

Ring Dials (Farmers' Rings)

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1. General Remarks

Ring dials (fig. 1) are portable sundials of a rather simple type. Sometimes they are called “poke dials” *i.e.* pocket dials, because one could easily carry them in the pocket. In German they are usually named “farmers’ rings”. This may result from the fact that these rings could be produced cheaply and therefore also the average man could afford such a dial. Its easy handling could be another reason for the wide acceptance.

Usually simple ring dials consist of a metal ring of about 2 inches in diameter. The ring can be suspended. A pin hole somewhere in the upper part of the ring forms its gnomon. For use, the suspended ring has to be turned towards the sun so that sunlight can pass through the pin hole and cast a spot of light onto the opposite inner surface. The time is read off the scale there.



Foto P. A. Kraml

Fig. 1: Farmers ring (© Stift Kremsmünster)

This sundial type shows the current time by measuring the sun's altitude. For that reason it can be designed only for the latitude where it is used. And, of course, as in all altitude sundials, one must know if the time is measured before noon or after noon. For any sun altitude in the morning we can find the corresponding sun altitude in the afternoon.

Because of the simple construction, many people think that these poke dials do not function exactly. They are right, yet only if the scale on the inner surface does not show date lines. We will discuss that later on. It has to be admitted though exact time reading is often prevented by the small size of ring dials, in spite of precise construction.

Simple ring dials were accepted for measuring time in many areas until the 19th century. Yet they can be found only rarely in museums these days. Maybe, many were lost because of their small size or perhaps because of their low material value. Besides, the interest in such rings and knowledge of them do not seem to be very great. This could also explain why sometimes astonishing errors can be found even in catalogues of very interesting collections.

2. Some History

Some authors maintain that even the Romans used simple ring dials. Searching for more detailed descriptions leads to the result that their portable dials were different from the type discussed here. Actually, these Roman “ring dials” are cylindrical boxes. They consist of a circular disk. The pin hole in the cylindrical edge forms the gnomon. The scale for the hour lines is not placed on the inner surface of the cylinder but on the circular disk. Fig 2 shows one of this type, discussed by Drecker ([5], Abb. 88 and p. 60). As one can see, the method applied is quite different from that of the ring dials discussed here. Two other modern descriptions of portable Roman dials show big differences to ring dials, too (refs. [1], p. 143-145 and [9], pp. 40).



Abb. 88

Fig. 2: Roman sundial ([5])

It is also sometimes claimed that Bonetus de Latas, often noted as Jacob ben Emanuel Provencalis, was the inventor of the ring dial. In 1493 he described a signet-ring dial which had a small astrolabe instead of

the signet. The sunrays passing through the pin hole cast a light spot on the inner surface of the ring, where the sun's altitude was read off. Using this altitude and using the signet-astrolabe an expert was able to tell the time. The sun's altitude was measured similarly to the manner in which the altitude of the sun was determined with our ring dials. Finding the correct time afterwards became a rather difficult thing only possible for highly educated people.

According to modern findings it can be stated that the first ring dials were invented some years before Bonetus de Latas. In copies of works by Regiomontanus and Peurbach, hints can be found that they must have had the idea for ring dials as the first ones. Zinner tends to the opinion that Peurbach (born 1423 in Peurbach, Austria) invented the ring dial and Regiomontanus (born 1436 in Koenigsberg near Nuernberg and Peurbach's student and friend in Vienna) improved it. Around 1457 Regiomontanus is said to have constructed ring dials with two pin holes and calculated the two hour-line scales inside ([12], p. 613). He also gave hints on how to manufacture them. Additionally, we know works by Peurbach where he presented tables for the sun's altitude and a description of ring dials ([8] p. 193 and pp.244).

At the beginning of the 16th century, these ring dials were quite common and in use. A German notice from 1522 says that people preferred the ring dials with two separated scales for the hour lines. Also in other European countries they must have been in use, which is indicated by publications describing ring dials. A well known book by Orontius Fineus (Oronce Finé), printed in Paris in 1531, describes ring dials very clearly [7]. In the late 16th century Cosimo Bartoli translated this book into Italian¹.

