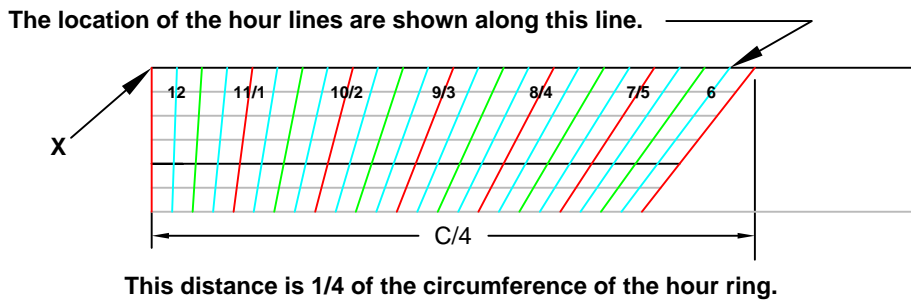


Figure 3

This distance is 1/4 of the circumference of the hour ring.

The size of the hour ring must be determined. Figure 3 shows that the circumference of the hour ring can be laid out using the "Dialling Guide". As the time range of the sundial is 6 a.m. to 6 p.m. only half of the hour ring or C/2 is required. The width "W" of the hour ring will be 1 inch.

It is likely that the layout of the hour lines will be done directly on the material used for the hour ring. Let's assume that this is a piece of flat metal that is 1 inch wide and has a length equal to C/2 ($C/2 = \pi \times D/2 = 12.6$ inches) as a minimum. Draw a horizontal line across the centre of the hour ring. Draw a vertical line down the centre of the hour ring. Figure 4 illustrates the above discussion.

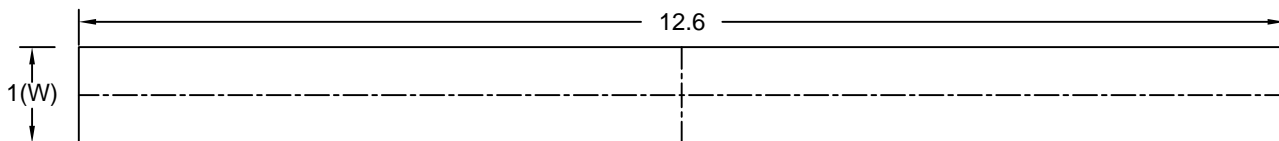


Figure 4

The hour ring is now ready to have the hour lines marked. This step is carried out the same way whether you are designing an equatorial ring sundial for the Northern or Southern Hemisphere. The "Dialling Guide" shown in Figure 3 will be used. Marking the points for the hour lines is a four step process as shown in Figure 5. These steps can be carried out in any order. The vertical 12 hour line must lie against the vertical centre line and the point "X" placed in the four 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 6. These are the hour lines. All that is left is to label the hour lines.

