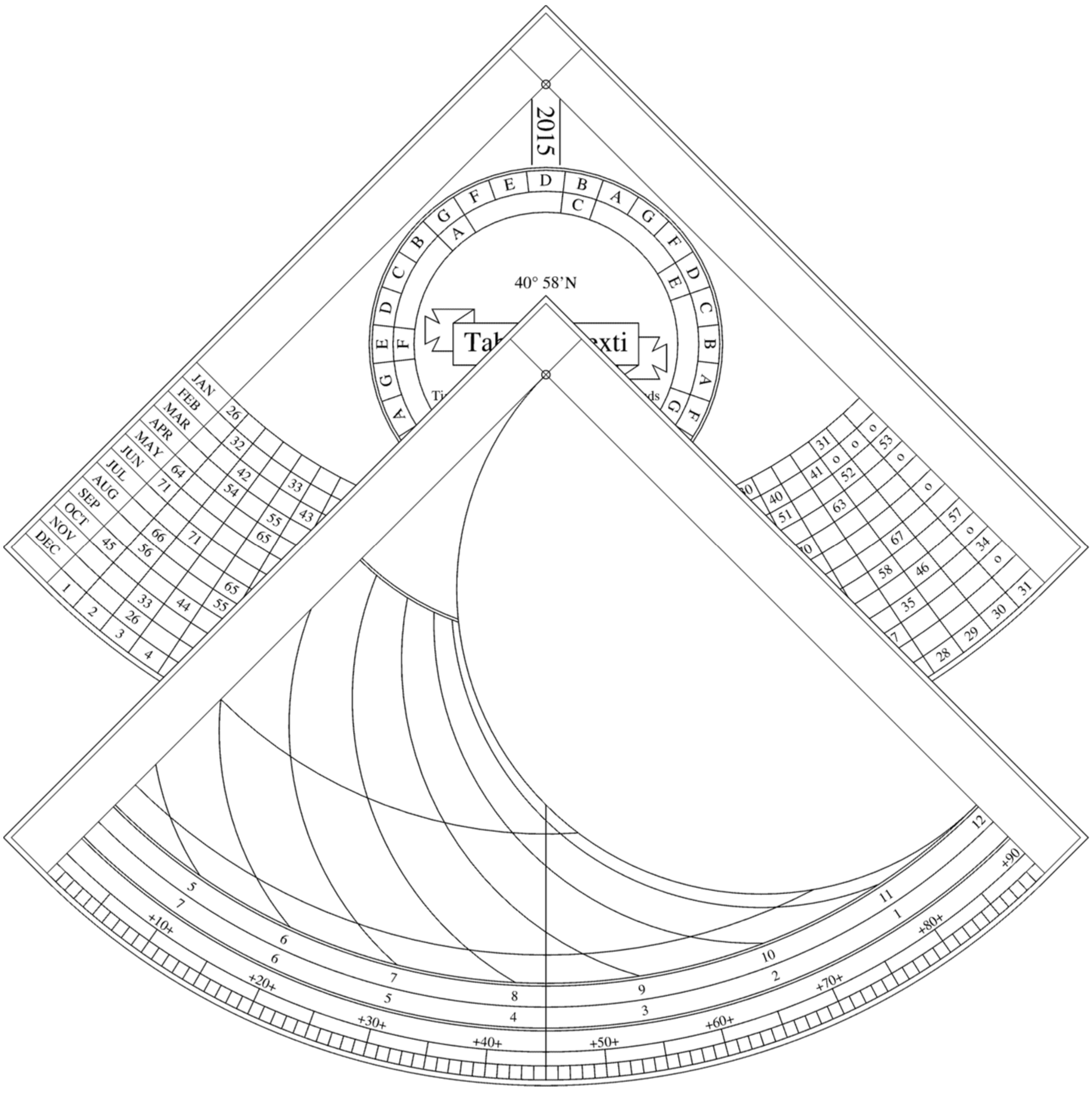
Telling Time with Richard II

An Introduction to the Horary Quadrant



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Acknowledgements

British Museum Quadrant 1: k134400_l.jpg and ps112955_l.jpg from http://www.britishmuseum.org/explore/highlights/highlight_objects/pe_mla/t/the_richard_ii_quadrant.aspx.
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Dorset County Museum Quadrant: DCM-horary quadrant-1398.jpg.
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This is a handout for my class "Telling Time with Richard II"

Copies of this handout are available on my website at www.astrolabeproject.com

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Introduction

The Find
In the mid 1970s Christopher Becker was playing in an old farm shed at his family's cattle station in Queensland, Australia when he found an odd piece of brass in a bag of old spare parts. He kept it as a keepsake and in 2011, after seeing a photo of a similar piece, had it examined by a museum. His keepsake was quickly identified as the second earliest dated British scientific instrument in existence, an equal hour horary quadrant from 1396 [Bloom]. This find, associated with King Richard II (reigned 1377-1399) joins three similar instruments associated with the 14th century king. These four pieces are important both for their association with an important historical figure, and because they can be dated exactly.

Quadrants
There is an entire class of measuring instruments that fall under the general description of "quadrant". These vary widely in design and function, from simple devices to measure angle from the horizon to extremely complex computational devices like the Sine Quadrant and the Astrolabe Quadrant. Our subject today is one of the simpler types of quadrant: The Horary Quadrant.

The Horary Quadrant
In the Middle Ages there were a variety of methods and tools for determining the time of day. These ranged from simple tricks with shadow length [King] to sundials to sophisticated astronomical instruments like the astrolabe [Morrison]. The class of devices known as horary quadrants fall in the middle of this range. More portable than sundials, but much simpler to use than an astrolabe, they allowed the user to determine the time of day quickly and easily with a good deal of accuracy.

The Period
Because the instruments are dated, we know what years they are from (1396-1400); and we can place the latitude they were designed for (southern England). But this type of device was used over a much longer period (from the tenth century onward) and wider area (the Middle East and Europe) [Viladrich 283].

Construction
The four examples the form the basis of this class are all brass, the lines scribed and engraved, and the numbers punched [Ackermann & Cherry 18]. These are relatively small devices: 90 mm (3.5 inches) in radius, much smaller than other types of quadrant.

