

THE GNOMONIC CIPHER

attr. DAN BROWN

FACT

The Egyptian sun-god Aten is well documented via ancient hieroglyphics.

All references to sundials and gnomonics are correct as are the topographical details of present-day Rome.

The story so far...

Robert Langdon, the renowned Harvard professor of religious iconology, finds himself once again in Rome investigating a series of brutal murders.

The killings have all been carried out by the evil Sodun, a giant white-robed member of the fanatical Ortus Solis sect, a group that still worships the Egyptian sun-god Aten.

It was Christmas Eve and just two days earlier a senior Italian Admiral had been found murdered in the Basilica di Santa Maria degli Angeli e dei Martiri.

The Admiral's body had been placed precisely on the winter solstice end of the famous *meridiana*, or noon line, laid down by Francesco Bianchini in 1703.

The carefully calibrated ruler that Bianchini had used when setting out his line had been wrenched off the wall of the presbytery and plunged into the victim's mouth. Forensic experts had noticed that the ruler was angled at just under 42 degrees to the horizontal and it was orientated due north.

As a noted expert on the Ortus Solis sect, Langdon had been hauled out of his bed in Harvard and flown to Rome. By the time he arrived, there had been two more murders.

The French naval attaché had been found dead in the Convento di Trinità dei Monti and the body of an American Commodore had been discovered in the Palazzo Spada, close to the offices of the *Segreteria Generale del Consiglio di Stato della Repubblica Italiana*.

Langdon visited the sites and immediately confirmed police suspicions. The murders were the work of the Ortus Solis sect. His guide was Nicola Thamesino, a distinguished Anglo-Italian *gnomonista* (diallist in English but dialist to Langdon, an American). Nicola was as well-known for her Mediterranean beauty as for her prowess at gnomonics.

By now, Langdon had been without sleep for 41 hours, 54 minutes and 11 seconds. He badly needed a *cappuccino*.

'I know just the place,' said Nicola and she took him to Bar La Meridiana, Via di Campo Marzio, 47. They took stock.

'All the victims have been senior naval officers and in each case the murder has been in a building with an indoor sundial,' said Langdon by way of summary. 'Let's see. What other places in Rome have indoor sundials?'

'Well obviously there is the Tower of the Winds in the Vatican and...'

Nicola's thoughts were interrupted by a most fearful scream from the back of the bar. Everyone present froze in stunned silence as a colossal white-robed figure stumbled out into the street carrying a limp blood-stained body over his shoulder. Another victim of the Ortus Solis sect.

By the time Langdon and Thamesino got to their feet, the evil Sodun was already some distance away heading for Piazza di Montecitorio. Nicola instantly appreciated the significance.

'We should have realised,' said Nicola. 'Bar La Meridiana fits the pattern.' Langdon exhaled. He was puzzled. 'But the first three murders were all in buildings with indoor sundials. How does a modern bar fit the pattern?'

Nicola gave a hurried explanation. 'Down in the basement of Bar La Meridiana there is a fragment of the great *Horologium Solarium*, the giant sundial constructed by Emperor Augustus. Its gnomon is still standing though not in its original position. It is in Piazza di Montecitorio, close to the Parliament Building.

'The gnomon is a massive Egyptian obelisk which was first erected by Psammetichus II in Heliopolis, close to the temple dedicated to the sun-god Aten. The obelisk now serves as the gnomon for a modern noon line.'

When Langdon and Thamesino reached the Piazza they came upon a grisly scene. Sodun had vanished out of sight but he had carefully laid down his victim right in front of the Parliament Building.

The terrible blood stains did not hide the gold braid and brass buttons of the uniform of a senior naval officer. His body exactly coincided with the shadow of the obelisk which indicated that the time was a quarter to one.

Langdon turned to Thamesino. 'What can this mean?' he asked. Nicola drew a quick breath. 'It means that Sodun has been reading Tony Moss limericks,' she said enigmatically.

