

BIFILAR SUNDIAL

by Fer J. de Vries

Introduction

Hugo Michnik of Germany invented the bifilar sundial in its horizontal form in 1923. His idea was the first really new sundial type since centuries.

Instead of a pole style or other single gnomon, two crossing wires are used.

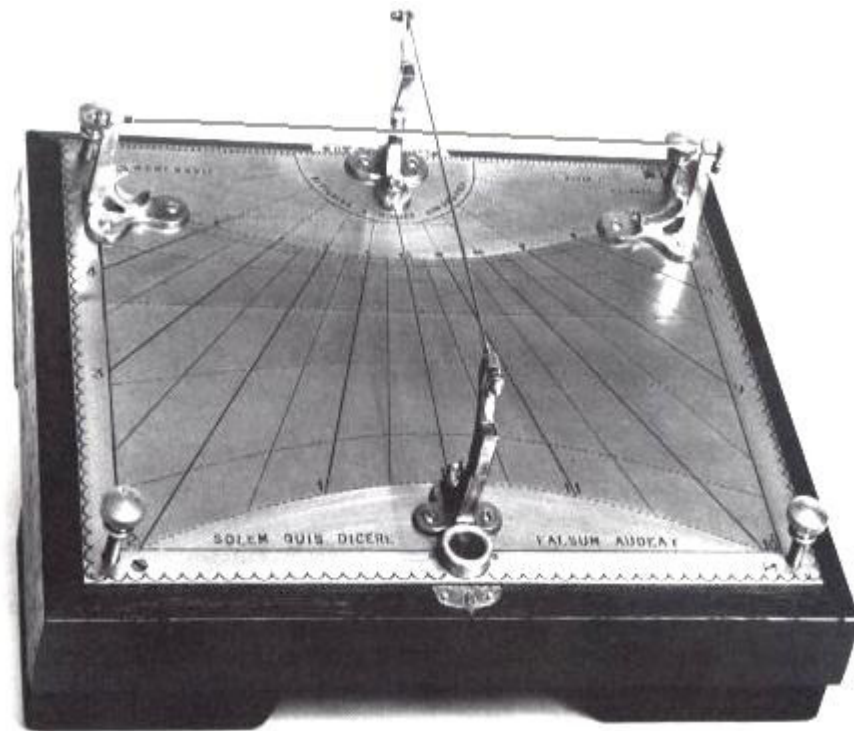
One wire runs north-south, the other east-west.

They are parallel to the dial plate but have differing heights.

At a certain height ratio, all hour lines come out equally spaced, fifteen degrees apart, like on an equatorial sundial.

The sundial is read where the shadows of the wires cross.

A procedure for this simplest form is described here.



Example of a bifilar sundial. From: Die Sonnenuhr, René R.J. Rohr

A bifilar sundial could also be called a two-wire dial or a cross-wire dial, but instead of wires, the edges of planes could be used.

For a long time after its invention, not much was published about the bifilar sundial. About 1980 however, this dial began to attract interest again, and it was developed further. One example, the use of curved wires, is shown below.



Bifilar sundial with curved east-west "wire" in Appingedam

Basic procedure, part 1

This page describes the basics of a **bifilar** sundial.

The description is limited to the horizontal implementation as first described by Hugo Michnik in 1923.