Association with Richard II

The four quadrants are:

1. The Queensland Quadrant
- Dated: 1396
- Latitude: 52 (London) (based on personal examination of lines and tables, the altitude table is identical, possibly made with the same punches as #3 below)
- Decoration: Stag with crown (back)
- Associated with: King Richard II [Bloom]
- Current location: Sold at auction, current owner unknown
- No photo available for use, but good photos can be found at: http://www.abc.net.au/news/2011-11-09/one-man27s-trash-is-another27s-centuries-old-treasure/3654974

2. Dorset Museum Quadrant
- Dated: 1398
- Latitude: 51
- Decoration: Stag (back), tree (front)
- Associated with: King Richard II's half-brother John Holland, the Duke of Exeter [Ackermann & Cherry 21]
- Current location: Dorset Museum

3. British Museum Quadrant 1
- Dated: 1399
- Latitude: 52
- Decoration: Hare (back), stag with crown (front)
- Front marked with a series of arcs and labeled on the edge with the zodiac positon of the sun.
- Associated with: King Richard II [Ackermann & Cherry 20]
- Current location: British Museum

4. British Museum Quadrant 2
- Dated: Undated, date computed to be 1400
- Latitude: 52
- Decoration: None
- Front marked with a shadow square. Back contains a Tabula Paschalis (Easter table)
- Associated: Definitely part of the group, but not associated with an individual [Ackermann & Cherry 3]
- Current location: British Museum

By a combination of dates, workmanship, and decoration involving badges all four instruments are firmly tied to Southern England near the turn of the 15th Century, and are closely associated with King Richard II.

Dorset County Museum Quadrant

11 Horary quadrant, gilt brass, two sights, string and bead missing, an hour scale, engraved with the white hart crest of Richard II without the collar, the emblem used by the king's half-brother, John Holland, the Duke of Exeter, visited Dorchester, dial dated 1398.

Dorset County Museum
Horary-quadrant; brass
Dated 1398
Latitude: ~51
Radius: 80 mm

British Museum Quadrant 1

British Museum
Museum number: 1860,5-19.1
Horary-quadrant; brass
Dated 1399
Latitude: ~52
Radius: 90 mm

British Museum Quadrant 2

British Museum
Museum number: 1856,0627.155
Horary-quadrant; brass
Dated 1400 (computed)
Latitude: ~52
Radius: 89 mm

Design

Two Approaches to Time
During the medieval period there were a number of methods used to divide up the day. These fall into to major categories: The Equal Hour system and the Unequal Hour system.

The first (Equal Hour) method is the one you are familiar with from your daily life. The day is divided into 24 hours of equal duration, with the number of hours of daylight depending on the time of year.

The second approach, used extensively in the medieval period, is the Unequal Hour. In this system, the day is still divided into 24 hours, but no matter the time of year, the day and night are each divided into 12 hours. This means that in the Summer a daylight hour is longer than a nighttime hour; and the reverse is true in the winter.

"I will meet you at 10 tonight" vs. "I will meet you at the third hour of the night"

The unequal hour system was used for Christian prayer times among other uses (Sext = the sixth hour of the day (Noon), None = the ninth hour of the day)

For example: During the second week of Pennsic War, the unequal hour in the day is 70 minutes long and the unequal hour of the night is 50 minutes.

Equal Hours

1. 24 hours in a day
2. An hour is 60 minutes long
3. Daytime hours and nighttime hours the same length
4. Night time and day time different lengths

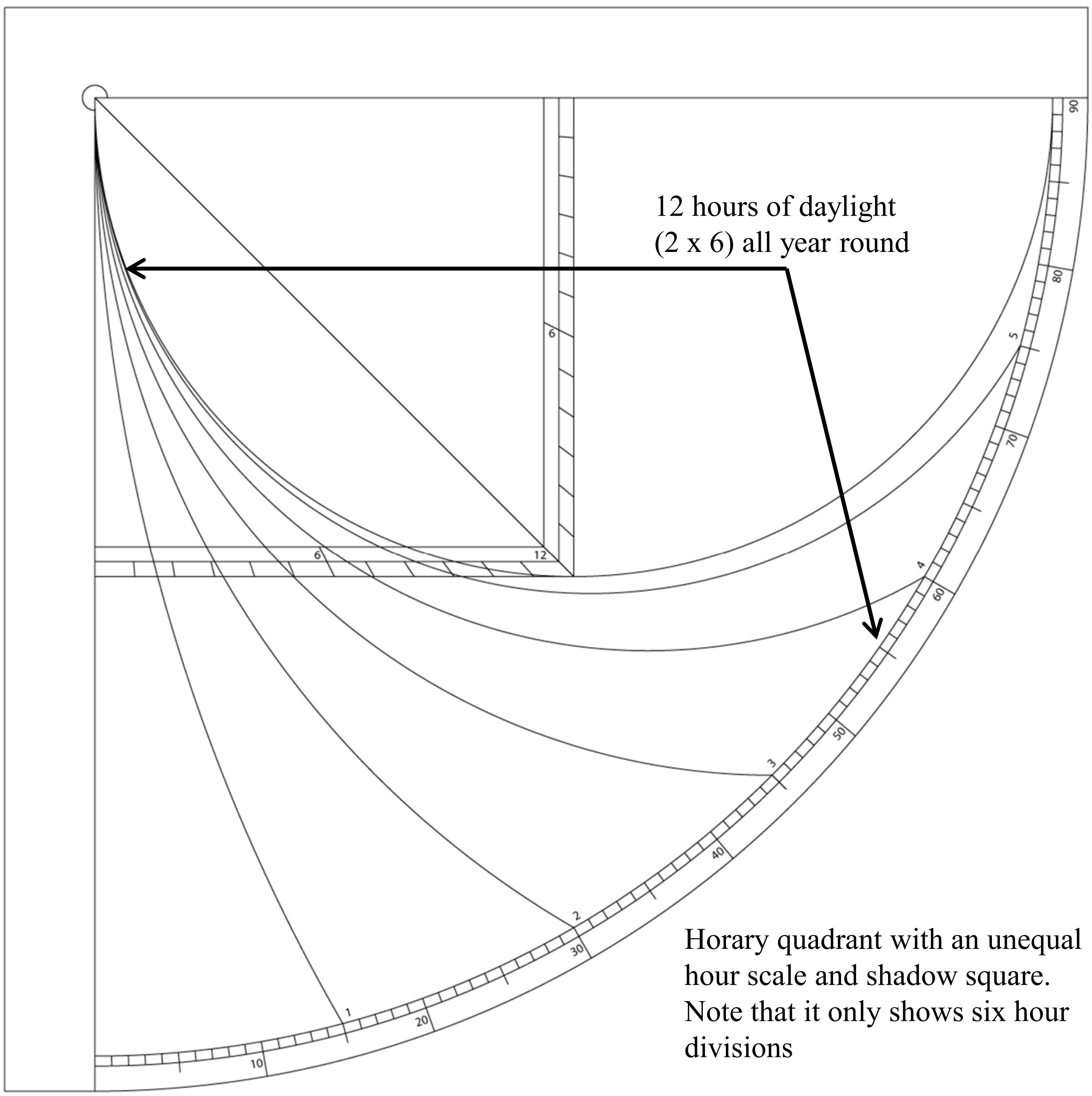
Unequal Hours

1. 24 hours in a day
2. The length of an hour varies over the course of a year
3. Daytime hours and nighttime hours different lengths most of the year
4. Night time and day time each 12 hours long

Horary quadrants that use the equal hour system are rarer, especially in the Middle East [Viladrich 283] where more universal instruments were desired.