In 1562 Andreas Schoener from Nuernberg pointed out a problem in the construction of ring dials which was not considered before ([10], Blatt 83): Neither in the famous book by Orontius nor in the books by Sebastian Muenster had it been noted that the height of the light spot cast onto the inner ring surface changes if one turns the suspended ring until this light spot is no longer in the center of the inner surface but nearer to its edge. This problem will be discussed in chapter 3.3.

We do not know if and how often the improvement proposed and constructed by A. Schoener was realized. We only know that hardly any ring dials can be found with this correction included. Maybe, the manufacturers found it too difficult. Maybe, it is only because most ring dials are rather narrow compared to their diameter. In this case the correction is negligible.

About 20 years after Schoener's book, we find the first notices on ring dials with movable pin holes ([12], p. 615). We do not know if this changed the acceptance of ring dials very much, but we know that these ring dials were accepted and used by many people in southern parts of Germany right up to the 19th century. So ring dials were an early and successful miniaturisation which lasted for more than 300 years. This is rather astonishing if we consider that very exact mechanical pocket watches had long since been in production in the 19th century. But, of course, mechanical watches were much more expensive.

The area where ring dials were used is not limited to the southern German area. This fact is supported, on the one hand, by early prints in other countries ([2] and [7]). On the other hand, we also know that most of the extant dials today were manufactured in England and not in Germany ([3], p. 21). So they must have been in common use there.

3. Construction

3.1 Old constructions

For the construction of ring dials many old books suggest that one use a flat rectangular strip of metal and engrave the scales shown in fig. 3. Afterwards this strip is bent into a perfect ring where AC is fixed to BD. AC(BD) is at the same time the point of suspension.

¹ Some years ago Peter Drinkwater produced an English booklet to interpret Oronce Finé's solar horology [ref. 6].

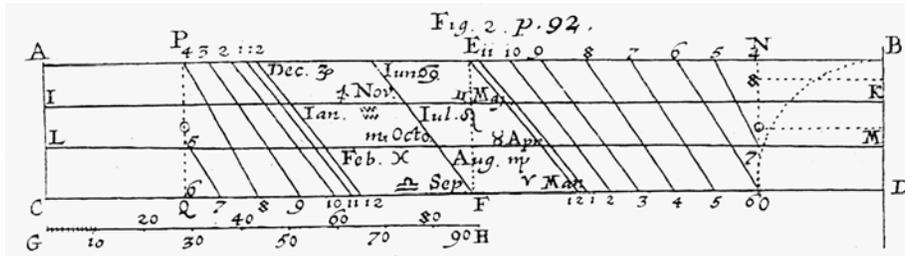


Fig. 3: Construction of a ring dial (ref. [11])

The date lines AB, IK, LM and CD in fig. 3 are arranged corresponding to the Zodiac. The scale for the winter period is drawn on the left half of the strip, the scale for the summer period on the right. The pin holes are positioned on lines PQ and NO. Scale GH at the bottom is used to transfer the different altitudes of sun onto the strip. Sun altitude zero is at the level of the pin holes. Although, this is not exact the hour lines drawn are straight.

3.2 Time Reading in the “Central Plane“

If we draw a circle parallel to the inner edge of a ring, a plane is defined which cuts the original ring into two rings. Let us define now the „central plane“ as the plane parallel to the inner ring’s edge which contains the pin hole, too. It is usually situated in the middle of the ring’s width.