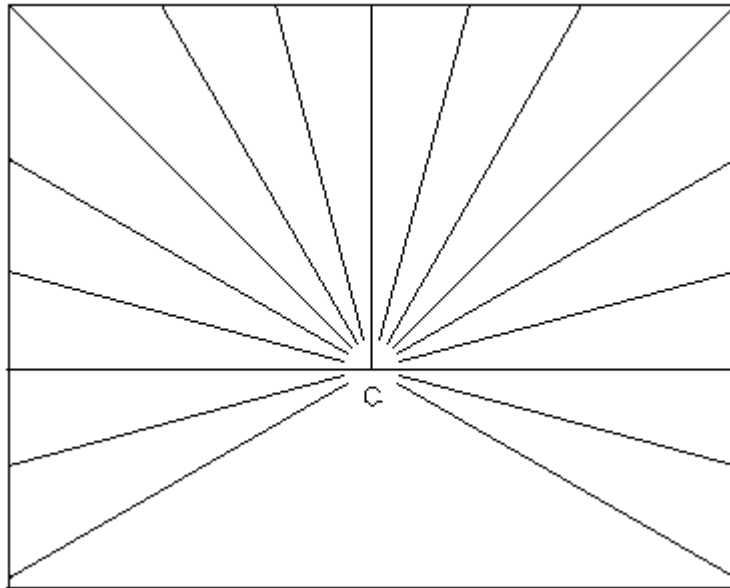
The hour lines

Draw the necessary hour lines as if on an equatorial sundial.

All hour lines are fifteen degrees apart.

Of course, half-hour lines could be drawn every 7.5 degrees, or even quarters of an hour, or minutes.

All this is easily done with compass and ruler, and no special constructions or calculations are needed.



Hour lines spaced at 15° intervals

The wires

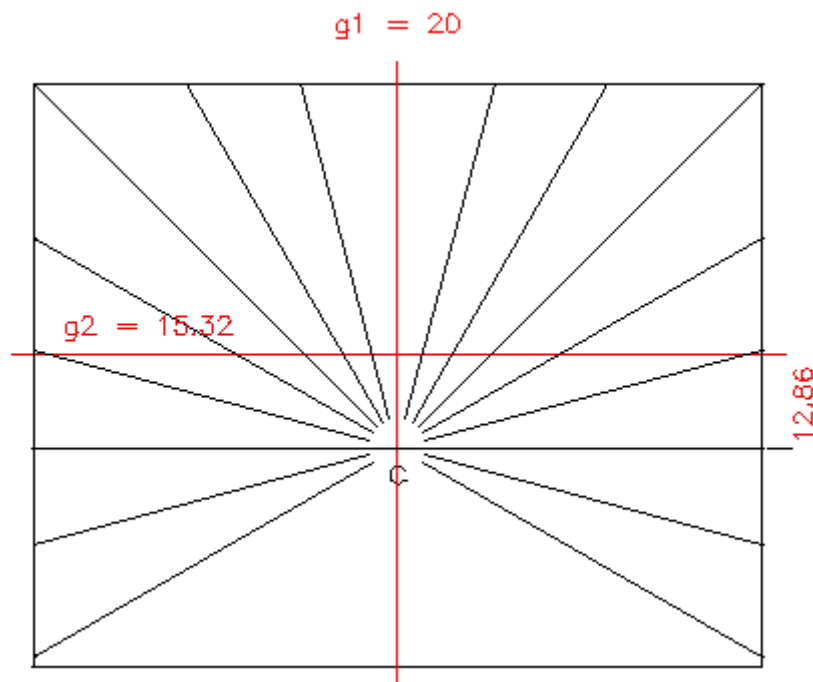
The north-south wire should be over the north-south line (which is also the substyle) at a height g_1 that may be chosen freely. The height of the east-west wire should then be $g_2 = g_1 \cdot \text{SIN}(\text{latitude})$.

If, for example, $g_1 = 20$ mm and the sundial is intended for a latitude of 50 degrees, then $g_2 = 20 \cdot \text{SIN}(50) = 15.32$ mm.

But where should the east-west wire be?

It should be over a point that is on the north-south line, a distance $y = g_1 \cdot \text{COS}(\text{latitude})$ from centre C.

In our example, this would be $y = 20 \cdot \text{COS}(50) = 12.86$ mm.



