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RESEARCH

Baroque Oval Churches: Innovative Geometrical Patterns in Early Modern Sacred Architecture

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Abstract Italian religious architecture of the late Cinquecento is marked by an innovative interpretation of the canon of the central plan that generates a new type of Baroque church: the elongated central space. By building oval churches covered with oval domes, Jacopo Barozzi da Vignola (1507–1573) introduced a new pattern into the architectural shape grammar. The geometry of the oval figure gracefully combines the theoretical concept of cosmic centrality and the pragmatic necessities of liturgical linearity. However it raises a number of design problems for which architects devised various and inventive solutions. The comparison of various churches dating back to no later than the end of the Seicento, highlights the diversity of all the projects. Although every church is unique in its layout, design, features and decoration, all oval churches propose similar challenges to their designer, the most important of which are the choice of the geometrical pattern, the dome, and the façade.

Keywords Oval churches · Italian baroque · Religious architecture · Central space

Introduction: the Concept of Centrality

Sacred architecture of the Italian Renaissance is marked by the dissemination of a special kind of building: the centrally planned church.

The morphological features of the centrally planned church are quite simple and therefore recognizable. They differ from other models such as the basilica type or Latin cross type in the sense that the inner space does not expand longitudinally but

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radially, and in concentric rings, from a centre which is the core of the sacred space. Either circular, square or polygonal in plan, the central area is usually covered with a dome, and is dedicated to hosting the worshipping congregation. In centrally planned churches, the dome rises over the heads (and souls) of the worshippers, thus creating a different spatial relationship between the single individual and the house of God.

The spread of centrally planned churches from the second half of the fifteenth century onward, is part of the more general renaissance of Classical culture as a whole, evidence of which is found in every field of sciences and arts. Following the example of the then recently rediscovered architectural treatise by Vitruvius, *De Architectura Libri Decem* (Ten Books On Architecture, c.15 B.C.),[1] Leon Battista Alberti (1404–1472) wrote his own treatise entitled *De Re Aedificatoria* (On The Art Of Building In Ten Books, c.1450): the first of the many literary works on architectural theory that would be produced in the centuries that followed. Although similar to Vitruvius's manuscript in its structure and purpose, Alberti's text is unquestionably a modern text, in which design principles are formulated according to the then current principles of Humanism. Vitruvius's and Alberti's theories on sacred buildings, for instance, differ quite sharply. While in his book on temples Vitruvius only mentions round temples in passing, Alberti recommends nine possible geometrical diagrams for temple design, six of which are circular or polygonal, and only three of which are rectangular. The square, the hexagon, the octagon, decagon and dodecagon are the recommended polygonal shapes, and he insists on the fact that their angles must be precisely drawn, equal to one another; otherwise they won't be regular and inscribed in a circle. The circle seems therefore to be the ultimate reference, since it is—Alberti states—the favourite shape of nature.

One of the most famous early examples of a centrally planned church is Santa Maria delle Carceri, designed by Giuliano da Sangallo (1445–1516), built in Prato (Tuscany) in 1485. A composition of squares, circles, cube and sphere, its geometrical diagram is the paradigm of symbolic solid geometry. In the same years, around 1489, Leonardo da Vinci (1452–1519) filled many pages of his sketchbooks with drawings and studies on the theme of the centralized church, exploring several different geometrical options, varying the basic polygon used in plan, going from the square to the octagon, and the circle. All plan diagrams are completed by a perspective view of the possible volume that can be built from the plan sketch (Xavier 2008). Donato Bramante's (1444–1514) proposal for the new church of San Pietro in Rome is directly connected to Leonardo's studies. Leonardo and Bramante were both at the Milanese Court of the Duke Ludovico Sforza *Il Moro* at the end of the fifteenth century and they most probably collaborated while studying new models for church design. The influence of this research extends to most of the centralized churches that were built in the first half of the sixteenth century. The church of Santa Maria della Consolazione in Todi (Umbria), on which construction

[1] *De Architectura Libri Decem,* written around 15 B.C. and dedicated to Emperor Augustus is the only theoretical and technical treatise on architecture that has come down to us from Classical antiquity. The latest English translation of Vitruvius' text is *On Architecture*, translated by Richard Schofield (Vitruvius 2009).

started around 1508 under the direction of Cola da Caprarola (?–1518), is almost exactly the same as one of the sketches in Leonardo's *Manuscript B*. The church of the Madonna di San Biagio at Montepulciano (Tuscany), built by Antonio da Sangallo the Elder (1453–1534) between 1518 and 1545, is also said to have been strongly influenced by Bramante's studies for San Pietro in Rome.