Langdon ignored this remark. Reading Sodun's mind, he had just realised that another killing was imminent. 'Quick,' he said, 'I think I know where the next murder is going to be.'

It was Nicola's turn to be puzzled. 'Where?' she asked. 'Surely not the Tower of the Winds?' Without giving her the courtesy of a reply, Langdon hailed a cab and bundled Nicola into the back. '*Dove vi porto, signori?*' enquired the driver. 'Basilica di Santa Maria Maggiore,' replied Langdon.

In his studies of Italian art, Langdon dimly remembered a painting in the Basilica of two figures seated side by side. 'You will see,' he said, describing the painting to Nicola, 'that one of the figures is holding a sundial.'

The cab stopped outside the Basilica. Langdon paid the driver. The couple went in. Everything seemed normal. A party of German monks was being guided around and there were numerous other visitors walking about in ones and twos.

Langdon quickly felt on familiar ground. He remembered all the side-chapels, the geometric patterns in the *pavimento* and the abundance of monuments. What he was looking for was in the vaulting high above.

‘There,’ he said pointing upwards, ‘that’s the painting and you can clearly see the sundial.’ Nicola was surprised that she had not come across this picture. There were indeed two figures. The one on the right, that of a bearded man, was holding a sundial.

Following an unpleasant incident involving the noon line in Saint-Sulpice in Paris, Langdon had learned a good deal about sundials. He could now tell which part of a sundial was the gnomon and which part was the dial.



Photograph by Fred Sawyer

The sundial in the picture was curious. It had a square dial with a nodus near the top right-hand corner. The hour lines went round anti-clockwise, just as on an ordinary wall dial, but the first hour line on the left, which was roughly horizontal, was labelled XII instead of the more usual VI, or 6, for six o’clock.

Langdon had visited Italy often enough to have come across sundials marked out in Italian hours, the number of hours since the most recent sunset. On average, Italian hours are six hours ahead of ordinary hours. At the equinoxes they are precisely six hours ahead and XII corresponds to 6 a.m., the time of sunrise, 12 hours after sunset.

Italian hours might explain why the first line was labelled XII but somehow this dial didn't look like any Italian-hours sundial that he had seen before.

If a wall sundial is direct south-facing, the nodus is generally on the vertical centre-line of the dial. Here, the nodus was in the top right-hand corner. This suggested that the dial declined to the west.

In summer, 12 hours after sunset, the sun would be on the wrong side of the wall to cast a shadow and in winter, 12 hours after sunset, the sun would be below the horizon. An Italian-hours line labelled XII didn't make sense.

The inner ends of the hour lines seemed strange too. Langdon was accustomed to these ends falling on a hyperbolic arc, known to diallists as a constant-declination curve.

This curve should be appropriate for the winter solstice. On this dial, the inner ends of the hour lines seemed to form a closed curve, one which was more like an ellipse than a hyperbola.

'I don't understand this dial,' concluded Langdon. 'The hour lines seem all wrong for an Italian-hours dial. If it weren't for the labels XII, XIII and XIV, I would say that the hour lines are almost set out like the ordinary hours on a regular wall sundial.'

'What you refer to as ordinary hours,' noted Nicola, 'we call French hours. You will know that French hours were imposed on Italy in Napoleonic times. But your comments are justified. The hour lines do seem to be set out rather like those on a French-hours sundial.'

'I know,' continued Langdon, 'that Italian hours indicate the number of hours since sunset and I know that the time of sunset varies from day to day. The hour lines have to be skewed to account for this. They shouldn't be like the hour lines on a French-hours dial.'

'Just look, for example, at the line which would be labelled XVIII if the numbers didn't run out at XIV. That line is close to vertical. It is almost like a noon line. That can't be right. Using Italian hours, XVIII corresponds to noon only at the equinoxes. That line ought to be leaning over?'

'You are too set in your ways,' teased Nicola. 'You are thinking of the Italian-hours dials you have seen in Italy. This one is drawn for a different latitude.'