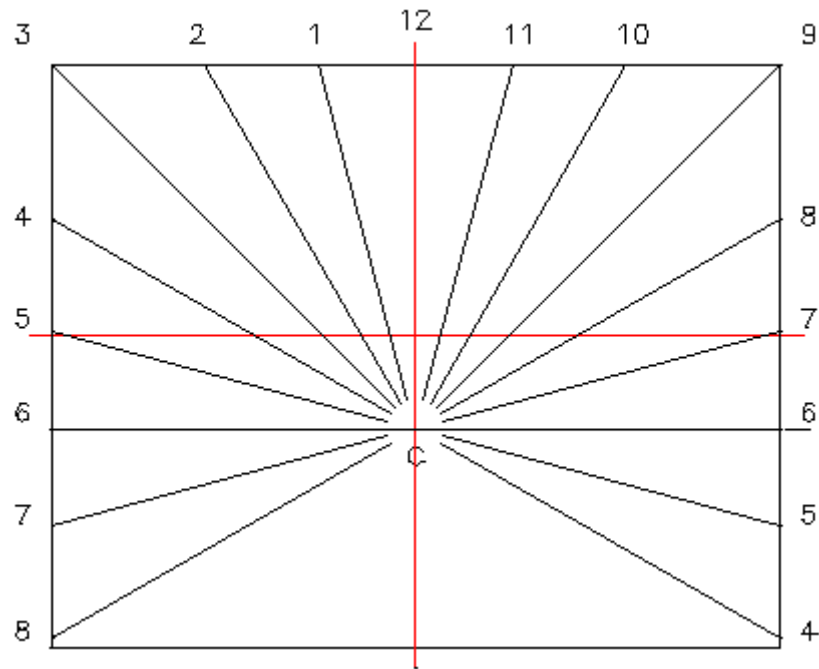
Position of the wires

Placing numerals, and the final result

In the Northern Hemisphere, the hour numbers run clockwise, in the Southern Hemisphere anti-clockwise.

If the hour lines and numerals are on a plate that can rotate about C, then any correction (for longitude or Equation of Time) may be applied by such rotation.

This is a great advantage of any sundial with equiangular hour lines.



The final result for a horizontal bifilar sundial on the Southern Hemisphere

Universal horizontal bifilar sundial

Draw twenty-four hour lines, all spaced fifteen degrees. (*Not shown in the figure*)

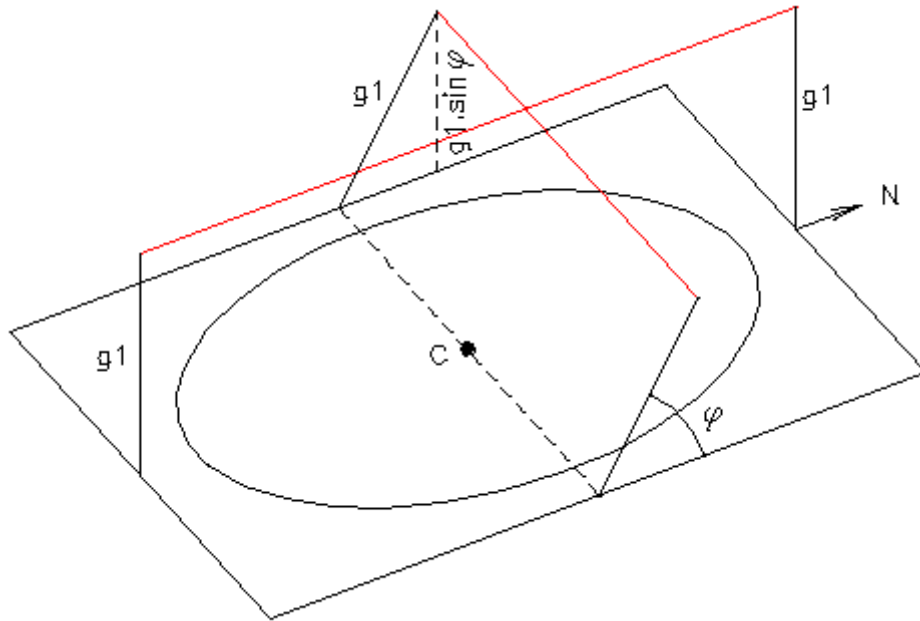
Place a wire over the north-south line, at height g_1 .

Place a similar wire over the east-west line through C, but make the supports rotatable about the east-west line.

Adjust the angle between the supports and the horizontal plane to the desired latitude.

This will automatically place the east-west wire at a height $g_2 = g_1 \cdot \sin(\text{latitude})$ and distance $y = g_1 \cdot \cos(\text{latitude})$ from the hour line centre C.

Swinging the wire northward produces a sundial for the Northern Hemisphere; swinging it southward produces one for the Southern Hemisphere.