Oval Diagrams and the "Elongation of Centrality"

Italian religious architecture of the late sixteenth century is marked by an innovative interpretation of the canon of the central plan that generated a new type of Baroque church in which the central space is elongated. By stretching the central circle into an oval, longitudinality is added to the building, without cancelling the feeling of centrality. In the mid-sixteenth century, Jacopo Barozzi da Vignola (1507–1573) introduced a new pattern into the shape grammar of sacred architecture. He and his disciples were the first to design, and actually build, churches with oval plans and oval domes. From a functional point of view, the geometry of the oval figure gracefully combines the theoretical concept of cosmic centrality and the pragmatic necessities of linearity required for processions and liturgical celebrations. However, it raises a number of design problems for which architects devised various and inventive solutions. Several examples are given here, chosen among actually built and still existing churches dating back to no later than the end of the seventeenth century. The examples chosen all regard churches as a whole, and exclude the study of single rooms, chapels, courtyards or any oval part of a vast church or a monastic ensemble. The following study focuses on the oval geometry of elongated centrality applied to church design.

Around 1550-51, while working on the construction of the Villa Giulia in Rome for Pope Julius III, Vignola was asked to build a votive chapel to commemorate the pope's escape from the prison in which he had been held after the Sack of Rome, an escape that occurred on November 29, 1527, on the day of Sant'Andrea. Vignola therefore designed the chapel known today as the church of Sant'Andrea in Via Flaminia, a simple building that nevertheless challenges the rigidity of the combination of cube and sphere. Here, Vignola elongated the classical shapes of the square and the circle into a rectangle and an oval: the central space of the chapel is rectangular and covered by an oval dome. As the first oval dome built in Rome, Sant'Andrea in Via Flaminia marks a turning point in the history of Renaissance architecture and its innovative geometry would inspire European architects throughout the seventeenth and eighteenth centuries (Fig. 1).

The Ancient Roots of Oval Geometry

Vignola's aspiration to experiment with new oval forms for church design was not the result of a personal whim, but stemmed from ongoing contemporary research on ancient Roman architecture. The investigation of classical monuments by Renaissance architects was not limited to the study of temples and the five orders, but also

Fig. 1 Jacopo Barozzi da Vignola, Sant'Andrea in via Flaminia, Rome 1550–51 (Photo: Sylvie Duvernoy)

comprised the study of civic monuments. Because of their particular oval shape, amphitheatres caught the attention of well-known architects such as Giovanni Battista da Sangallo (1496–1548), Baldassare Peruzzi (1481–1536), Sebastiano Serlio (1475–1554) and Andrea Palladio (1508–1580), all of whom measured, surveyed, and analysed the remains of—mostly—the amphitheatres of Verona and Rome.

Classical Roman architecture displays a vast array of building types for entertainment—theatres, odeons, stadiums, circuses and amphitheatres—each of which had a specific form, consistent with its function of housing a specific kind of event: plays, music, sport games, and horse races. Amphitheatres were designed by Roman architects to host a kind of event that did not exist in ancient Greece: the gladiator fight, whether between gladiators (*munera*) or between gladiators and beasts (*venations*). The very first amphitheatres were built in southern Italy, in Campania, around the middle of the second century B.C. and were from their very beginnings characterized by an oval form never previously applied in architectural design and never used for other building typologies in antiquity, with the sole exception of the so-called oval forum of Gerash in Jordan. From the first century B.C. to the end of the third century A.D., amphitheatres were erected in all the territories of the Roman Empire and evolved from the primitive structures of the Republican period, whose stone seats were simply laid on the solid ground, to the sophisticated monuments of the Flavian dynasty, whose annular sitting areas were supported by a complex system of radiating walls and vaults, and whose exterior façades became increasingly elaborate.

Recently, scholars in architectural history, interested in the relationships between mathematics and architecture in antiquity, surveyed and studied the remains of a large number of Roman amphitheatres for the purpose of trying to unveil the intended geometric order of their design and of possibly making some progress towards the understanding of the cultural relationships between science and art in classical antiquity. The general discussion about amphitheatres regards the true nature of the curves that give form to the monuments. Are they elliptic or oval?