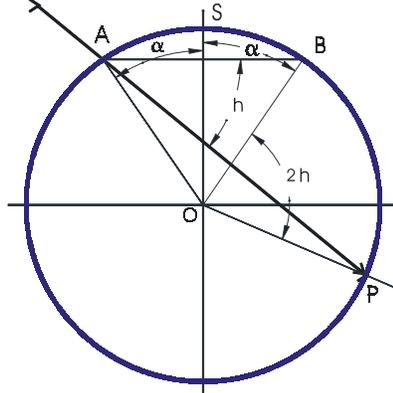


Fig. 4: Path of light in ring dials

Further, let us consider the case that the light spot cast onto the inner surface is situated in this central plane. This is shown in fig. 4: Point S is the suspension point and B the upper edge of the scale for the hour lines. The sun light passes through the gnomon hole at A and casts a spot of light on P. The horizontal sun ray through A casts a spot on B, where the time of sun rise or set can be read, if this is done on the actual date line.

For the position of the light spot P we can calculate the angle $\gamma = (\angle SOP)$ as

$$(1) \quad \gamma = \alpha + 2h$$

where $\alpha = (\angle AOS)$ marks the position of the gnomon hole and $h = (\angle BAP)$ the sun’s altitude. For construction the angle α can be selected at will within 0 to 90 deg. From geometry we know that the

angle $(\angle POB)$ is twice the angle $(\angle PAB)$, because the angle measured from the centre of a circle to any arc(PB) of the circle is twice the angle which is measured from any point on the circle line (for instance from point A) to the same arc(PB).

The sun’s altitude h is calculated by

$$(2) \quad \sin h = \sin \delta \cdot \sin \varphi + \cos \delta \cdot \cos \varphi \cdot \cos \tau$$

where δ = the sun’s declination, φ = the latitude, and τ = the sun’s hour angle.

According to formula (1) the difference of two hour lines is determined by the difference of the sun’s altitudes. Taking into account formula (2) we can say that the difference of altitudes varies with the calendar date (or the sun’s declination) and with latitude.

**Differences of the Sun’s Altitude [in deg] from 10 to 12
True Local Time**

	winter solstice	equinox	summer solstice
latitude 48 deg	9,62	6,59	4,91
latitude 44 deg	11,46	7,47	5,39

From the table we can conclude:

- a) The difference between two hour lines depends on the date. Thus exact ring dials must show date lines for reading the correct time.
- b) The difference of the hour lines varies with latitude. Therefore, the scale of a ring dial is only correct for the latitude used in the construction. Changing the suspension point or moving the gnomon hole cannot adapt for another latitude.

It should be added that the sun's altitude changes little at times near noon. The hour lines are close to each other. This makes exact time reading nearly impossible. But, of course, this is a problem in all altitude sundials.

3.3 Laterally Offset Time Reading

As mentioned earlier, Andreas Schoener was the first to point out that a correction in formula (1) must be made if the sun's light spot on the inner ring surface is outside the central plane (*i.e.* is offset).

Thus, let us consider this situation: If the freely suspended ring rotates around its point of suspension, then the sunlight passing through the pin hole forms a lateral area of a cone. The vertical direction through the pin hole is at the same time identical with the vertical axis of this cone. If this cone touches the inner ring surface, then the ring is touched in the central plane. At this level no other sunray has reached the ring surface. The farther away from the central plane, the farther down the ring surface is reached by the sunrays of the lateral cone. To calculate the correct position of the offset light spot an angle β has to be added to the sun's altitude. Drecker ([5], pp. 90) calculated this effect and found :

$$y = \frac{d}{\sin h} \sin(h + \alpha + \beta) \sqrt{\sin(2h + \beta) \sin(\beta)} \quad (3)$$

where h = the sun's altitude, α = the position of the pin hole, β = correction for h , d = the ring diameter, y = offset of light spot from the central plane. The calculation of the corrected position of the light spot is a bit complicated, because one cannot easily invert this formula to $\beta = \dots$, but calculations are easy by using computer software.