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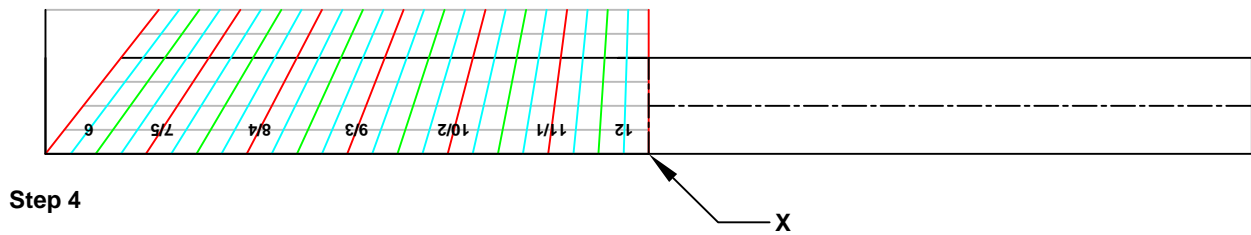
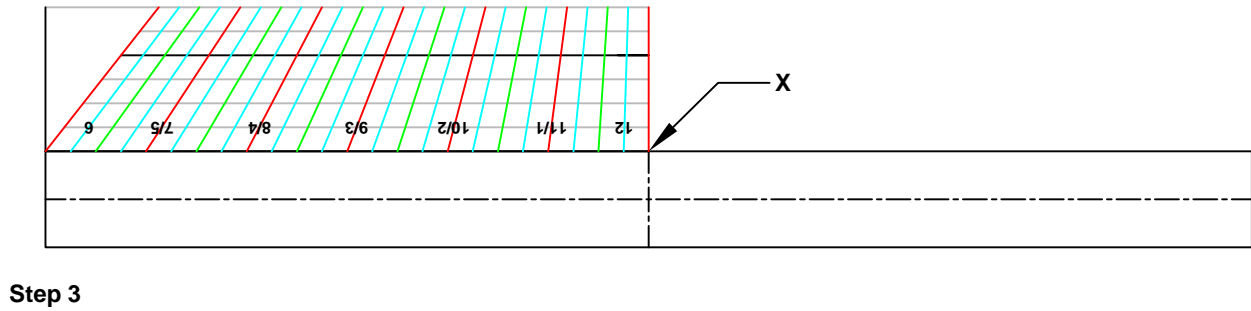
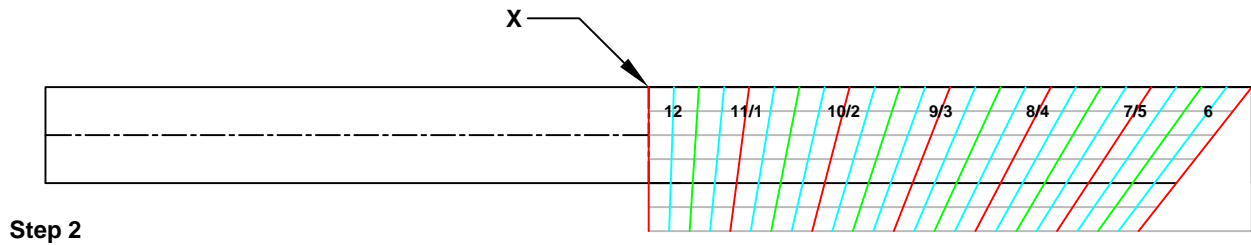
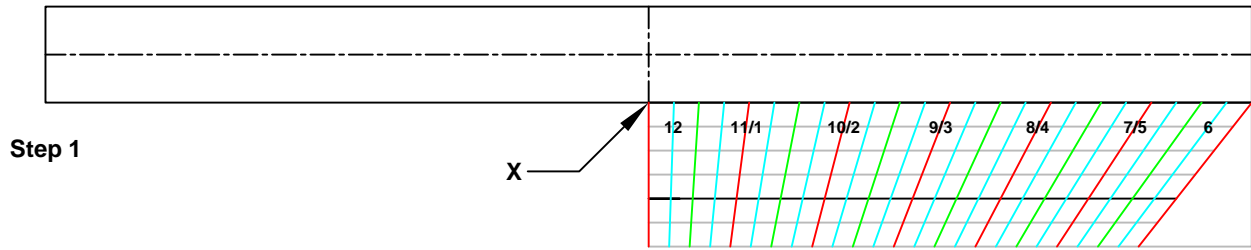


Figure 5

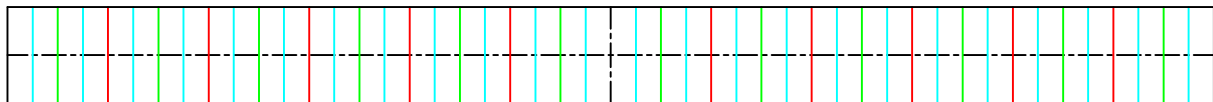


Figure 6

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The hour lines are numbered as shown in Figure 7. In the Northern Hemisphere the arrow on the gnomon faces north and the sun moves from right to left, east to west. In the Southern Hemisphere the arrow on the gnomon faces south and the sun moves from left to right, again east to west. As a result the order of the hour numbers is reversed between the two sundials. The 6 a.m. and 6 p.m. hour numbers do not fit on the hour ring but the ring could be lengthened to permit these to be included.

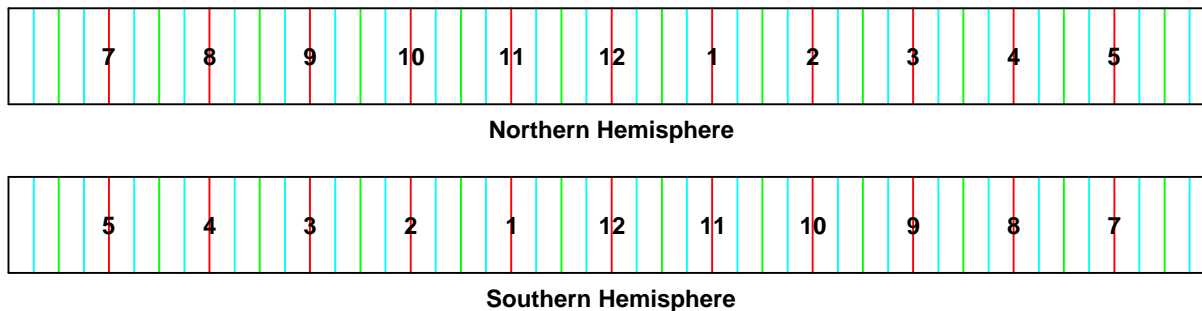


Figure 7

The hour ring must now be formed into the shape of a semi-circle with a diameter of 8 inches. These instructions do not cover this construction process.