Ellipses and ovals have different mathematical properties. The tracing of an elliptic curve relies on the prior determination of the length of its main axes and on the position of its two focal points. The construction of an oval consists in joining four or more segmental arcs of different dimensions and different radii, which meet where they share the same tangent. The centres of an oval can be arranged according to a variety of patterns. However, regular ovals have four centres symmetrically set on two perpendicular axes. Any ellipse can be closely approximated by a regular oval made of four arcs and vice versa. In fact, an oval and an ellipse having identical axes are very similar as far as visual perception is concerned, and this optical similarity is the underlying cause of the ambiguity of the geometrical terms that is found in many texts (Fig. 2).

Together with the parabola and the hyperbola, the ellipse belongs to the family of the conic sections. The study of the conic sections appeared in ancient Greek geometry as a tool for problem solving when Menaechmus (380–320 B.C.) proved them to be useful for devising a solution to the question of the duplication of the cube. Nevertheless they soon became a field of interest in their own right and significantly enriched the variety and the beauty of the grammar of geometrical shapes, which up to Plato had mostly been restricted to polygons and circles, polyhedra and spheres. Apollonius of Perga (262–190 B.C.) is regarded as the father of the complete theory on conic sections. His authoritative treatise, *Conics*, is highly theoretical, but explains—in passing—some specific properties of the ellipse that makes its application in architectural design possible. Specifically, proposition fifty-two of book three shows that, from any point on the curve, the sum of the distances from this point to each of the foci is constant, and is equal to the main axis. This peculiar property makes it possible to trace an ellipse thanks to the so-called gardener method. Such an interesting property could hardly have escaped the practical mentality of Roman engineers and *agrimensori*, land surveyors.

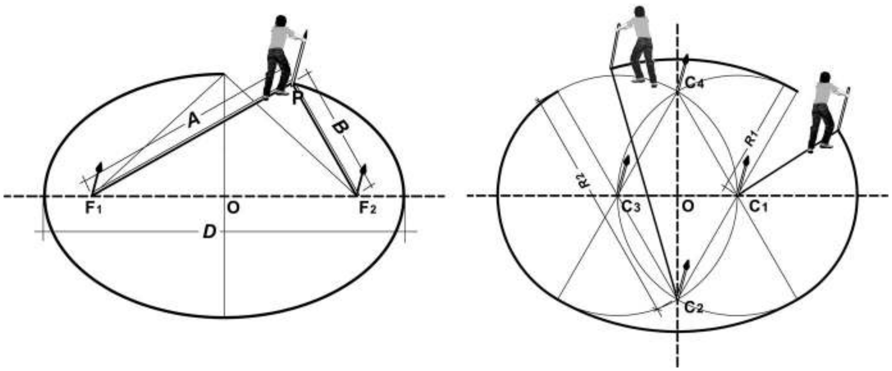

Fig. 2 The mathematical difference between an ellipse and an oval (Drawing: Sylvie Duvernoy)

The mathematical discussion about ellipse versus oval and their use in architecture is already present in Renaissance literature and underlies some later, important discoveries achieved in other fields of scientific research (see below).

Renaissance Textual and Graphic Sources

Renaissance architects' interest in oval shapes as a possible variation on the theme of the central plan is best evidenced in the sketches by Baldassare Peruzzi and in Sebastiano Serlio's treatise *L'Architettura*, where these geometric shapes are discussed at length. Both sources are related, in the sense that Serlio worked under Peruzzi's guidance in Rome from about 1514 until the Sack in 1527. Peruzzi is known for his studies on ancient architecture and Giorgio Vasari (1511–1574) says that he even planned to publish a book on the classical monuments of Rome (Vasari 1997). We may speculate that some of his studies were conducted together with Serlio, since Peruzzi bequeathed his drawings to his pupil, who most probably used them to prepare the illustrations for his own treatise (see below). These two literary sources mention no other classic reference for oval geometry than the Roman amphitheatre. It seems therefore that the study of this peculiar monumental typology was sufficient for the authors to establish morphological rules (Figs. 3, 4).