Universal bifilar sundial

Other lines

Many other lines may be applied to a bifilar sundial, but that is outside the scope of this basic article. These lines are subject of a more extensive procedure. *See basic procedure, part 2.*

Remarks

The bifilar sundial is not suitable for low latitudes.

As shown by the universal instrument, the east-west wire will be almost in the dial plane, and the dial would have no practical use.

Likewise, the bifilar dial is not attractive for use on either Pole.

Both wires will be at the same height, and might just as well be replaced with a single gnomon.

basic procedure part 2

The bifilar sundial on an arbitrary plane

Here is a worked example for a bifilar sundial with equiangular hour lines on an arbitrary plane.

The starting data for this dial are:

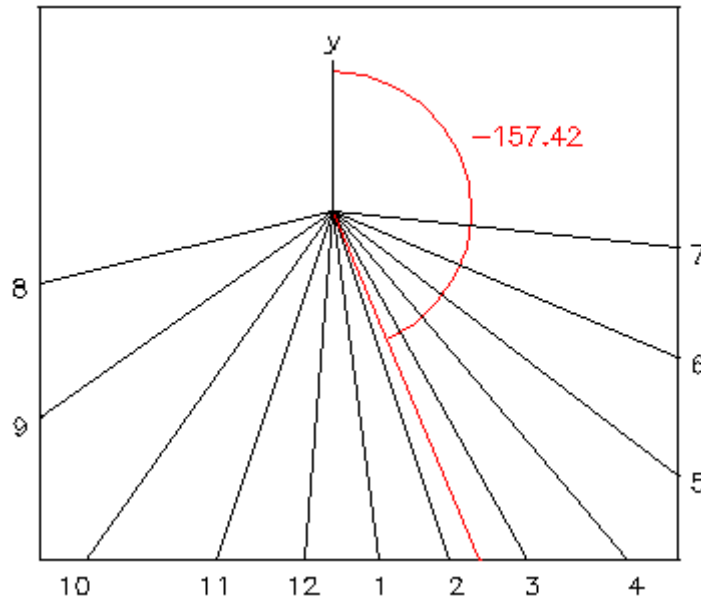
- Latitude: 50 degrees (northern latitude)
- Inclination of the plane: 100 degrees (a wall leaning forward 10 degrees)
- Declination of the plane: 25 degrees (a plane facing 25 degrees westerly of south)

We calculate some sundial constants for the plane as if we were planning to build an ordinary sundial.

- Style height, $v = -44.97$
- Hour angle of the substyle, $t_s = 36.04$ (= 2 hours 24 minutes)
- Angle between substyle and y-axis, $b = -157.42$

These values can be calculated with the computer program ZW2000, downloadable from www.zonnewijzerkring.nl.

ZW2000 will also draw the bifilar sundials discussed here.



Location of the substyle on the pole style sundial

These constants tell us that the dial face corresponds to a horizontal plane in a southern latitude of 46.71 degrees and a longitude of 36.04 degrees westerly of ours (translation rule).

The hour lines run anti-clockwise (the style height is negative).

The pattern for apparent solar time on this dial is pictured above.

Of particular interest are the location of the substyle and the value for the style height.

Instead of a pole style, we place a gnomon of height g perpendicularly to the sundial, at a distance of $g / \tan(|\text{style height}|)$ from the hour line centre.