'But surely the time of sunset varies from day to day wherever you are?' challenged Langdon. 'The XVIII Italian-hours line can *never* be vertical?'

'Not so,' said Nicola. 'On the equator sunset is at 6 o'clock by the sun every day of the year and 18 hours after sunset it is always noon.'

Langdon thought for a moment. He realised that whatever the time of year and whatever the time of day, exactly half the earth was in daylight and the other half was in darkness. The great circle dividing light from dark always intersected the equator at two points 12 hours apart.

'So,' continued Nicola, 'on any sundial at the equator, Italian hour lines and French hour lines exactly coincide. The only difference is that there has to be a six-hour shift in the two sets of labels.'

‘You think this dial is drawn for the equator then?’ said Langdon.

‘No,’ replied Nicola. ‘I didn’t quite say that. If this dial were set out for the equator the XII Italian-hours line, which would coincide with the 6 a.m. French-hours line, would be horizontal and it isn’t. It clearly slopes.’

‘Yes but surely the slope is simply a consequence of the dial declining to the west?’ argued Langdon.

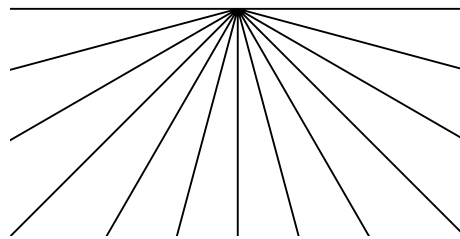
‘Not if it is at the equator,’ said Nicola. ‘Look, why don’t we sit down and I’ll show you.’

Langdon and Thamesino sat down on a nearby pew and Nicola took her laptop out of her bag.

‘Let’s start at the very beginning,’ said Nicola as she loaded her favourite dialling software. ‘We’ll set up a simple French-hours dial on a direct south-facing wall at the equator.’

Nicola opened the appropriate dialogue box and set the dial-type to *ore francesi* and the latitude to 0° . She also set the dial to be direct south-facing and confirmed that the wall was vertical.

A window on the laptop instantly displayed an elegant fan-shaped array of lines.



‘This is the prime example of an equatorial sundial,’ explained Nicola. ‘The plane of this dial is not simply parallel to the plane of the equator, it is *in* the plane of the equator. Everything is nice and easy with an equatorial dial. The 13 hour lines are spaced at exactly 15° intervals.’

‘The 6 a.m. line is the top one on the left and the 6 p.m. line is the top one on the right. You can see that they are both horizontal and that the noon line in the middle is vertical.’

‘Could you put in the hour lines between 6 p.m. and 6 a.m.?’ Asked Langdon.

‘Yes I could but there wouldn’t be much point,’ reasoned Nicola. ‘On the equator the sun always sets at 6 p.m. and always rises again at 6 a.m. Between those times the sun is below the horizon and cannot cast a shadow. My software takes the view that if there is no sun then there are no hour lines!’

‘Can you put in the numbers?’ asked Langdon.

‘Certainly’, replied Nicola. She clicked a button and the morning hour lines on the left were duly labelled 6 to 11 and the afternoon hour lines on the right were duly labelled 1 to 6. The vertical noon line was labelled 12 as expected.

‘Now watch what happens if I change the dial type to *ore italiane*.’ The change to Italian hours made no difference at all to the hour lines but the 13 labels changed and now ranged from XII to XXIV.

‘I am not really ready for Italian hours,’ said Nicola, ‘so I’ll go back to *ore francesi* and I’ll also remove the numbers.’

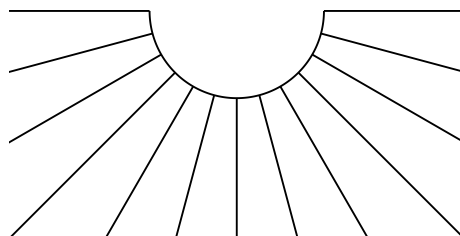
‘Can you put in the two arcs for the winter and summer solstices?’ asked Langdon.

