BOLOGNA

For Connoisseurs

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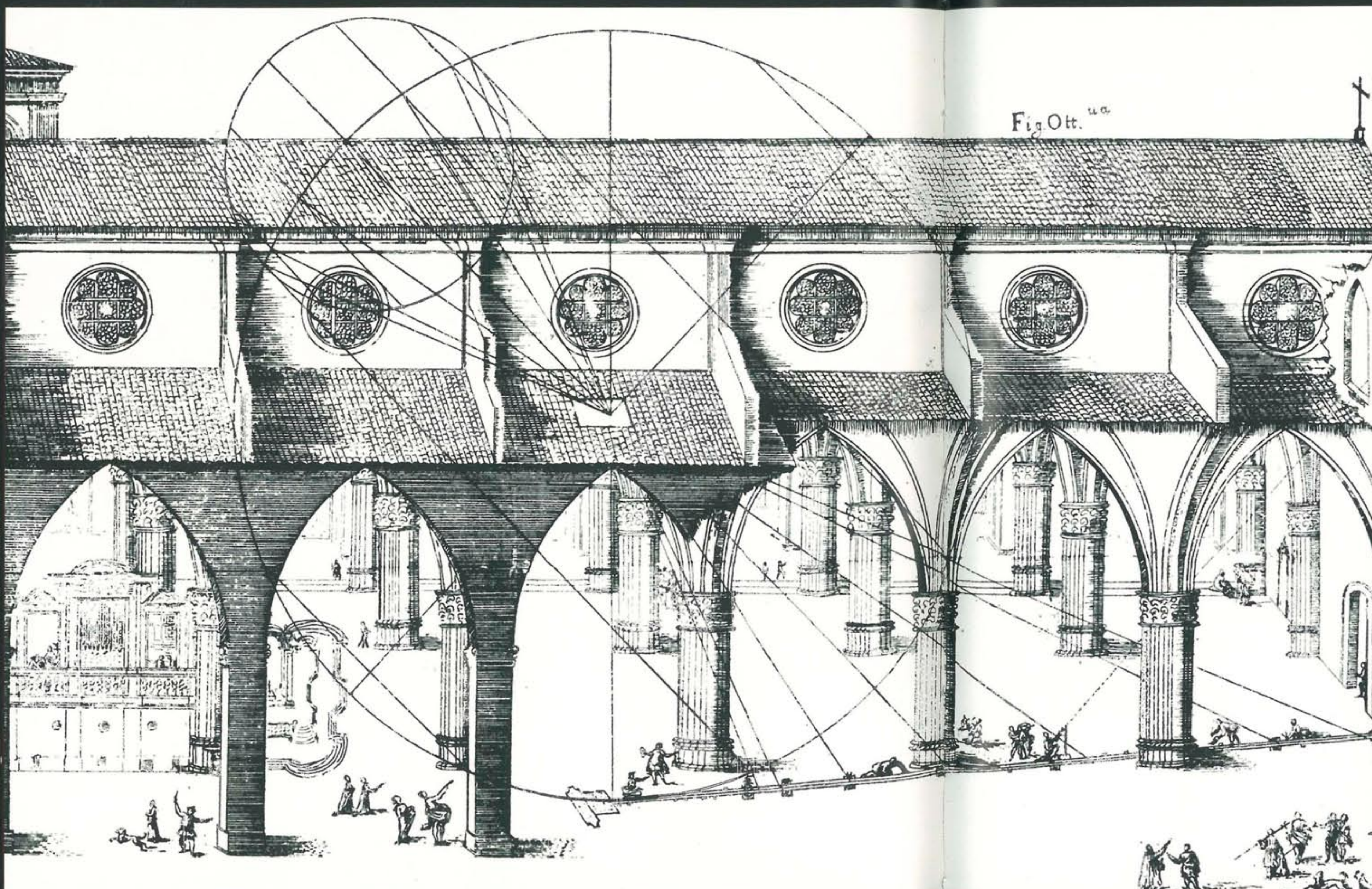
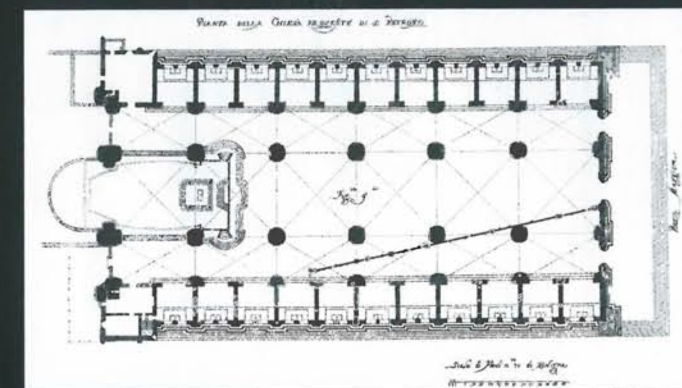
MARKING TIME