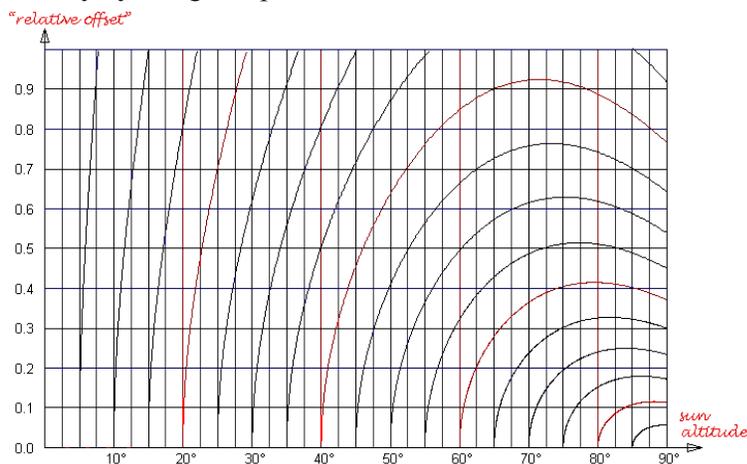


Fig. 5: Correction of altitude for offset light spots and $\alpha=50^\circ$

that the gnomon hole and the central plane are positioned in the middle of the ring.

The calculation for fig. 5 was done with vectors without using formula (3). This method shows the correct results, too, in the case of 2 possible solutions for a single value of v . This happens for high sun altitudes and/or bigger ring widths. The solution can be found in the mathematical appendix.

If we calculate the "relative offset" $v = y/d$ from (3), then we see that the result contains only the variables α , h and β . Therefore, the calculated correction must be the same for all latitudes. Schoener showed his result in a figure similar to fig. 5. The figure displayed has been calculated for pin hole position $\alpha = 50^\circ$, the same value which was used by Schoener².

Reading this graphic we must not forget the following: If the ring's width is 50% of its diameter (= 0.50) then the biggest relative offset is not $v = 0.5$ but $v = 0.25$, this for the case

² Schoener uses 25° but he measures all angles seen from the circle line and not from the center.

Schoener did not calculate the corrections. He found his solution geometrically by construction and put the results into a graphic. His construction is rather hard to decipher, but only small differences in some parts can be found when comparing his graphic with the calculated one above. Thus we may conclude that his construction is correct.

Fig. 6 shows one half of the inner surface of a ring dial, containing a scale that includes the corrected

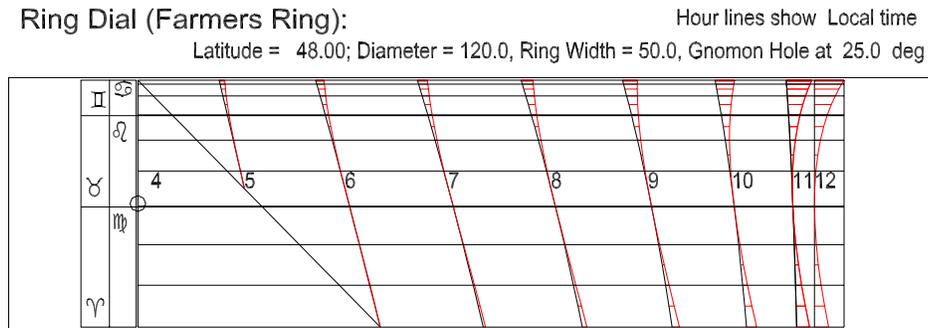


Fig. 6: Hour lines of a ring dial with and without Schoener's correction positions of offset light marks. The scale was constructed, as all scales in this article, by using software SONNE. The date lines are arranged according to the sun's declination. We also could say that they are arranged according to the Zodiac. The hour lines show true local time for the summer period. The lower part in each hour line (more to the right) shows the hour line calculated with Schoener's correction included.

Considering that $v = y/d$ is independent of the ring's diameter we also may enlarge this construction. All used formulas discussed above are independent of the ring's size, and Schoeners correction remains the same, too, if a ring is (centrally) enlarged. Thus the result after the enlargement is exact, too.

This discussed correction for offset light spots could be avoided if a ring dial with a horizontal gnomon slot instead of a gnomon hole is constructed. The only question then: How can we construct a ring dial with a movable horizontal gnomon slot?