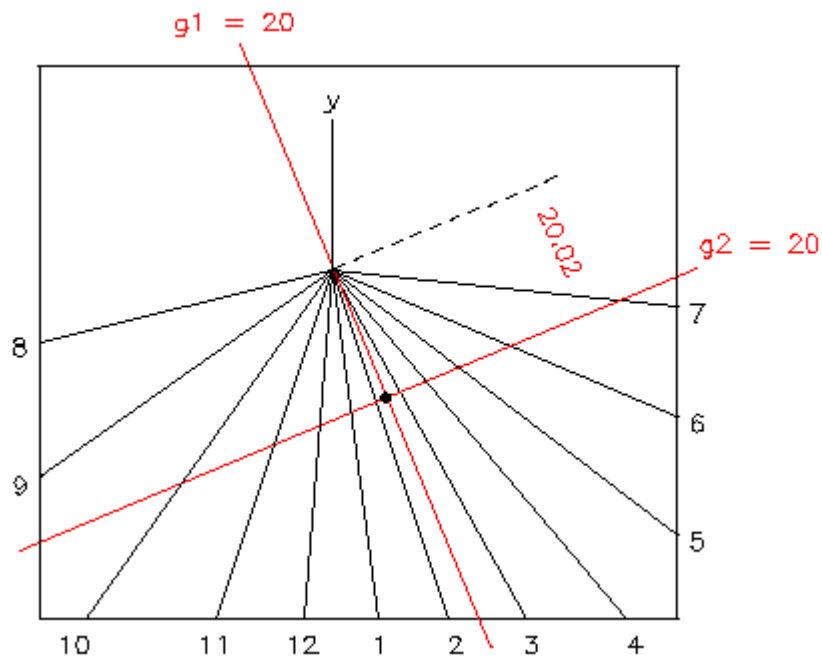
In our example we choose $g = 20$ mm, making this distance $20 / \tan(44.97) = 20.02$ mm.

The top of the gnomon is an indicator on the now imaginary pole style, and the sundial will function as before.

Now, we place two wires in the same height equal to $g = 20$ mm, through the gnomon top and parallel to the dial face. We remove the gnomon.

One wire should be over the substyle, the other at right angles to it.

The wires intersect and the sundial will function as before, but it is still not the wanted bifilar dial.



Still the same sundial

Transformation

Now we lower the wire which is at right angles to the substyle, to a height of $g_2 = g_1 \cdot \text{SIN}(\text{lstyle height})$.

This value is $20 \cdot \text{SIN}(44.97) = 14.13 \text{ mm}$.

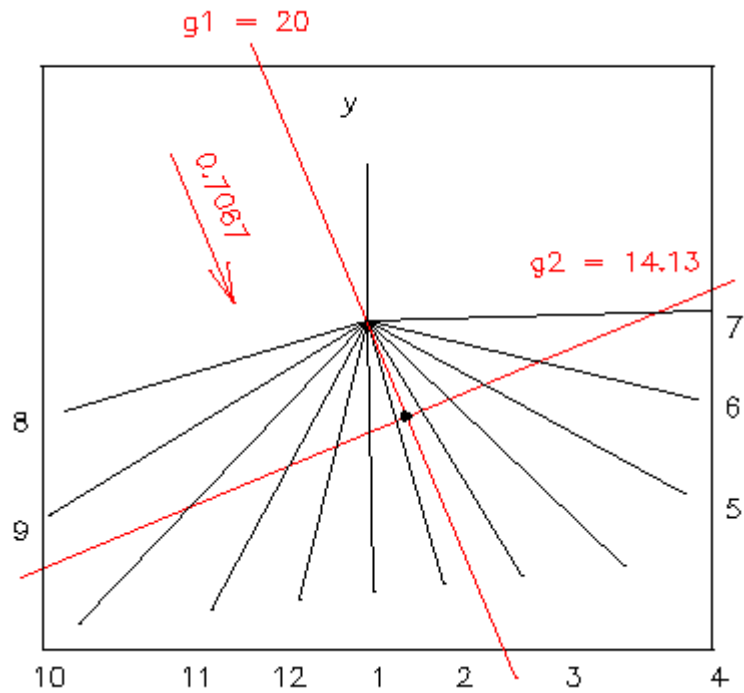
At any point in time, the shadow of the unchanged wire at g_1 will be in the same place, but that of the lowered wire g_2 will now have moved by a factor equal to $\text{SIN}(\text{lstyle height}) = \text{SIN}(44.97) = 0.7067$.

This will compress the sundial pattern in the direction of the substyle by that factor.

A photo copier could do this.

After this procedure, the sundial will look like the figure below.

The hour lines need to be extended somewhat.