The ability to measure time is fundamental to all kinds of scientific endeavour, from space exploration to quantum mechanics. Bolognese thinkers and innovators have been pioneers of the science of time, and a historic chronometric instrument still functions right in the heart of the city. By Robert Charles



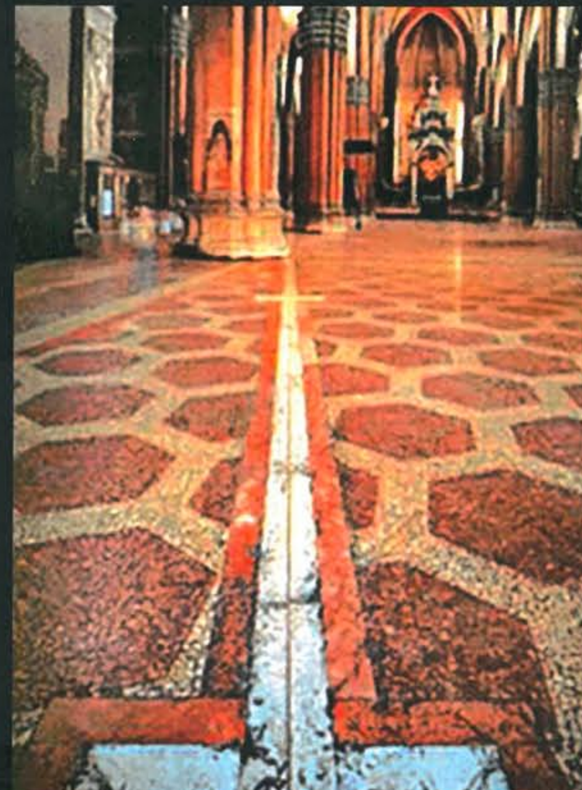


Go into the cathedral of San Petronio, on Bologna's main square, and your eyes are naturally drawn upwards by the vast soaring columns, which are like thick tree trunks in a well-ordered forest. Above each frilly capital are curved ribs – stylised branches that spread and conjoin to form a beautifully geometric vault. This high ceiling is an awe-inspiring example of the church-builder's art – but keep looking and you will see a strange and slightly incongruous design amid the arches. It is a tiny aperture, like the lens of a camera, surrounded by a golden sunburst. You might think it represents the all-seeing eye of God, but it has nothing to do with divine worship. It is part of a 'heliometer' or meridiana, a sophisticated astronomical tool constructed by Giovanni Domenico Cassini to help define and refine the slippery scientific concept of time.

The peephole in the ceiling is one half of the instrument; the other part of the meridiana is at your feet. It is a straight line, wrought in metal and extending for 67 metres (220 feet) diagonally along the floor of the church. The line runs due north–south, and is precisely aligned with the hole in the ceiling. So, under the right conditions, a spot of sunlight ▷

San Petronio (above) was an ideal site for a meridiana. The floorplan (top) showed how a north–south line would just fit between the piers of the church. The side view (left), depicted admiring crowds, and also demonstrated the geometric calculations behind the positioning of 'zodiacal plaques' on the meridian line

The meridiana is a small miracle of mathematics and engineering. The diameter of the hole in the ceiling (opposite and below) is precisely one-thousandth of its height above the floor. Sketches along the line show the elliptical shape that the sun's image should take at various points in its cycle. Cassini even calculated the effect that the curvature of the earth might have over the 67-metre length of his meridian line



In the late-medieval era the Church calendar came up against a crisis, and only a better understanding of solar time could put it right

can be seen to pass across the line at noon exactly. The point on the line at which it crosses depends on the time of year. When the sun is at its zenith during summer, the beam strikes one end of the line; at the winter solstice, when the sun is at its nadir, the angle of the beam is such that it strikes the other end. The line is carefully calibrated to mark the position of the sun at the spring and autumn equinoxes, too.