Design

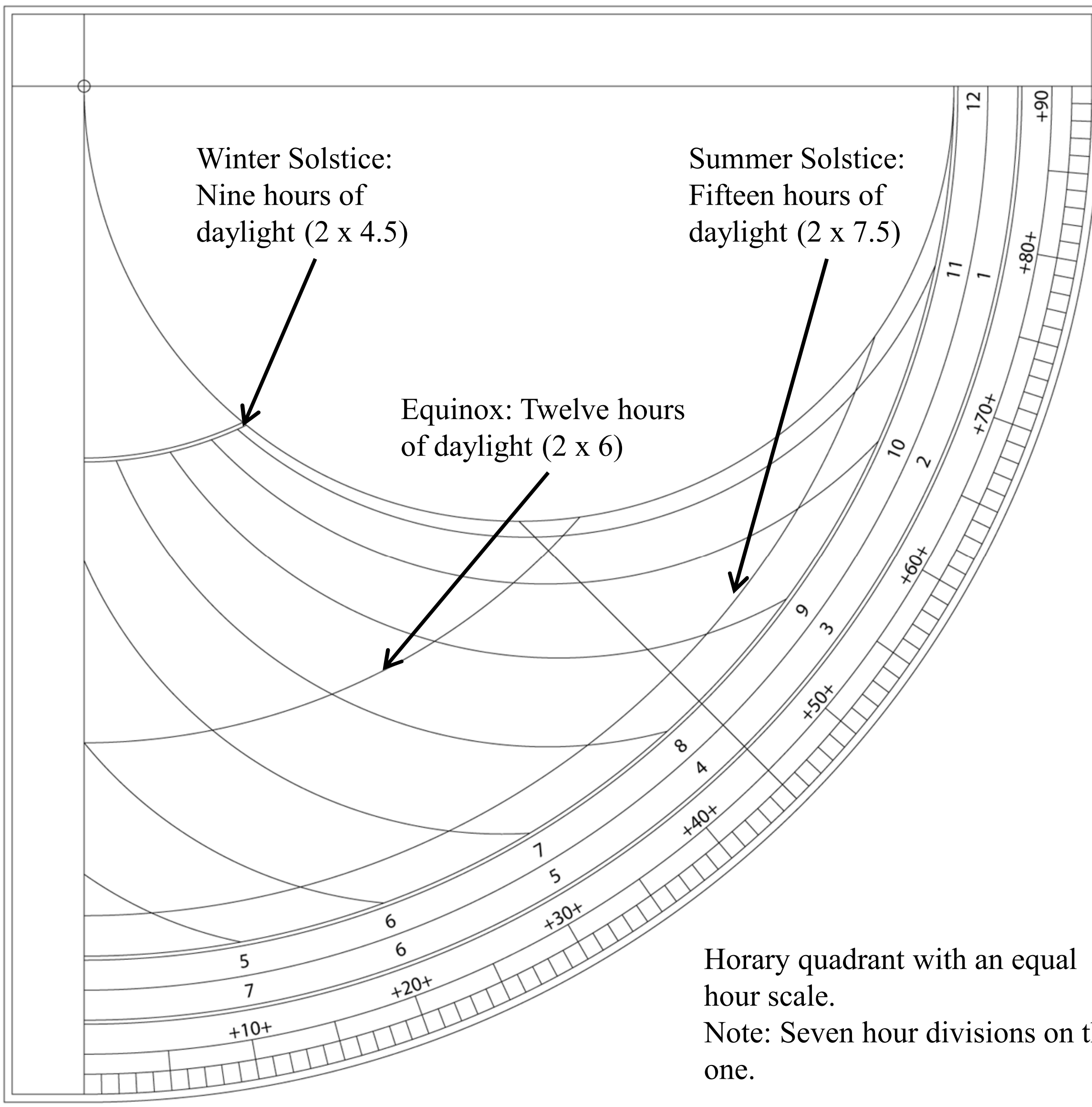
Unequal Hour Horary Quadrants
For simplicity's sake, most horary quadrants use the unequal hour system. This allows the face of the quadrant to be divided equally into six arcs (every 15 degrees or one for each hour between sunrise/sunset and noon), not allowing for season; and so the device can be used in any location.



Horary quadrant with an unequal hour scale and shadow square. Note that it only shows six hour divisions

Design

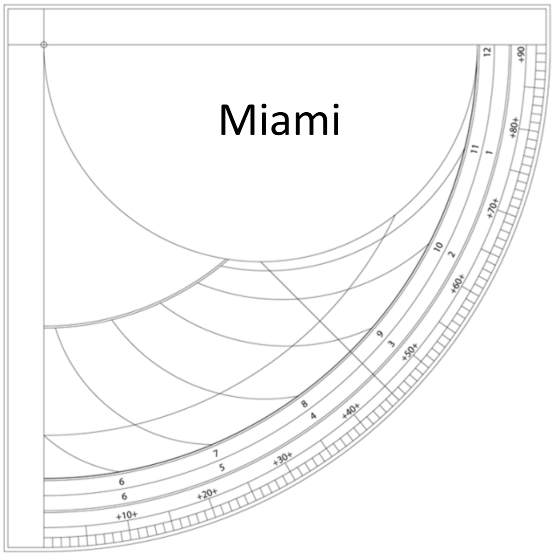
Equal Hour Horary Quadrants
Not as common are horary quadrants with equal hour dials. The hour arcs on these need to be carefully computed, and are only accurate for a specific latitude.

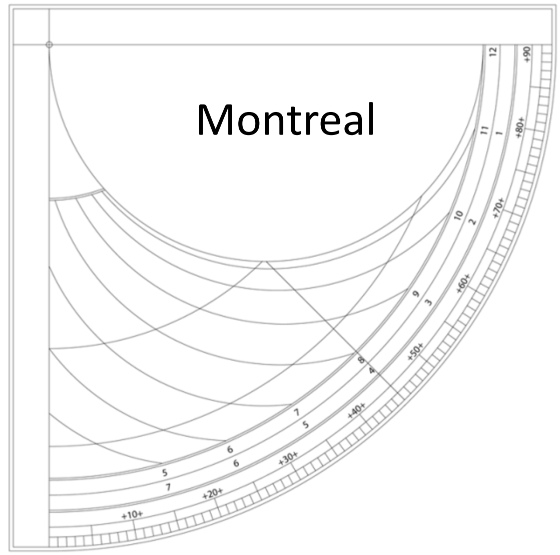


Horary quadrant with an equal hour scale.
Note: Seven hour divisions on this one.