4. Various Constructions

Even simple ring dials can be modified in many ways. Some possibilities are discussed in the following part.

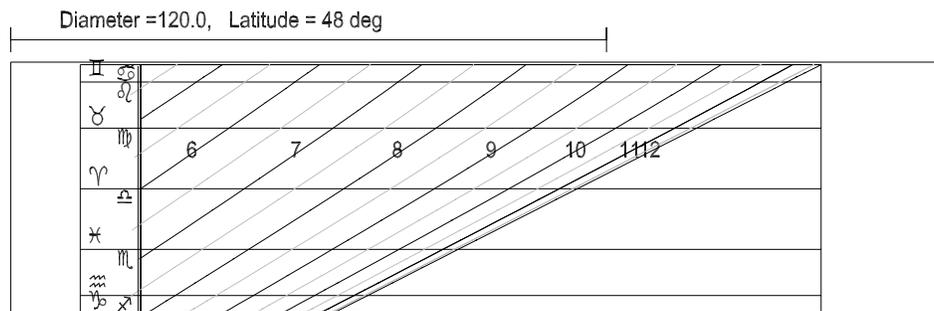


Fig. 7 : Ring dial with fixed pin hole - scale on the inner half circle

4.1 Scales with Date Lines

As mentioned above, exact time reading is only possible in ring dials if the scales for the hour lines have date lines too. Usually – but this need not be like that – the date lines are circles, arranged parallel to the inner edge of the ring. If we draw equidistant circles for each month, then the hour lines look rather complicated. If we arrange the date lines according to the sun's declination on this date, then the hour

lines are nearly straight. In old ring dials very often the hour lines are straight and the date lines are arranged corresponding to the Zodiac signs instead to the date. The construction of fig. 7 is made in this way for latitude 48 degrees. The date lines in fig. 8 are arranged in the same way. As one can see, the hour lines are nearly straight. Schoener's correction is not included.

4.2 Fixed or Movable Gnomon Hole

If the gnomon hole can be moved, then it must be positioned at the correct date mark to read the correct time. Horizontal on the opposite side of the pin hole the time of sun rise/set is indicated on the correlating date line.

In ring dials with movable pin holes each date line can be moved parallel to the edge of the inner ring surface. Of course the position of the pin hole must be adapted accordingly to this movement. Very often the date lines are shifted in such a way that the noon line becomes horizontal

The ring dial in fig. 8 shows a horizontal noon line nearly at the deepest point of the ring. Therefore the other hour lines are not inclined as much as in ring dials with a fixed pin hole. On the outer side of the ring (right in fig. 8) the date marks and the movable pin hole can be seen.



Fig. 8: Ring dial: pin hole movable (© M. Cowham)

4.3 Ring Dials with Several Scales

Very often ring dials do not show one scale of hour lines only but two. Then usually one scale is for the summer period, when the sun is above the celestial equator, and the second scale is for the winter period. In most cases the two scales are arranged on opposite parts of the ring. Two scales for hour lines allow more exact time reading: the distances between the date lines are wider and the inclination of the hour lines is smaller.

In fig. 9 such a scale for the summer period is shown. The gnomon is movable, because the 12-o'clock line is horizontal. The times of sun rise/set are shown where the single inclined line crosses date lines and hour lines.