So the heliometer is a means of observing and measuring the passage of the sun over the course of a year. But why is it in a church? The practical answer is that in the 17th century churches were the only buildings big enough to serve as such 'solar laboratories'. But it can also be said that a church was the right place for the meridiana, as the Catholic authorities had a desperate need to know the things that it could reveal.

Because in the late-medieval era the Church calendar came up against a crisis, and only a better understanding of solar time could put it right.

The measurements of time on a human scale are, of course, an outworking of the immutable facts of astronomy. A year is the time it takes for the earth to complete an orbit of the sun; a month is how long it takes for the moon to make a circuit round the earth; and a day is the time it takes for the earth to turn like a top on its own axis. For calendrical purposes, the length of a year, measured out in days, is the crucial figure. But days do not fit neatly into a year. The duration of a year is not 365 whole days, but 365.2422 – that is, 11 minutes and 14 seconds short of 365¼.

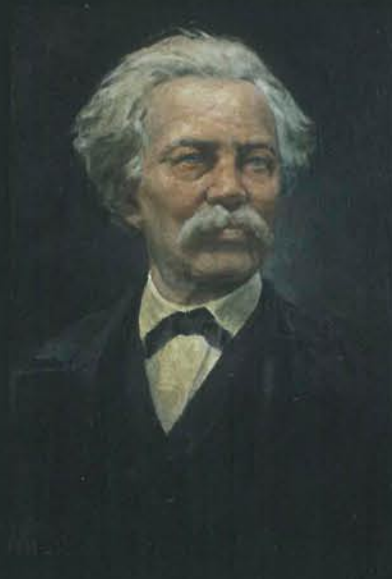
It follows that, from time to time, to keep the calendar on track, adjustments have to be made for the awkward fraction of a day at the end of each year. The Greeks and Romans knew this, and in 46 BC, Julius Caesar established a well-thought-out system whereby extra days – leap days – were added to some months in some years. But the knowledge of the ancients was not sufficiently precise – they didn't know about the 11 minutes and 14 seconds – and so the Julian calendar was no more than a workable approximation. Over subsequent centuries ▷

those lost minutes added up, with the result that the calendar got increasingly out of synch with the cycle of the seasons.

By AD 1500 the spring equinox was, on paper, occurring a full 10 days early: on 11 March rather than 21 March. This was a serious problem for the Catholic Church because the baseline for the calculation of the date of Easter was (and is) the spring equinox. A new reform of the calendar was required to bring it back in line with the observations of the astronomers – otherwise that movable feast would slowly creep back through the months and eventually collide with Christmas.

It was a Bologna-born pope, Gregory XIII, who pushed through these urgent administrative reforms. As a first measure, he decreed that 10 days would be excised from calendar time wherever his authority held sway. So it was that in Italy, France, Spain, Poland and southern Germany the day that followed 5 October 1582 was 15 October 1582. Other countries followed suit one by one – the nations of Protestant northern Europe did so reluctantly, because they did not want to be seen to be kowtowing to a Catholic directive: Scotland went Gregorian in 1600, Denmark and northern Germany in 1700, England and its empire in 1752. The Orthodox east was slowest to catch up. Russia stuck to the Julian calendar until after the Bolshevik Revolution of 1917, by which time the date was 13 days behind; Yugoslavia followed in 1919; Greece, at last, in 1923.