‘Well yes and no,’ said Nicola a little unhelpfully. ‘There are a couple of problems. For a start, it is a little silly to talk about winter and summer on the equator so let’s call them the December solstice and the June solstice.’

‘It is easy enough to put in the constant-declination curve for the December solstice. Let’s try that now.’

Nicola opened a dialogue box and keyed in the solar declination at the December solstice, -23.44° . The fan-shaped array of lines now had a semi-circular bite cut out of it.

Nicola explained that the constant-declination lines on an equatorial dial were always circles or arcs of circles.



‘By default, my software cuts off the inner ends of the hour lines at the December solstice curve, mainly because the shadow of the nodus can never fall in the region which has been cut out.’

‘I know you asked for the June solstice curve too but when I try to put that in you will see a more serious problem.’

Nicola keyed in the solar declination at the June solstice, $+23.44^\circ$, but this time the laptop gave a beep and an error message appeared.

‘Remember,’ said Nicola, ‘this dial is on a direct south-facing wall at the equator. From the March equinox to the September equinox the sun is in the northern hemisphere and can never shine on the south side of this wall. You can’t even draw the line for the equinoxes because that would be at infinity.’

‘I suggest we leave the outer ends of the hour lines bounded by some imaginary rectangular frame. After all, that is how things are in the dial in the picture.’

Langdon understood everything Nicola had said. He had also noticed that the left-hand half of the dial on Nicola’s laptop had a definite resemblance to the dial in the picture.

‘Okay so far,’ said Langdon. ‘I guess that the next step is to try changing the dial’s declination so that the 6 a.m. line slopes like the XII line in the picture.’

‘You weren’t listening,’ chided Nicola. ‘I’ve already said that changing the dial’s declination won’t make any difference to the slope of the 6 a.m. line. Watch this.’

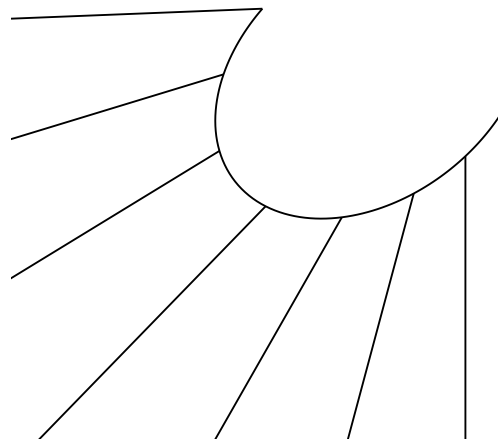
Nicola changed the declination to 10° west and then to 10° east. Each time, the semi-circle elongated horizontally to a semi-ellipse but the 6 a.m. and 6 p.m. lines stayed horizontal and the noon line stayed vertical. The angles of the other hour lines changed a little but not very much.

‘I’m sure you know that on a direct south-facing dial the 6 a.m. and 6 p.m. lines are always horizontal. You can’t shift them from the horizontal by changing the latitude. Well, if you are on the equator, you can’t shift them from the horizontal by changing the wall’s declination either.

‘To shift these lines from the horizontal you have to move away from the equator *and* change the declination from direct south-facing.

‘Let’s see what happens if we move to 10° south and arrange for the wall to decline 13° to the west. Let’s also cut out the right-hand half of the dial so as to be more like the picture.’

Nicola keyed in the revised parameters and there was a considerable change in the appearance of the dial. Only the hour lines from 6 a.m. to noon were now displayed and the shape of the December solstice arc had changed to an ellipse whose major axis was sloping at very roughly 45° .