Design

Limitation
The drawback to the equal hour dial is that it has to be designed for a single latitude, and only works accurately when near that latitude.

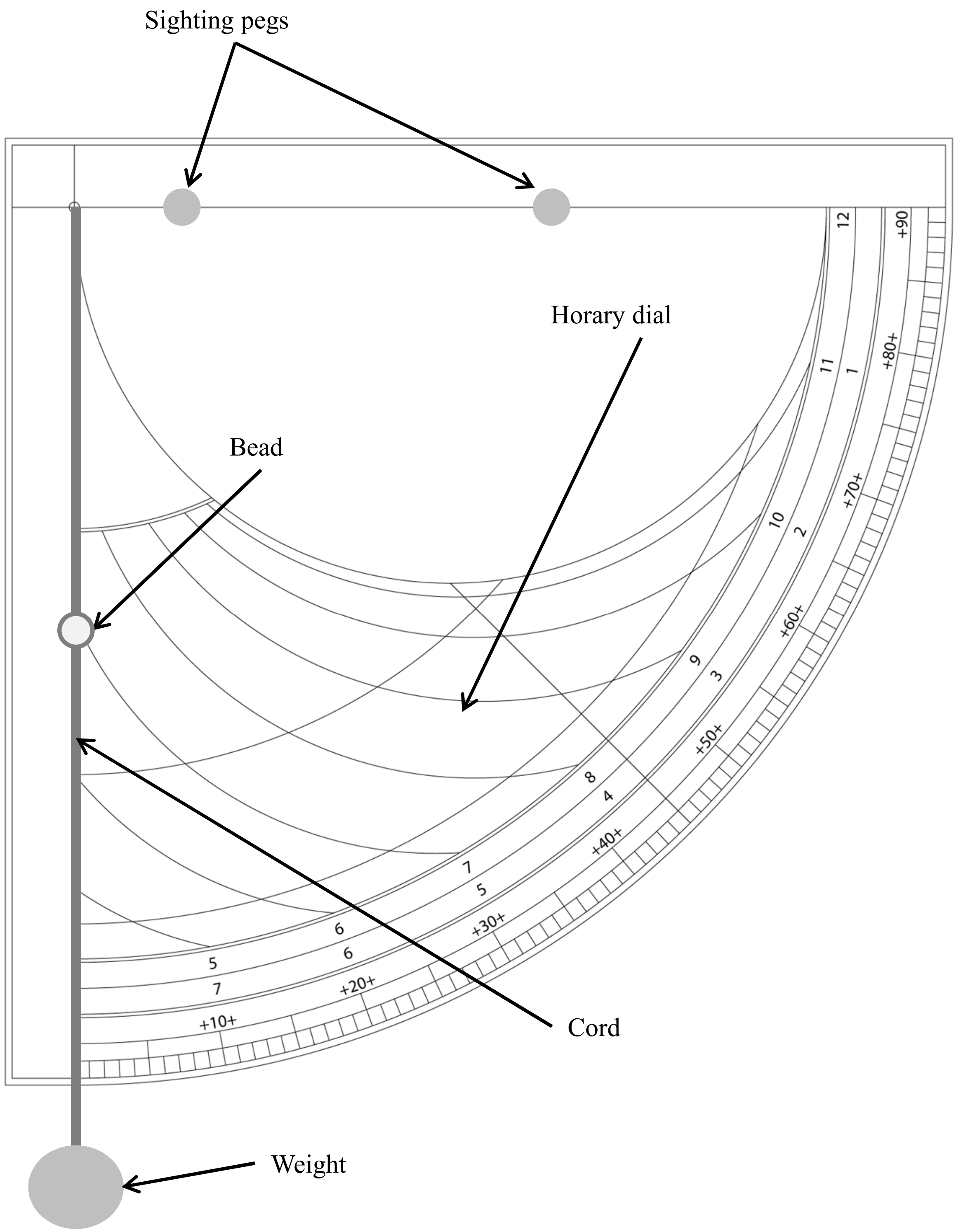




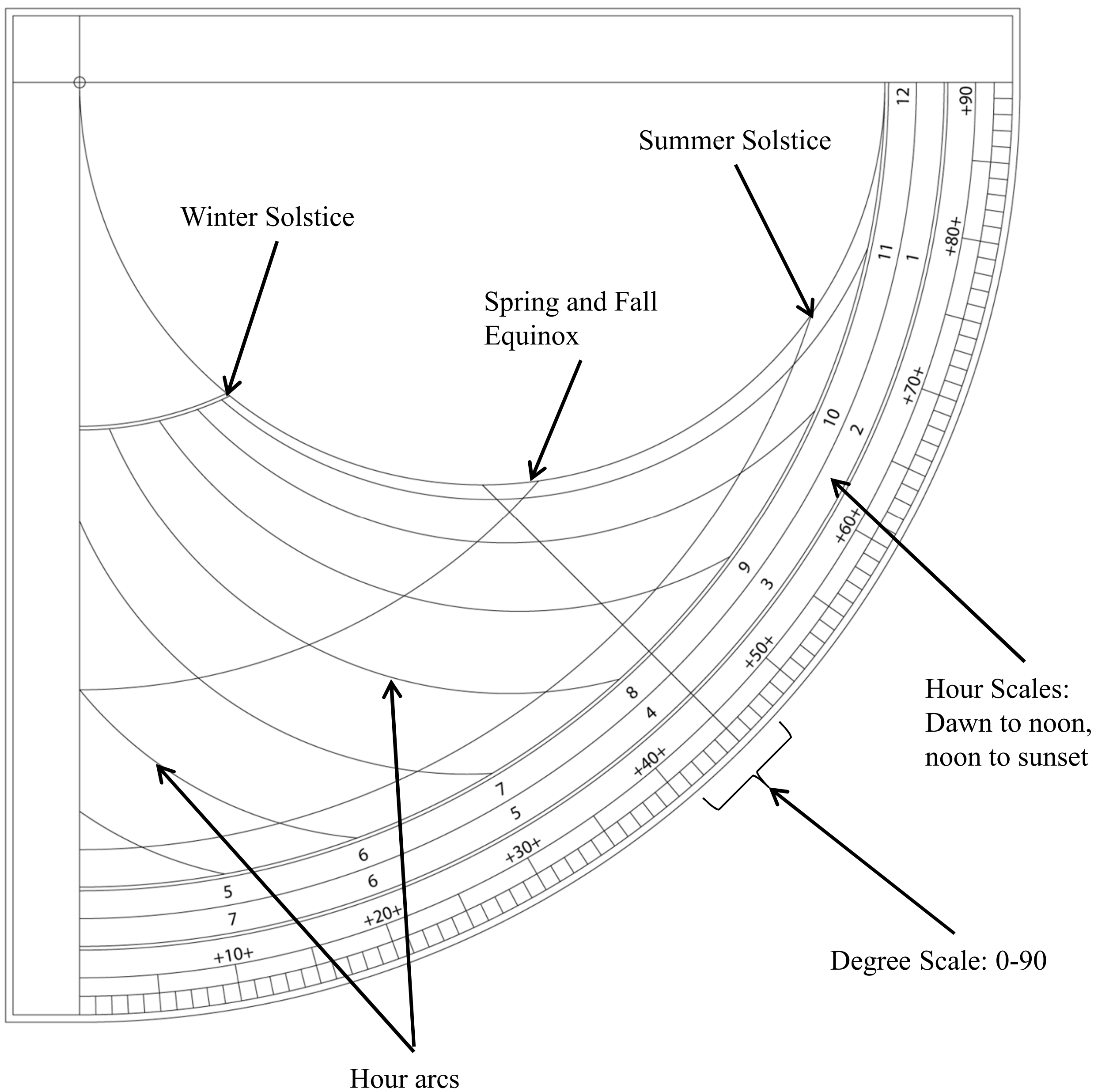
As you can see the position and number of hour lines change as the latitude changes. The further north you live, the lower in the sky the sun is for a given day of the year.