But revising the current date was only part of the solution. It was also necessary to arrive at a better definition of the length of a year, so that the problem would not recur – and that was the primary function of the first meridiana to be constructed inside San Petronio. This instrument was not Cassini's, but a less ambitious and less sophisticated version, built by Egnozio Danti in 1576. The data it provided was not quite accurate enough for the pope's needs, but calendar reform could not wait for technology to catch up, and it went ahead anyway. Cassini's bigger and better heliometer was commissioned and installed a lifetime later, in 1655, after Danti's meridiana had been demolished during building works at the church.



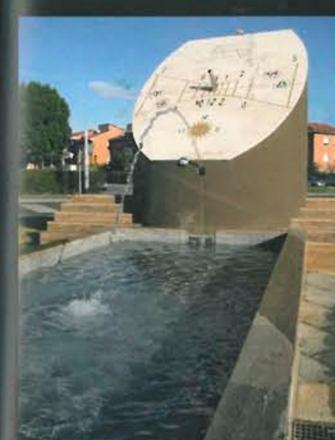
Giuseppe Barilli, known as Quirico Filopanti, the inventor of time zones

The new meridiana belatedly confirmed the solar data needed to calculate the date of Easter for ever after, but it did much more than that. In Cassini's day, Catholic theologians still maintained that the earth was the centre of God's universe. That doctrine had not changed in the 40 years since Galileo had been censured for asserting that the earth moves around the sun – and not vice versa, as the Church taught. Galileo's insight was deemed heretical because it implied that the world and the people on it are in no physical sense the focus of the Almighty's creation. Cassini's meridiana was one of the instruments that demonstrated the truth of Galileo's sun-centred view, and persuaded the religious authorities to accept it. By shining a sunbeam onto the church floor, the Bologna meridiana helped bring the light of science into the Church as a whole.

Careful observation of the annual progress of the sunbeam along Cassini's line proved many other things, for example, that at certain points in the year the earth slows down on its journey around the sun. This led to the conclusion that the earth's orbit is elliptical, not circular. Such discoveries reached far beyond the original ecclesiastical remit of the heliometer, and placed Bologna at the forefront of astronomy and the new science of chronometry. 'Many cities have a mechanical clock of an astronomical kind in their main square,' says Giovanni Paltrinieri, director of the Bologna city archives, and an expert in the history of time-science. 'And many cities can boast a great astronomer, or a tradition of craftsmen who created excellent machines for the measurement of time. But only Bologna can call itself the world capital of time.'

And Bologna has at least one more good reason for laying claim to that title. Another Bologna-born thinker made a key contribution to modern concepts of time. Giuseppe Barilli, born in 1812, was a professor of mechanics at Bologna University. He was also a political radical, and was forced to flee abroad after the fall of the Roman Republic in 1849. While in exile in London he wrote a strange metaphysical book, *Miranda, or a Book of Wonders*, which was published in 1858 under his political nom de guerre, Quirico Filopanti. Buried in its pages was a proposal to divide the earth into what he called 'longitudinal days' – 24 notional slices, like the segments of an orange, each one a thousand miles wide at the equator and an hour apart in time. This would solve the problem – no less pressing in its way than the medieval calendar crisis – of knowing the time of day in places that were distant, but connected by telegraph lines. If you wanted to send an urgent cable from London to New York, you might well need to know what time of day it would reach its American addressee. The problem was even more critical once railways became widespread and efficient enough to carry people swiftly over long distances. What time would it be when you arrived in, say, Moscow, having departed a day or two before from Berlin? It was hard to say, but not the same time as back in Berlin, that was for sure.

Barilli's longitudinal days – time zones, as we call them now – were a fine idea, timely in every sense, and eminently practical. But no one noticed. It was not until the 20th century that his proposal was adopted, and even then it happened piecemeal, one country at a time, as with the Gregorian calendar. And it came about without any acknowledgment of Barilli/Filopanti, who was by then long dead. But his contribution to time is remembered in Bologna, where he is held in honour and some of his manuscripts are preserved. Outside Bologna, he is immortalised by a useful iPhone app that instantly tells you the time anywhere in the world. The name of the app: Filopanti. ♦



Giovanni Paltrinieri is part of Bologna's longstanding preoccupation with time. He is an expert on the history of the city's contribution to time-science, and is a designer of sundials and solar clocks – many of which have been built at sites throughout the Emilia-Romagna region