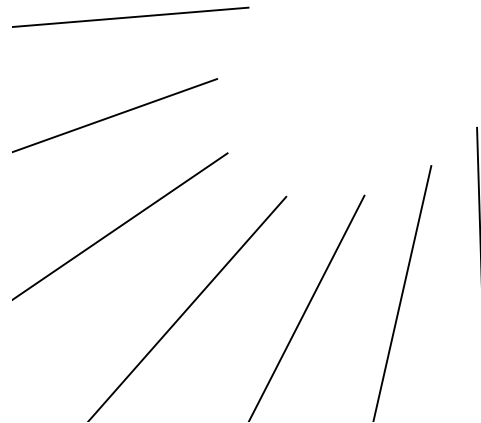
‘We are making progress,’ said Nicola. ‘The 6 a.m. line is at last sloping downwards a little though you will no doubt tell me that it doesn’t slope enough!’

‘Of course, the 12 noon line is still vertical. You won’t shift that from the vertical by changing the latitude or the declination of the wall. It *would* shift from the vertical if we arranged for the wall to lean forwards or backwards but I don’t think we need do that.’

‘Yes, that’s certainly progress,’ acknowledged Langdon enthusiastically, ‘but aren’t you still using French hours? What happens if you change to Italian hours now?’

‘We are still only a few degrees from the equator so Italian hours will be only a little different from French hours,’ said Nicola, ‘but you will see that the differences, such as they are, make our dial even more like the one in the picture.’

Nicola once again changed to *ore italiane* and she also turned off the December solstice curve because this doesn't explicitly feature in the picture.



'Hey,' said Langdon, suitably impressed. 'That's just great. You really have got very close to the dial in the picture.'

Nicola was quite pleased herself. 'You can see that the XII line slopes a little more than the 6 a.m. line did and you can even see that the XVIII line is not quite vertical. Its upper end is a little to the left of its lower end, just like the XVIII line in the picture.'

'I could make the lines a little longer perhaps and try a few more adjustments but I think this is as close as we need to make it. Let's have a proper look at the picture again.'

Langdon and Thamesino got up from the pew and walked back to their original vantage point. They were comparing the version on the laptop with the dial in the picture when they were simultaneously struck by the significance of the shadow of the nodus that the artist had carefully added to the dial.

The artist had clearly and deliberately painted the shadow to indicate XIII-hours Italian time about three days after the December solstice.

'Robert,' said Nicola. 'I think the next murder is going to take place here tomorrow about five in the morning. That's 5 o'clock on Christmas day.'

Langdon had had much the same thought himself but he had decided against this interpretation. Having written several books on religious symbology his attention was drawn away from the representation of the sundial itself.

'You need to look at the whole picture and not just the dial. The artist has drawn the shadow falling on the XIII line as a direct reference to a little-known 13th apostle who was really a worshipper of Aten. Not surprisingly, early Christians did their best to suppress the fact that Christ's band of followers had been infiltrated.'

'Look at the two people in the picture. They seem to be pretending not to notice one another whereas, in fact, the man holding the sundial is having his right leg scratched by the handcuffed figure on the left.'

'This is an early form of Masonic greeting practised by members of the *Ortus Solis* sect. There are obvious references to bondage and other sexual themes here.'

‘Moreover, if you extend the line of the shadow on the sundial you will see that it falls on the head of the snake lower down in the picture. The snake clearly symbolises betrayal.

‘Of course, the dial is significant in itself. Remind me; did you say this dial was set out for 10° south?’

‘Yes,’ confirmed Nicola. ‘Look, you can see the data displayed on the laptop: *dieci gradi sud.*’

‘There must be an explanation,’ mused Langdon. ‘I don’t suppose there were any Italian colonies in the tropics?’

‘Italy didn’t really go in for colonies,’ replied Nicola, ‘at least not in the days that many other European powers were conquering the world. Of course we had Imperial Rome and the Holy Roman Empire. No I can’t think of anywhere, at least not anywhere *dieci gradi sud.*’

Hearing the latitude expressed in Italian for a second time had a remarkable effect on Langdon. He felt the last pieces of the puzzle were falling into place.

‘Did you say *dieci gradi*?’

‘Yes, *grado* degree, *gradi* degrees.’