The simpler Unequal Hour dial does not have this limitation, but is much less useful in a world where the equal hour system has become the standard.

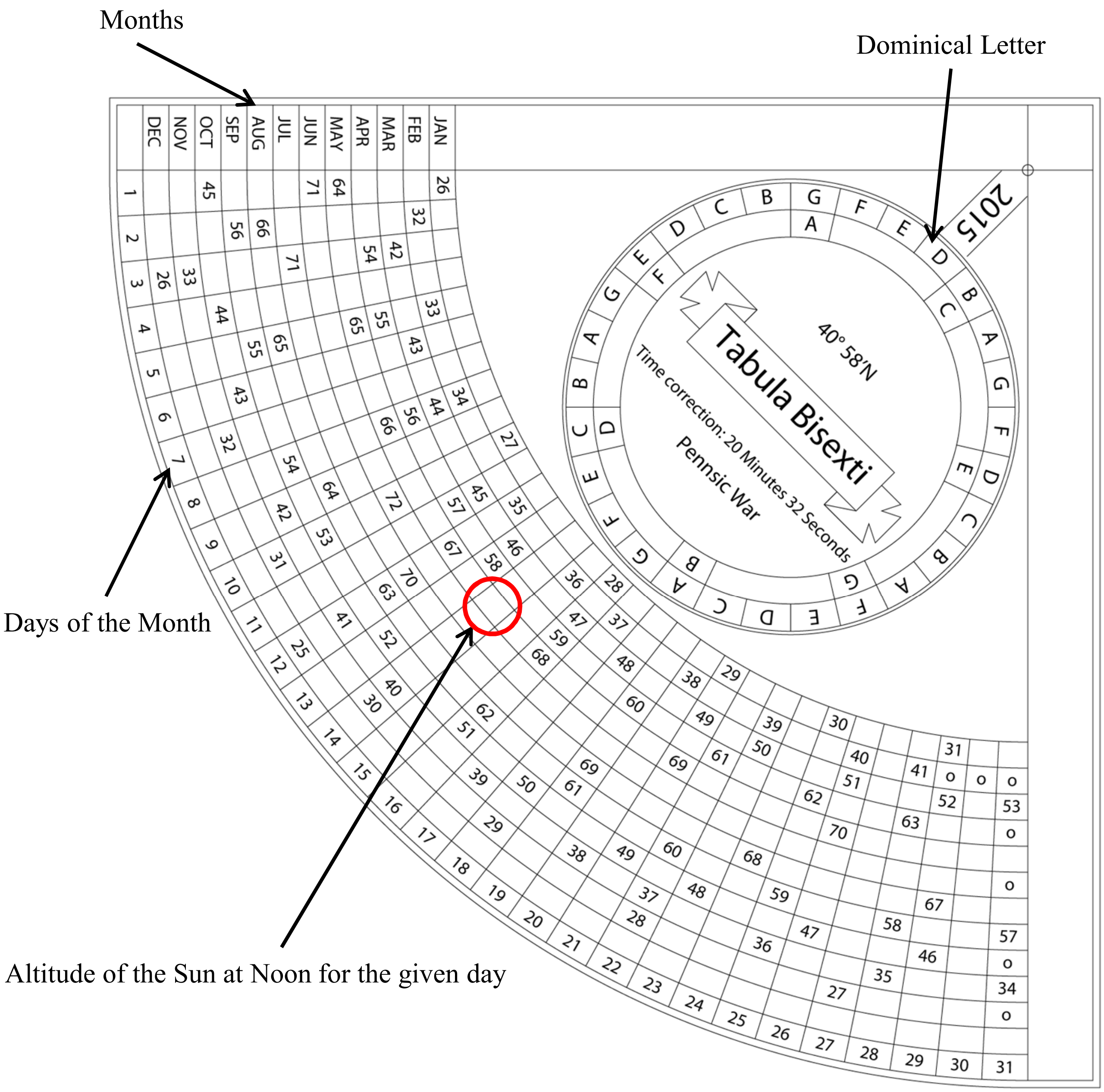
Parts of the Horary Quadrant



Parts of the Horary Quadrant
(Front)