If you wish to build an equatorial ring sundial with a diameter larger than 18 inches there are two ways to go about this. If you can print the large "Dialling Guide" at two times the scale the range of diameters available would be 20 to 36 inches. The time interval remains at 15 minutes. If you do not have this capability then you can change the span of the hour lines on the large "Dialling Guide". The present span is 6 hours. This can be changed to 3 hours by renumbering the hour lines so that every second one is now a full hour line. This results in changing the time interval from 5 minutes to 2.5 minutes. This means that now every second line is 5 minutes apart. Doing this effectively results in doubling the scale of the "Dialling Guide" and the range of diameters available would again be 20 to 36 inches. However when laying out the hour lines there will be more steps required. First lay out, for example, the hour lines from noon (12) to 3 p.m. Move the "Dialling Guide" to the 3 p.m. line and then lay out the remaining hour lines from 3 p.m. to 6 p.m. Follow the same process for the morning hour lines. But no modifications are necessary as this "Dialling Guide" is also available with 5 minute intervals.

The equatorial ring sundial can indicate the time from sunrise to sunset. The hour ring can be extended to include additional morning and evening hours. This is not difficult and is illustrated in Figure 8. The range of the hour lines in this figure is 4 a.m. to 8 p.m.

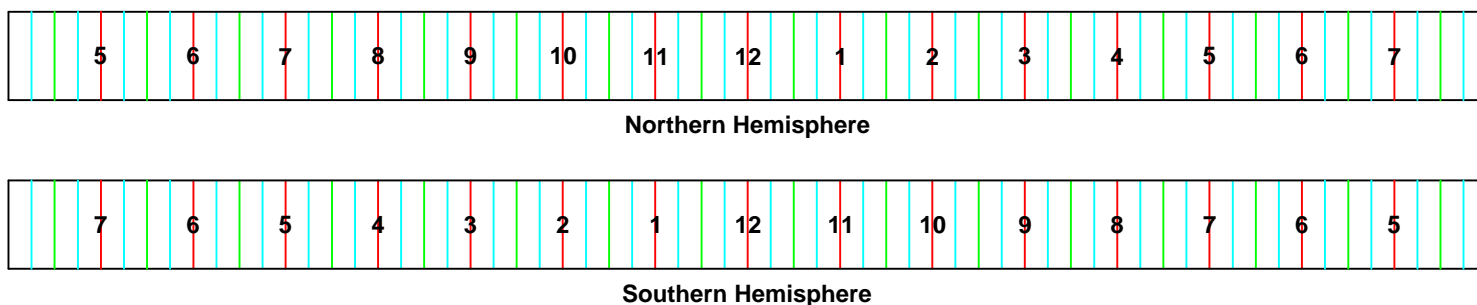


Figure 8

Figure 9 illustrates a modified top view of the hour ring after it has been made into a semi-circle. The hour lines and numbers would not appear as shown. The figure is useful to illustrate a couple of points. The hour lines radiate from the centre of the gnomon at 15° intervals for the full hours as would be expected for an equatorial sundial. The 6 a.m. and 6 p.m. hour lines are located on a horizontal line at the ends of the semi-circle. These hour lines are 180° apart. The 12 (noon) hour line is perpendicular to this horizontal line as shown.

Other details of the equatorial ring sundial are shown in Figure 1. The meridian ring is perpendicular to the hour ring and is used to position the gnomon. The gnomon is normally a rod and is positioned so it runs through the centre of the hour ring and perpendicular to the plane of the hour ring. The entire sundial is tilted to position the gnomon at an angle equal to the latitude of the sundial's location as shown in the figure. The sundial can be permanently fixed on the base with the gnomon at the correct angle or the sundial can have a pivot as shown in the figure. The pivot allows the gnomon to be set at any angle and the sundial can then be used anywhere. If you are making a small diameter equatorial ring sundial a thin wire can be used for the gnomon. As the time is read from the centre of the gnomon's shadow on the hour ring, the wire will cast a narrower shadow and make reading the time easier.