‘Just like the Latin *gradus* for a degree or a step or a unit of measure,’ noted Langdon. ‘Can you remind me about Bianchini and his ruler, the one that was found in the Admiral’s mouth?’

‘That’s a very rash request,’ said Nicola. ‘Francesco Bianchini is my hero and once I start talking about him, it is difficult to get me to stop! To me, he is the greatest *gnomonista* that has ever lived, greater even than Cassini.

‘Bianchini was born in Verona and during his life he was a historian, an archaeologist, an astronomer, a mathematician, a lawyer and a theologian. He was also a Canon of this Basilica.’

‘Is he buried here?’

‘Yes, but not in the part of the Basilica open to the public. His tomb is in an area where Canons of Santa Maria Maggiore are buried and you have to use a different entrance. But I digress. You asked about his ruler and I can certainly tell you about that...’

‘When Francesco Bianchini set out the great *meridiana* in the Basilica di Santa Maria degli Angeli, metres and millimetres were a long way into the future.

‘Bianchini used his own unit of measure which was one-hundredth part of the height of the *foro gnomonico* (the hole in the roof of the Basilica which serves as the nodus) above the *pavimento*. This is the unit of measure that is inscribed on his ruler. All his calculations were based on this unit.

‘In recent years this *meridiana* has been much studied by well-known Italian diallists, particularly Mario Catamo and Cesare Lucarini who painstakingly surveyed every feature on the *pavimento* of the Basilica that was even remotely associated with the *meridiana*.

‘There are many arcs of stars on the *pavimento* arranged as hyperbolic curves which are associated with particular declinations of the sun but one arc doesn’t fit the pattern.

‘This is an arc of a circle rather than a hyperbola. The *pavimento* is nowhere near being parallel to the plane of the equator so this circular arc cannot possibly be a constant-declination curve.

‘The surveyors carefully measured the radius of this circular arc but no one was able to explain its significance. The surveyors had, of course, used metres and millimetres.

‘Now there has been some debate in England recently about whether those who record historic sundials should use Imperial units of measure as well as metres and millimetres.

‘Using the units of measure that were employed originally can be very important and, of course, they won’t necessarily be Imperial units. In the case of the *meridiana* in the Basilica di Santa Maria degli Angeli, it seemed obvious to use Bianchini’s own unit of measure.

‘When I converted the radius of this mysterious arc of stars into Bianchini units I was amazed to discover that the radius was close to 173.2 units. I remembered from my school days that 1.732 is the square-root of 3.

‘By using the Theorem of Pythagoras it is easy to see that each of the stars in the arc was 200 Bianchini units from the *foro gnomonico*. I hope I don’t need to explain that $\sqrt{200^2 - 100^2}$ is close to 173.2!

‘I believe that these stars indicate a test arc that Bianchini set out to check the accuracy of his own surveying.

‘Alas, I don’t quite see what this has to do with our dial being set out for 10° south?’

Langdon was all too aware of the significance. ‘Tell me,’ he said, ‘just how long is a Bianchini unit?’

‘Well,’ said Nicola, ‘the *foro gnomonico* is 20.34 metres above the *pavimento*, which means a Bianchini unit is just over 203 mm.’ She held her hands about eight inches apart.

‘So, ten Bianchini units would be about two metres? Now look again at that snake. The snake isn’t looking up at the faces of the figures in the picture, it is looking down on us, inviting us in turn to look down. The sundial is inviting us to move ten units to the south. Let’s see...’

Langdon carefully noted the orientation of the Basilica before looking down at his feet. He then took a couple of long strides to the south. ‘Ah, just as I thought.’

‘What have you seen?’ asked Nicola.

‘Look, there is a grille in the floor here. I have a distinct feeling that this is not going to be nice.’ Langdon bent down and peered into the grille. When he stood up he was ashen faced.

‘There is a freshly-severed human arm just under the grille. It is still in the shirt sleeve of its owner. The shirt has gold cuff-links. They are emblazoned with anchors...’

Unfortunately, Mr Brown’s manuscript runs out at this point.