*Transformation by a factor in the indicated direction
Hour lines are now equiangular.*

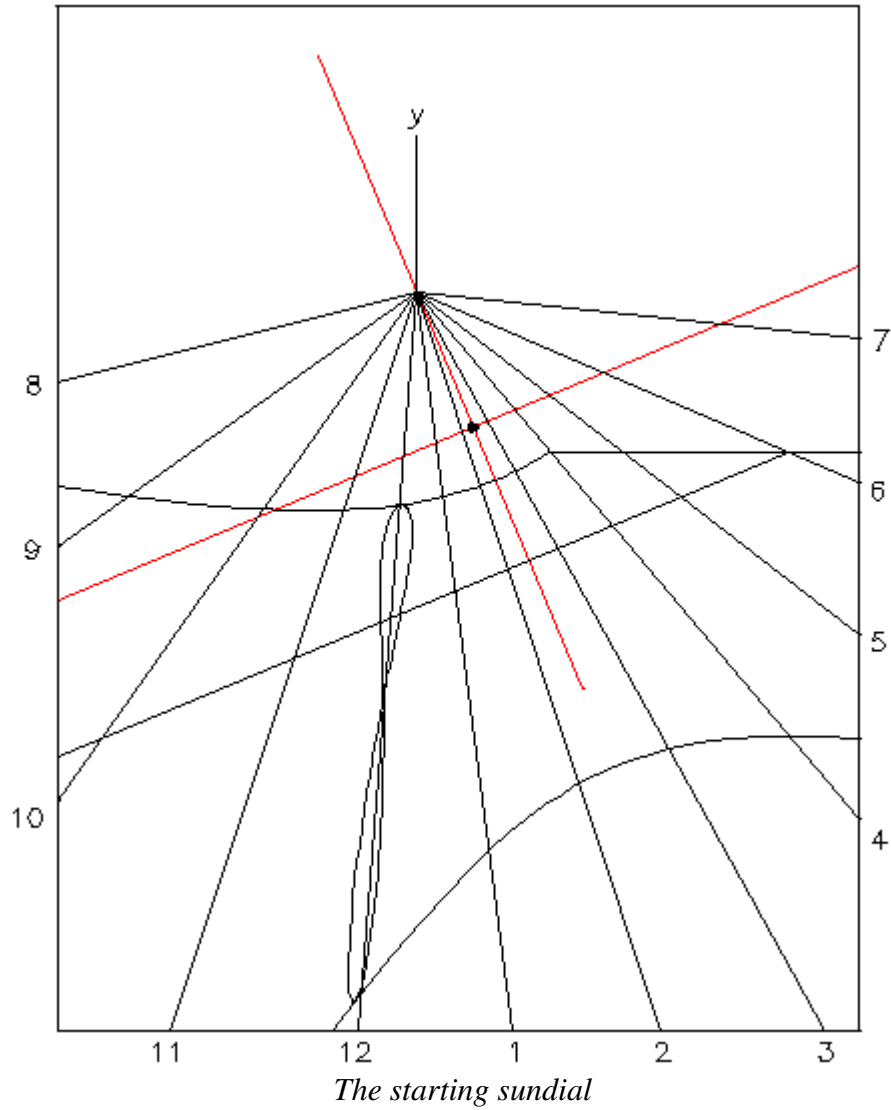
Other sundial lines

The transformation just applied to the apparent solar time hour lines is equally applicable to all other sorts of lines on a sundial.