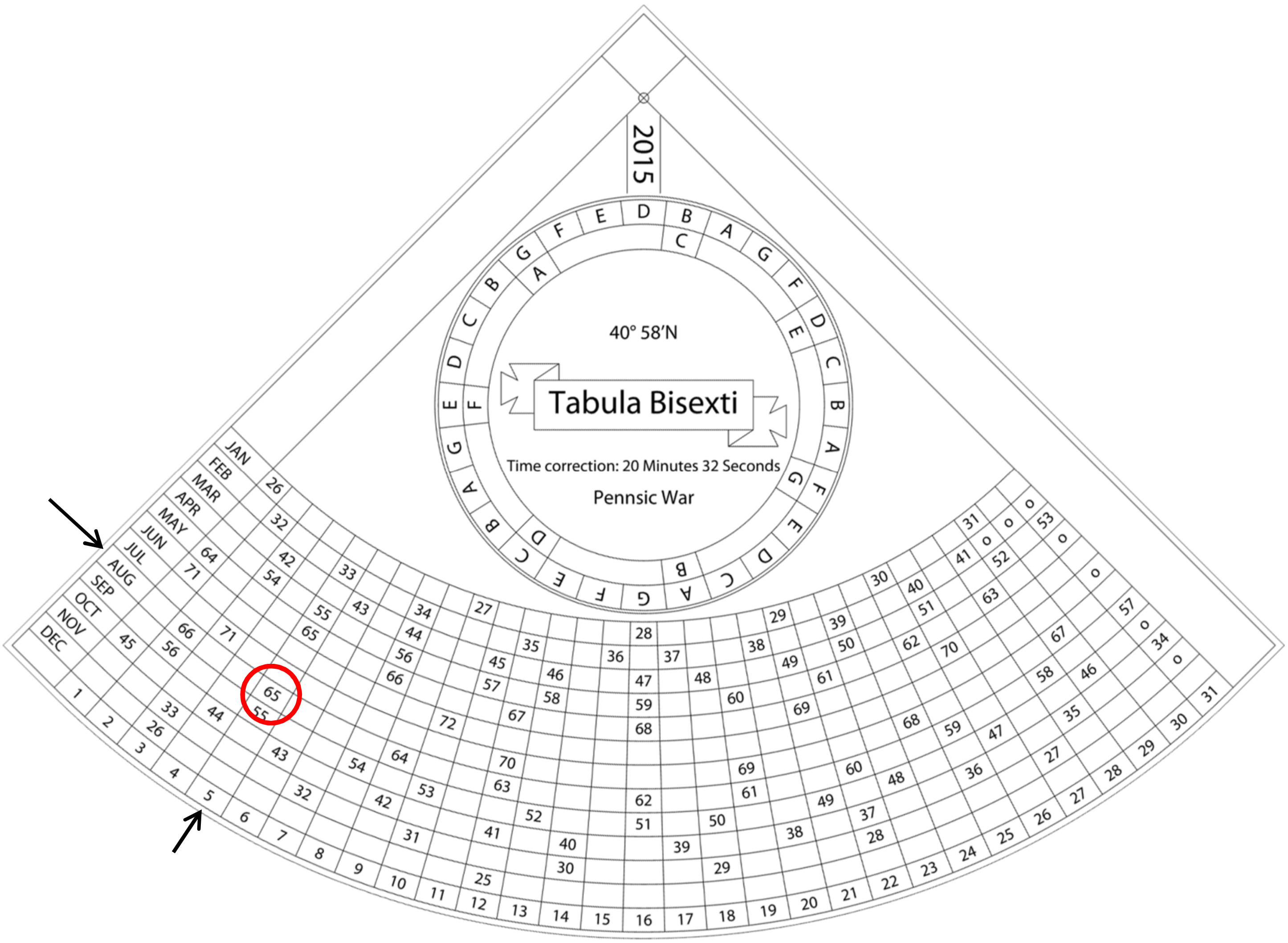


Parts of the Horary Quadrant
(Back)



Note: The altitude number changes when the next degree is reached [Ackermann & Cherry 5]. 41 is marked, 41.1 - 41.9 are blank, 42 is marked. Therefore the blank space at May 14, halfway between 67 and 68, is read as 67.5 degrees.

Using the Horary Quadrant



To determine the time of day:

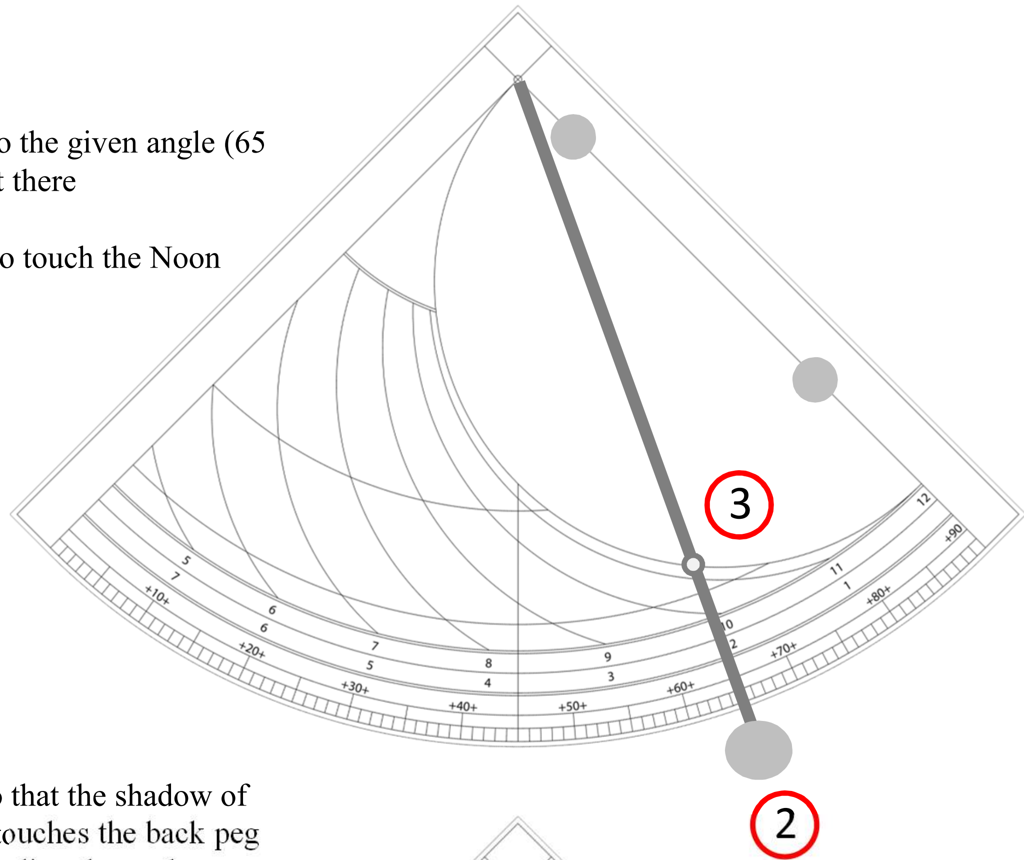
Using August 5 as an example:

1. Find the Sun's altitude at Noon for the given day. Looking at the table for the 5th of August, we find an altitude of 65 degrees.

