

OF ANALEMMAS, MEAN TIME AND THE ANALEMMATIC SUNDIAL - PART 1

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There is an interesting irony in the fact that the analemma ('Figure 8') curve has become a familiar feature on the classical sundial over the last century and a half, but has only rarely been seen on the analemmatic sundial.¹ One might expect the similarity in names to suggest more of a kinship between the dial and the curve. The purposes of the present article are (in Part 1) to consider this irony - a consideration which requires something of an etymological journey - and (in Part 2) to elaborate on the design of a standard-time analemmatic sundial which reinforces the kinship by reuniting the dial and the curve.

HISTORY AND ETYMOLOGY

In order to proceed, we need to understand the concept of the analemma in a more general setting. Not only is the word *analemma* seldom used today outside of the 'gnomonic community', but when it is used, its meaning tends to be only a narrow derivative of its original sense:

The word *analemma* means much the same as *lemma*; the analemma is for graphical constructions what the lemma is for geometrical demonstrations; it is a subsidiary figure which is *taken up* to shorten and facilitate the construction of the principal figure.²

The particular analemmas which in ancient times proved to be of most use in the design of sundials appear in the works of Vitruvius and Ptolemy. Writing in the first century BC in *De Architectura*, the Roman engineer Marcus Vitruvius Pollio noted that "in order to understand the theory of these dials, one must know [the theory] of the analemma".³ However, the analemma to which he referred was not the now familiar curve relating apparent and mean time. What Vitruvius alluded to was a *graphical procedure equivalent to what is known today as an orthographic projection*. Although he did not provide instructions for its use,⁴ Vitruvius made it clear that the analemma was at the core of the ancient practice of sundials.

Early in the second century AD, Claudius Ptolemaeus wrote *De Analemmata*, a more detailed presentation⁵ of a method for projecting the principal circles of the celestial sphere onto a plane - the projection being from a point at an infinite distance along a line perpendicular to that plane. After describing the coordinate system resulting from his projection, Ptolemy presented two distinct methods for determining the coordinates; one method was trigonometric, the other was nomographic - basically, he invented an instrument. This instrument - Ptolemy's analemma - was composed of two pieces: a carpenter's square⁶ and a plate of wood or metal with inscribed scales and curves. It allowed one to read values of coordinates directly from the analemma diagram by use of the carpenter's square as a straight-edge.

The analemma is thus also *an instrument which implements a graphical procedure*. This sense of the word is apparent in such references as Regiomontanus' 15th century introduction of a "universal rectilinear analemma"⁷ - now generally implemented as an altitude dial on a card; St. Rigaud's publication of his version of that dial as a *New Analemma*,⁸ and John Twysden's 1685 *Use of the Great Planisphere called the Analemma*. Note also Valentin Pini's 1598 discussion of Ptolemy's work, in which he introduced his own analemma - a simple armillary dial.⁹

The analemmatic sundial we know today was probably invented some time in the period¹⁰ between 1532 and 1640. The timing could not have been more unlikely for the introduction of a modern sundial based on an ancient analemma:

[The ancient] type of dial has fallen into disuse, since we stopped dividing the day into temporary hours. The Ptolemaic theory would therefore be perfectly useless to us today, if his constructions could not be equally adapted to the new system . . . When the book of the Analemma was published for the first time by Commandin, in 1562, gnomonics had already been founded on totally different principles. See the *Horologigraphia* of Munster, of which the first edition is of 1531, and the second of 1533.¹¹

Whoever invented the dial managed to combine the three senses of *analemma*¹² into a single accomplishment which not only bridged the centuries but transformed an old concept so that it made sense in a world of equal hours - the new paradigm of time measurement.

[The analemma was] applicable to the ancient dials which, as everyone knows, have their style perpendicular to their face. It had lost all practical utility with the modern dials, based since the 15th century on the inclination of the style parallel to the axis of the world. But the analemmatic dial, with perpendicular style, appearing in the texts of the 17th century, revived the use of the analemma through its geometric construction.¹³

The analemmatic dial is little else than the *graphical procedure* we know as *orthographic projection* turned into an *instrument* to tell time. Its ellipse of hour-points results from an orthographic projection of the sun's path from the pole onto the horizon circle. Authors ranging from Vaulezard¹⁴ in 1640 to Lalande, more than a century later, derived its distinctive declination scale for the placement of the vertical gnomon directly from the traditional analemma drawing.

The 18th century astronomer J.J. de Lalande was born in Bourg-en-Bresse (Ain), France, near the church of Brou, in whose grounds is found the oldest analemmatic sundial in existence.¹⁵ In 1756 he was concerned that the dial was deteriorating, so he had it reconstructed in stone at his own expense. The next year, he communicated to the Académie des Sciences a letter which identified the task of drawing and justifying an analemmatic dial as "one of the most complicated in all of Gnomonics".¹⁶ Lalande complained that earlier treatments of the dial either gave no demonstration that it was correct or gave an unsatisfactory, incomplete demonstration. Although his survey of the prior literature was far from complete,¹⁷ Lalande noted that he was forced to find his own demonstration of the correctness of the dial. In doing so, he "formed an extremely simple rule for finding the place of the style in all the months of the year".¹⁸ But what was the basis of this rule? As he noted himself, it was the ancient analemma.

This figure²⁰ shows an orthographic projection onto the meridian plane AZB. The horizon is AB, the pole P, the zenith Z, EO the projection of the equator, and CX the projection of the minor circle representing the sun's orbit on the given day. By selecting point D so that the lengths