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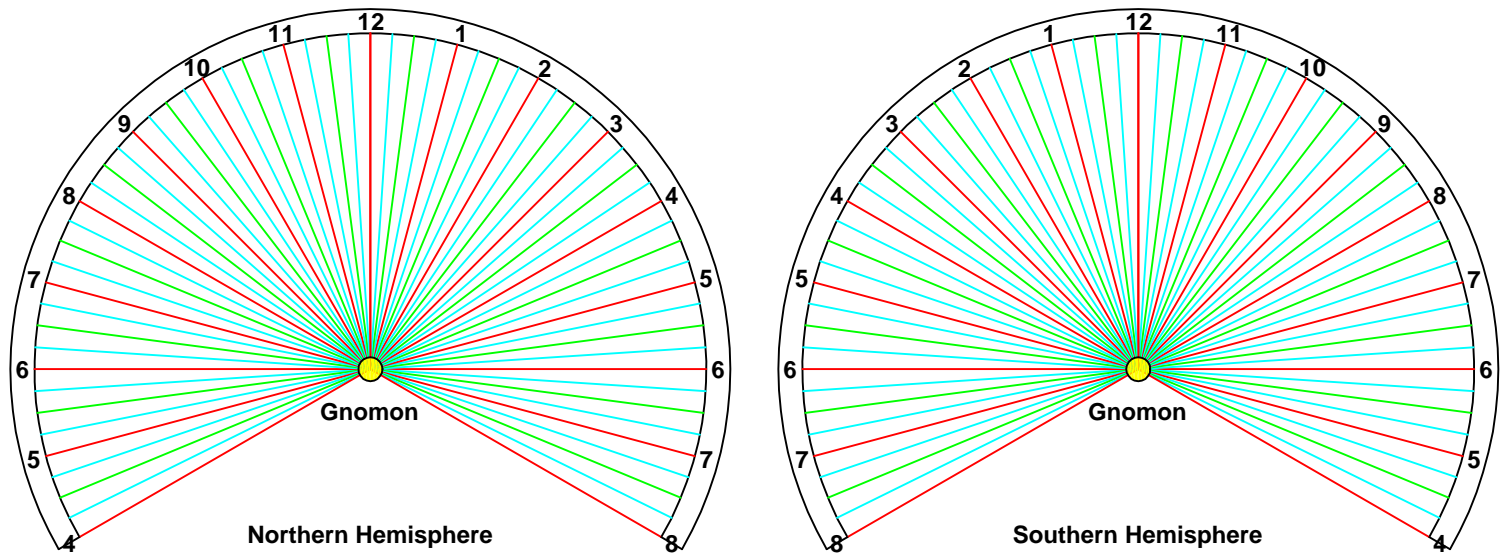


Figure 9

Including hours before 6 a.m and after 6 p.m. can result in a slight problem. An attempt to illustrate this is made in Figure 10. In this figure the sundial from Figure 1 is viewed with the hour ring positioned on a horizontal plane. This being an equatorial sundial the plane of the hour ring is parallel to the equatorial plane. The gnomon is perpendicular to the hour ring, passes through the centre of the sundial and points to the celestial pole. The meridian ring and the gnomon lie in the plane of the local meridian. The sun is parallel to the hour ring at the equinoxes and moves 23.44° above the hour ring at the summer solstice and 23.44° below the hour ring at the winter solstice.