Using the Horary Quadrant

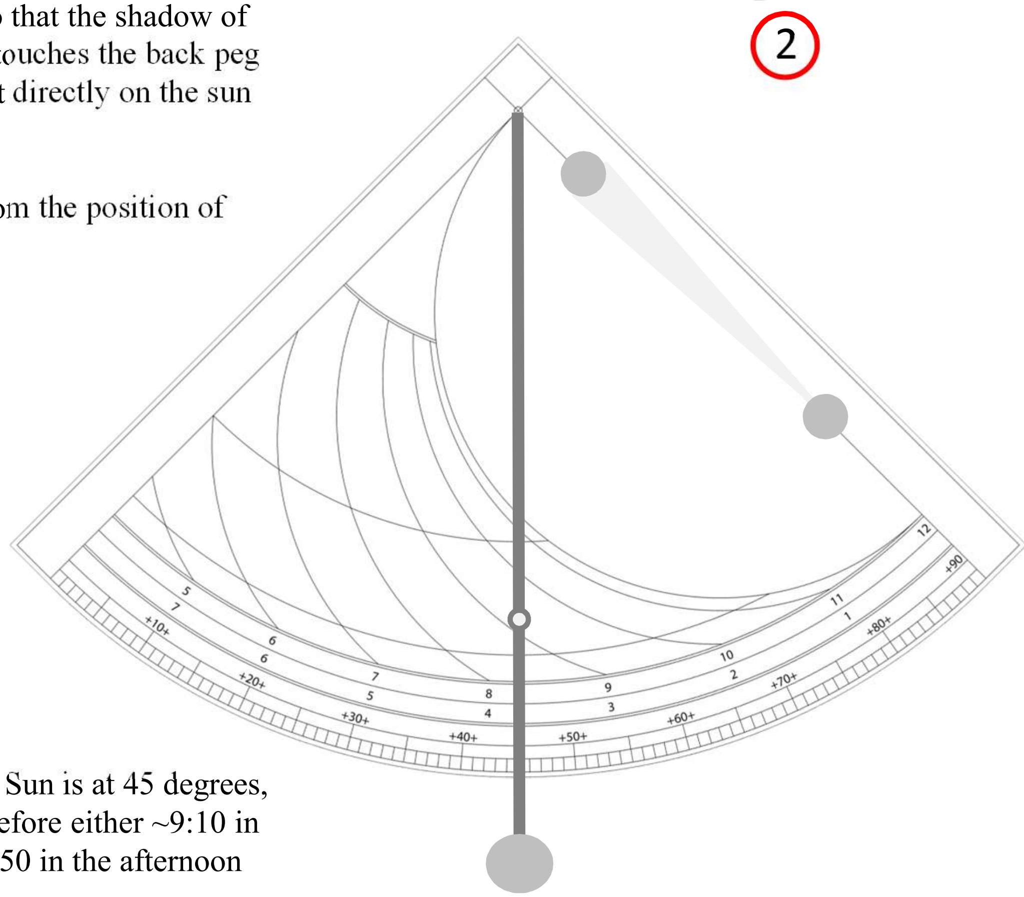
2. Rotate the cord to the given angle (65 degrees) and hold it there

3. Adjust the bead to touch the Noon (12) arc



4. Hold quadrant so that the shadow of the front sight peg touches the back peg (Note: Do Not sight directly on the sun with your eye!)

5. Read the time from the position of the bead.



In the example, the Sun is at 45 degrees, and the time is therefore either ~9:10 in the morning or ~ 2:50 in the afternoon

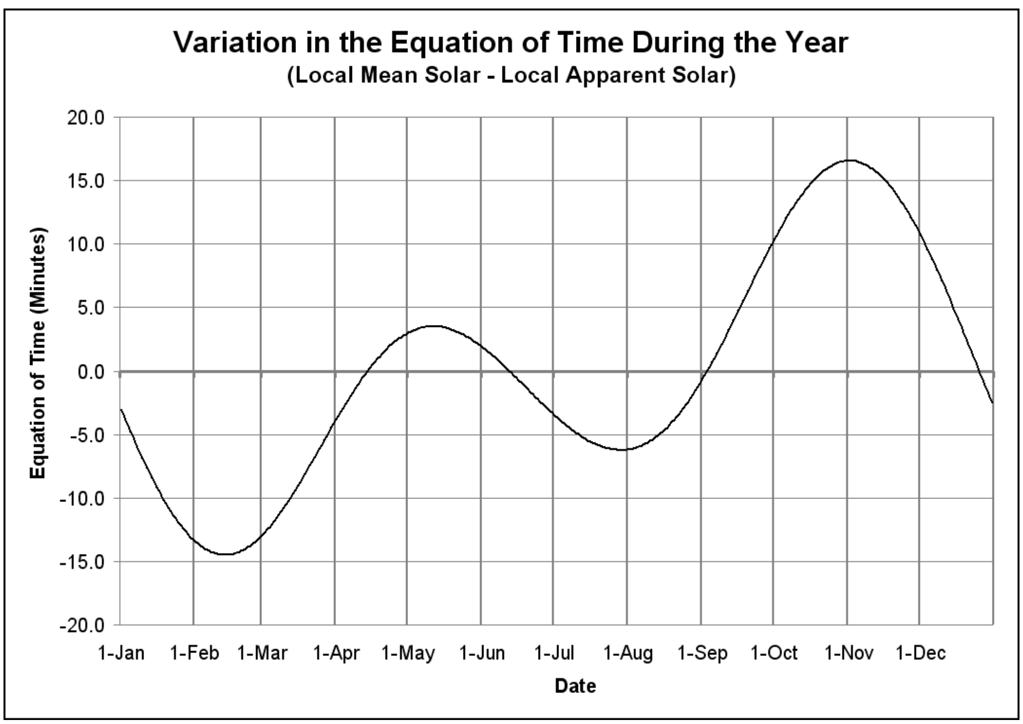
Dealing with the Modern World: Adjusting Local Solar Time to Local Standard Time

The horary quadrant is based on the Sun, and gives the time in local solar time. This rarely aligns with the time on the clock. To convert to local standard time you will need to make the following adjustments:

1. **Daylight Savings Time correction** -- if DST is in effect, you will need to add an hour to the time given by the quadrant.

2. **Time zone correction** -- as standard time uses the same time over the width of a time zone, you will need to add or subtract up to 30 minutes depending on where you are in the time zone. The time zone correction for Pennsic is +20 minutes.

3. **Equation of Time correction** -- depending on the time of year, solar time varies from clock time due to the eccentricity of Earth's orbit. The graph below gives the correction. To convert from solar time to clock time, subtract the number. To convert from clock time to solar time add the number.