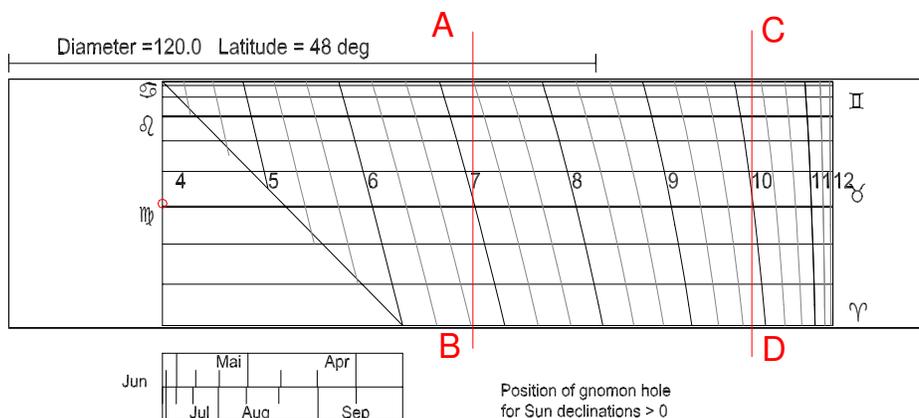


Fig. 9: Hour lines for the summer period and for movable gnomon hole

In the small rectangle at the bottom of the figure the date marks for the gnomon's position are drawn. They must be – seen from the suspension point – on the opposite side of the ring and on the outer part of the ring.

Very seldom ring dials with more than two scales are found. Sometimes such rings were constructed for the purpose of providing scales for various latitudes.

4.4 Scales with Horizontal Hour Lines

Such a ring dial is shown in fig. 1. As mentioned before, exact time reading is not possible in these constructions. But, if a movable pin hole is used, then the noon line (XII in figure 1) can be made horizontal and time reading is correct for noon. The other hour lines cannot be horizontal either. But for each inclined hour line an average height can be found. Now we can mark this average height in the ring – without drawing any date line! If two separate scales for winter and summer period are used, an average height of its own can be fixed for each period. Then the difference between the average value and the most distant correct value becomes smaller and more exact time reading is possible.

Such an average value is inserted in fig. 9 for the 7- and 10-o'clock line by drawing the straight lines AB and CD, both parallel to line 12. The figure suggests that the maximal error in time reading is about 20 minutes for the latitude of 48 degrees. So, one can see, that even ring dials without any date lines could have been a rather useful instrument of time measuring in earlier times, because for most people everyday life was not fixed up to the minute.

5. Mathematical Appendix

Here we give the result of the altitude correction if the sun spot on the inner ring surface is offset from the central plane. The figure below displays the coordinates used. The cross section of the ring with radius $r=1$ is seen in the x-y-plane. The axis of the ring dial, and also the offset of the sun mark is in the direction of the z-axis. The x-y-plane is at the same time the central plane which contains the gnomon hole in point A. The angle distance of A to the y-axis is α . The sunlight passing through A (actually its vertical plane) is rotated out of the x-y-plane by the angle ε . Then the position where the sunray intersects with the ring is calculated by

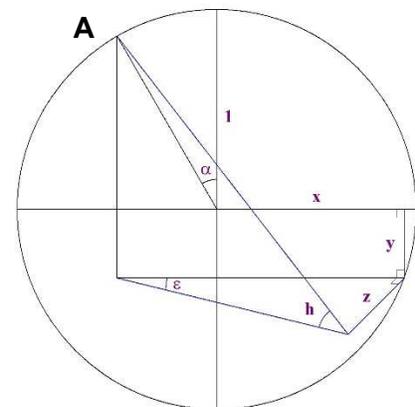
$$\begin{pmatrix} x \\ y \\ z \end{pmatrix} = \begin{pmatrix} -\sin \alpha + k * \cos h * \cos \varepsilon \\ \cos \alpha - k * \sin h \\ k * \cos h * \sin \varepsilon \end{pmatrix} \quad \text{where}$$

$$k = \frac{2 * (\sin h * \cos \alpha + \cos h * \sin \alpha * \cos \varepsilon)}{\sin^2 h + \cos^2 h * \cos^2 \varepsilon}$$

Using this result the relative offset v and angle β are calculated by

$$v = \frac{z}{d} = \frac{z}{2} \quad \text{and}$$

$$y = \cos(\alpha + 2h + 2\beta) \quad \text{or} \quad x = \sin(\alpha + 2h + 2\beta)$$



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The constructions are calculated with software SONNE. You can download this freeware from webpage <http://www.helson.at>

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***German information on 'Farmers' Rings in Low Latitudes' can be found in the
German essay 'Bauernringe'***