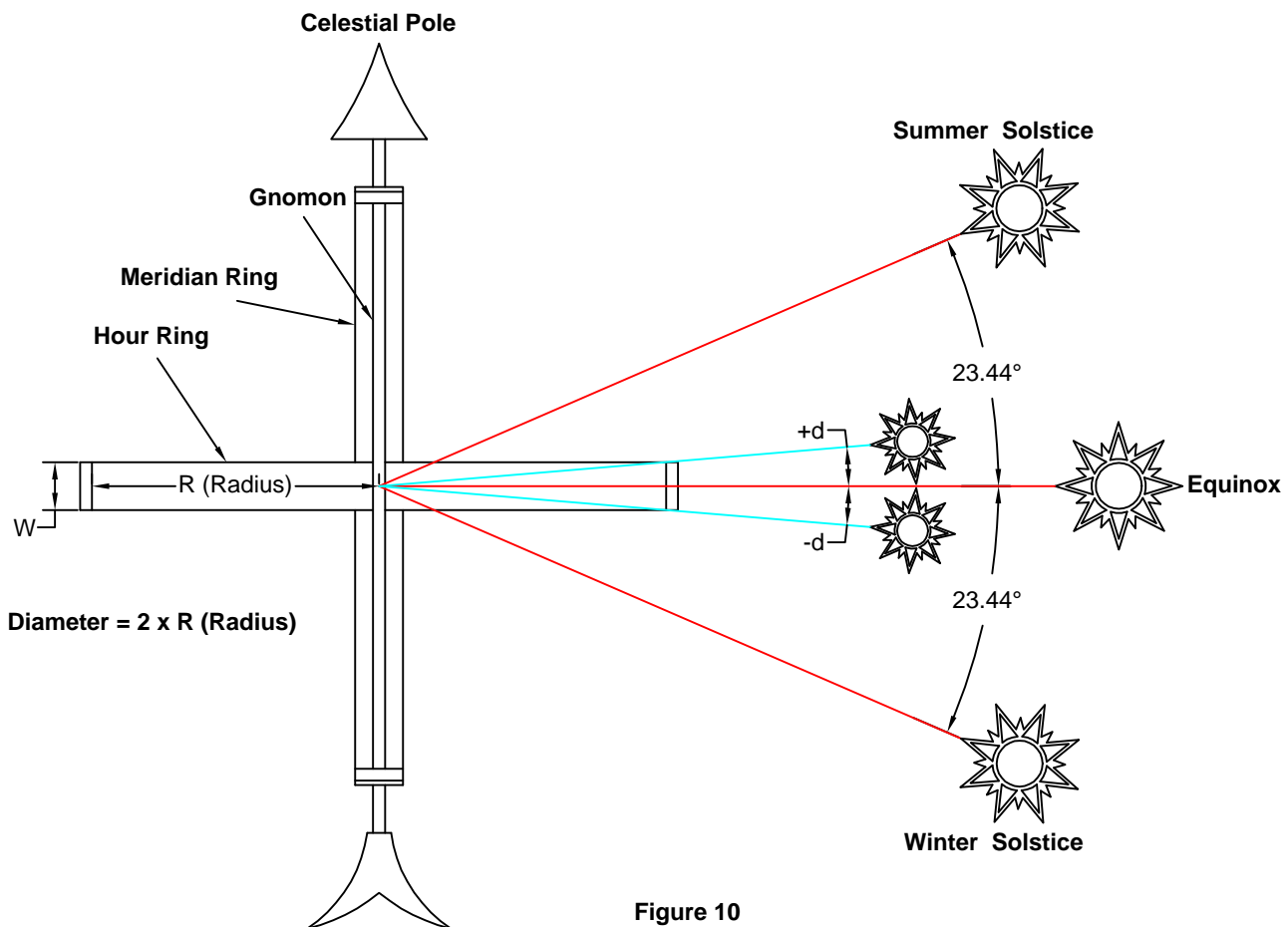


Figure 10

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Equatorial Ring Sundial

As can be seen from the figure the sun's declination must be " $\pm d$ " in order that it be above or below the hour ring. In the case of an equatorial ring sundial with an hour range from 6 a.m. to 6 p.m. this is not an issue and the sundial will indicate the time no matter what declination the sun is at. However when the equatorial ring is extended and hours before 6 a.m. and after 6 p.m. are included the hour ring will obscure the sun during certain times of the year. This period is determined by the declination value " d ". The sun is not obscured for the entire day unless the hour ring is a complete circle as would be found on an armillary sphere. The time period is determined by the number of additional hours before 6 a.m. and after 6 p.m. For example, if 2 additional hours are added before 6 a.m. and after 6 p.m. the sundial will not be able to indicate these two hours as well as an equivalent number of hours after 6 a.m. and before 6 p.m. The hours from 4 a.m. to 8 a.m. and 4 p.m. to 8 p.m. would not be available for certain periods of the year.

The periods of unavailability are affected by the diameter " D " and the width " W " of the hour ring. Figure 11 and Table 1 are provided to help determine these periods. The graph in Figure 11 is used to determine the sun's declination " d " required to bring it above or below the hour ring. Calculate the ratio of the sundial's hour ring diameter " D " to the width " W " (D / W) of the hour ring. From the graph determine the required sun's declination " d ".

Table 1 is the sun's declination for each day of the year. Find the days when the sun's declination is between the values " $\pm d$ ". There will be two periods when this will occur, around the spring and fall equinoxes.