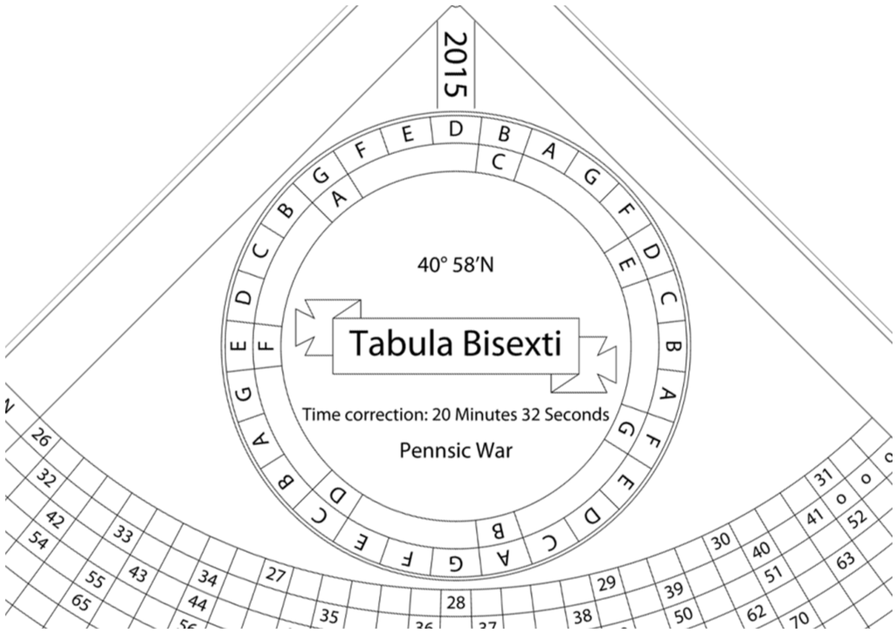


In our example the quadrant gave us a time of 9:10 in the morning to convert to EST:

- add 1 hour for DST – giving 10:10
- add 20 minutes time zone correction for Pennsic – giving 10:30
- subtract -6 minutes EoT correction from graph above – giving 10:24 AM.

According to the Open Source planetarium software Stellarium, the actual time will be 10:30, off by 6 minutes. In period, accuracy to within 15 minutes was considered good [Morrison 165].

The Tabula Bisexti

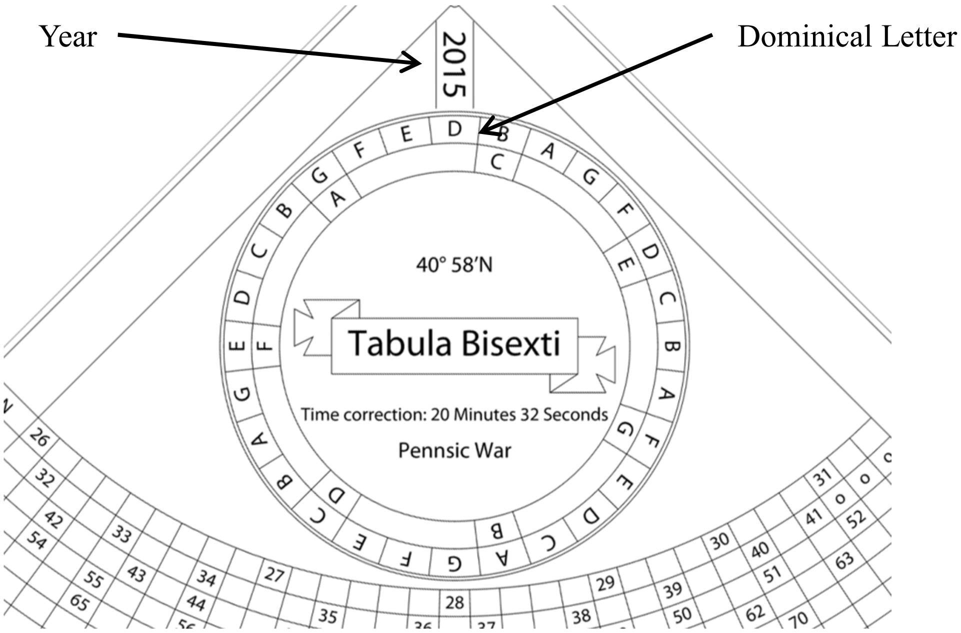


Three of the Quadrants under discussion are marked with a “Tabula Bisexti” (table of leap years) and one with a “Tabula Paschalis” (Easter table). A full discussion of the use of these is beyond the scope of this class. But a basic explanation of the theory and use of the Tabula Bisexti follows.

Our current calendar repeats every 28 years. That is, every 28 years the days of the week for each month will fall on the same days of each month. For example, July 14 is on the second Tuesday in 2014, so in 1987 it was also on the second Tuesday.

In the Catholic Church, Dominical letters are the letters A, B, C, D, E, F and G assigned to the days of the year in a repeating pattern with 1 January set as “A”. This is used as an way to keep track of what date goes with which date of the week. For example, if the first Tuesday of the year is a “C” day, every Tuesday that year will be a “C” day, and every “C” day, a Tuesday. The Dominical Letter for a year is the letter for the day Sunday falls on that year..

The Tabula Bisexti



Back to the tabula: The tabula bisexti is made up of a ring of 28 spaces, marked with the dominical letters repeating all around the perimeter. The year is marked at the top, and that year's Dominical letter is placed directly under it. As you can see this year's Dominical letter is "D"

There are 52 weeks in a year, made up of 7 days each, giving a total of 364 days out of the 365 days in a year, so there is a slippage of one letter every year. In 2014 the Dominical letter was "E".

As you will have noticed, some of the letters are doubled. This is to handle leap years. Every four years there are 29 days in February, instead of 28, this means the Dominical letter changes on the first of March. Next year the year will start with a Dominical letter of "C" and switch to a Dominical letter of "B" after the leap day.

References

Ackermann, Silke and Cherry, John. “Richard II, John Holland and Three Medieval Quadrants”, *Annals of Science* 56 (1999), pp. 3-23

Bloom, Clayton. “14th century timepiece unearthed in old farm shed” http://www.abc.net.au/news/2011-11-09/one-man27s-trash-is-another27s-centuries-old-treasure/3654974. Downloaded 25 Nov 2014

Bolado, Catherine. "Dorset County Museum turns back the clock“ http://www.dorsetecho.co.uk/news/9421377.Dorset_County_Museum_turns_back_the_clock/. Downloaded 25 May 2015

British Museum. “The Richard II Quadrant” http://www.britishmuseum.org/explore/highlights/highlight_objects/pe_mla/t/the_richard_ii_quadrant.aspx. Downloaded 16 January 2015

British Museum. “sundial / horary quadrant / altitude dial” http://www.britishmuseum.org/research/collection_online/collection_object_details.aspx?objectId=55090&partId=1. Downloaded 06 February 2015

King, David A. A Survey of Medieval Islamic Shadow Schemes for Simple Time-Reckoning. *Oriens*, Vol. 32 (1990), pp. 191-249

Morrison, James. The Astrolabe, Janus, 2007

Viladrich, M. "Medieval Islamic Horary Quadrants for Specific Latitudes and Their Influence on the European Tradition", *Suhayl – Journal for the History of the Exact and Natural Sciences in Islamic Civilization* (Barcelona) 1 (2000), pp. 273-355.