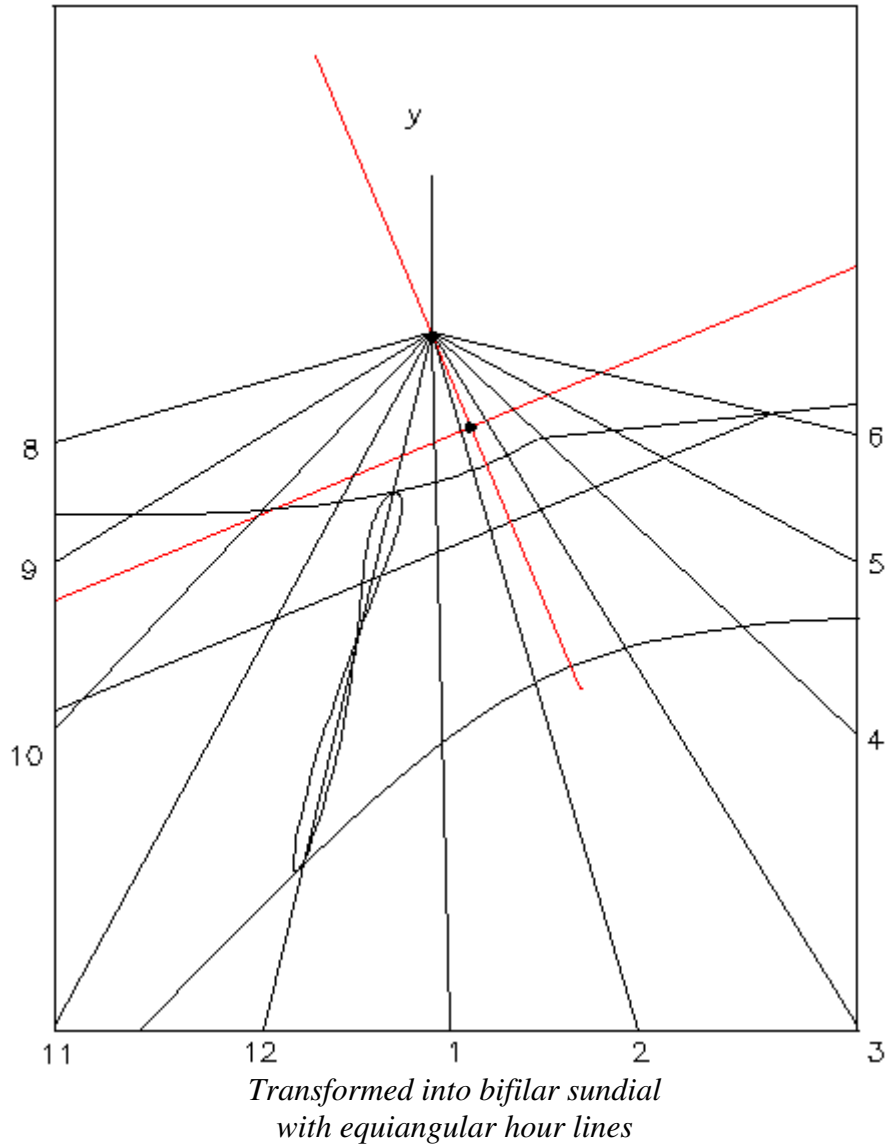
Here is the starting sundial again, expanded with three date lines, an equation of time curve around the XII-hour line and the horizon.

You could add various other lines if you wish.

The indicator on the (imaginary) pole style is once more replaced by a gnomon of height $g = 20$ mm, and that, in turn, by two wires at equal heights $g = 20$ mm.



We lower the wire at right angles to the substyle again by the factor $\text{SIN}(\text{lstyle height}) = \text{SIN}(44.97) = 0.7067$, which compresses the pattern by that factor. This creates the desired bifilar sundial with equiangular hour lines. Notice that after this procedure, the horizon line is no longer horizontal.



Summary

To construct a bifilar sundial, use an ordinary sundial, with all the desired lines, as a basis.

Through the point where the indicator for all these lines would be, place a wire in the direction of the substyle and let its height = g_1 .

At right angles, place a wire of height $g_2 = g_1 \cdot \text{SIN}(\text{style height})$.

Compress the entire sundial pattern in the direction of the substyle with the factor $\text{SIN}(\text{style height})$.

This will create the bifilar sundial with hour lines for local suntime all spaced fifteen degrees.

As you can see, there are no difficult equations and calculations at all, as long as you know how to construct the starting sundial.

Remarks

There are many more degrees of freedom in the construction of bifilar sundials.

The height factor for the second wire may be different.

Depending on value, the pattern is either compressed ($0 < \text{factor} < 1$) or enlarged ($\text{factor} > 1$).

But the hour lines will not be equiangular anymore.

The wires do not need to be parallel to the dial face, nor do they have to be at right angles to each other.

They do not have to be over the substyle, and they may even be curved.

However, all this would be outside the scope of these pages, which mean to present only the basics from 1923.

English translation: Ruud Hooijenga