Let's look at our equatorial ring sundial with hour lines as shown in Figure 9. The hour ring has a diameter of 8 inches and a width of 1 inch. The ratio " D / W " is equal to 8. From the graph in Figure 11 the required sun's declination " d " is slightly over 7° . Now go to Table 1 and find the days when the sun's declination is between $\pm 7^\circ$. The two periods are March 2 to April 8 and September 4 to October 11. For about 2 months of the year the sundial will not be able to indicate the times from 4 a.m. to 8 a.m. and 4 p.m. to 8 p.m. During the remainder of the year all the hour lines will be functional.

Happy Dialling!

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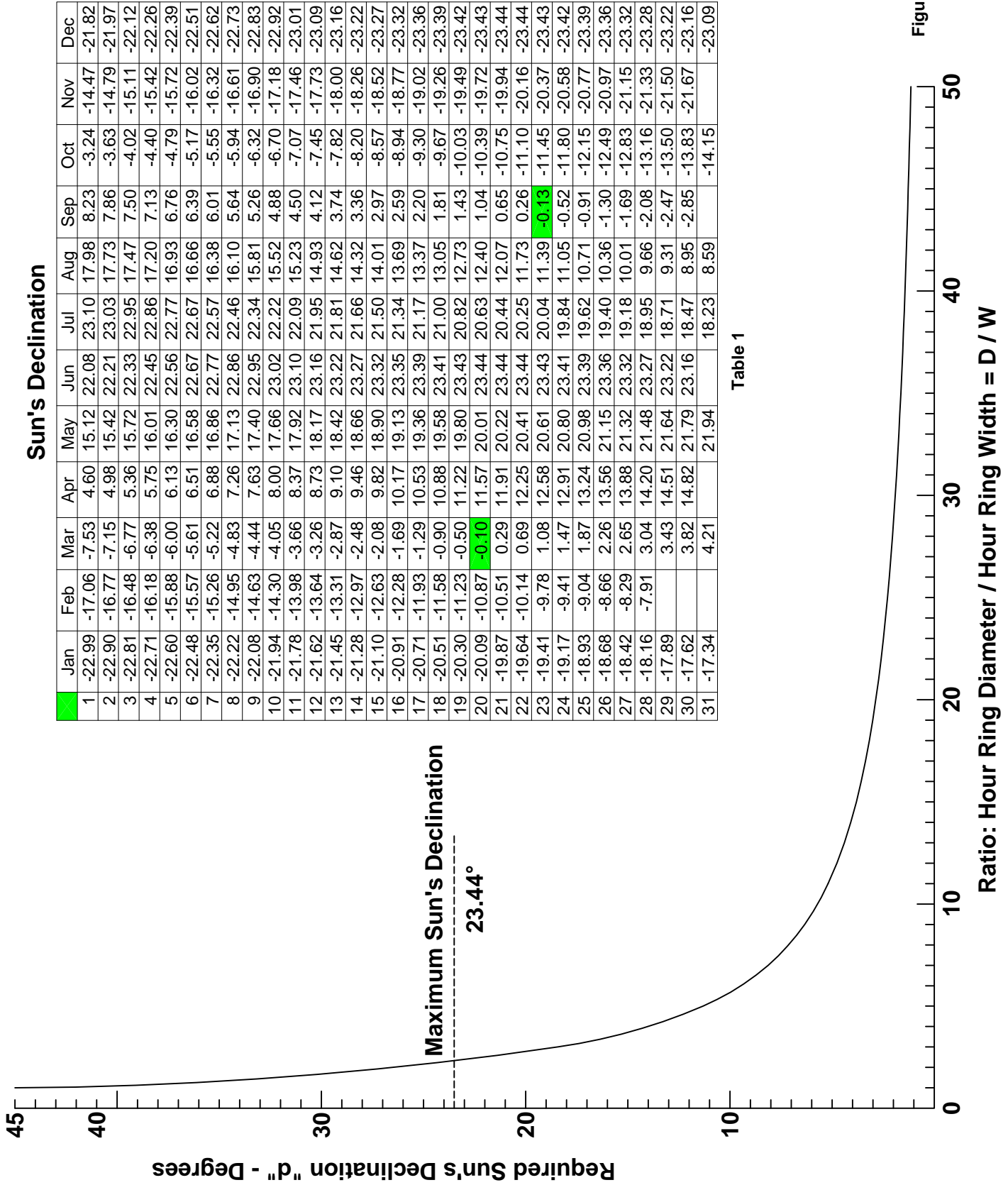


Figure 11