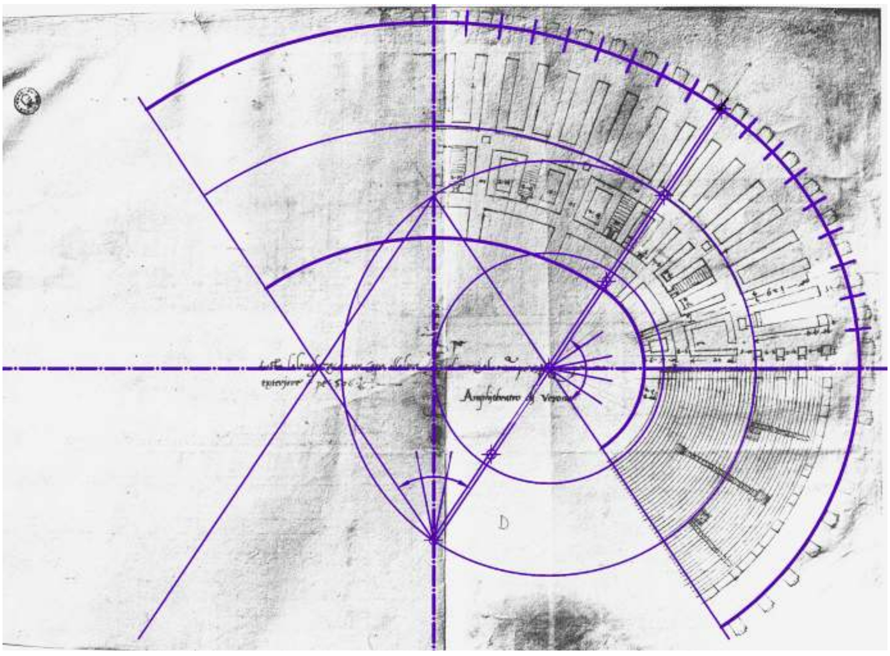

Fig. 3 Geometrical diagram overlaid on Baldassare Peruzzi's study of the Roman amphitheatre of Verona (Original drawing by Peruzzi: Biblioteca Comunale, MS, classe I, 217 v., Ferrara)

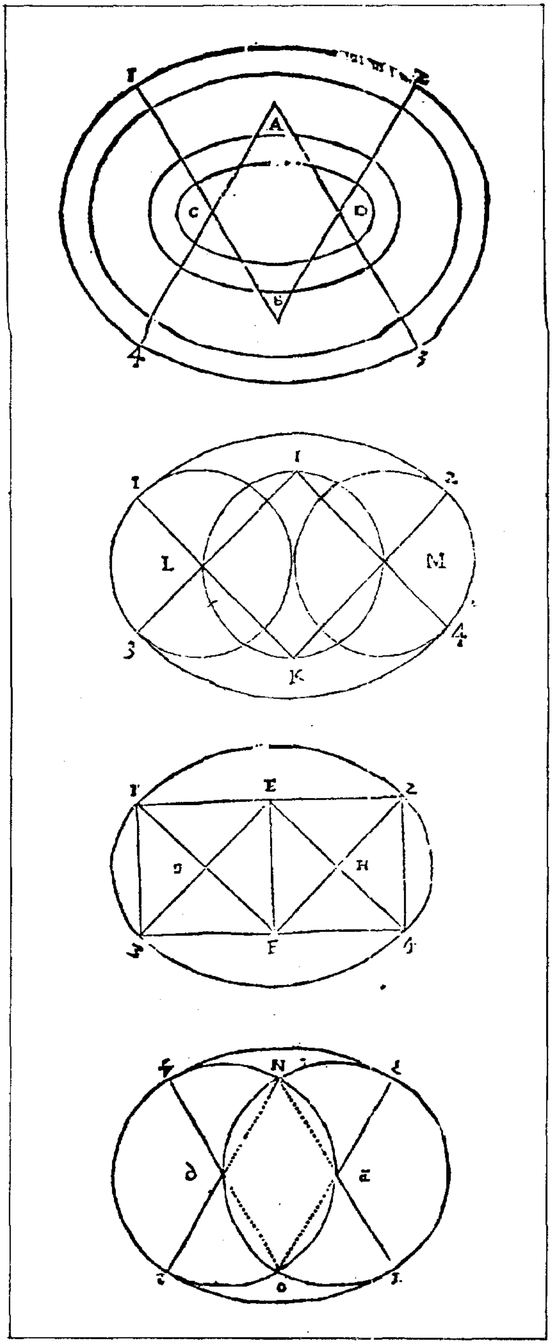

Fig. 4 Sebastiano Serlio, four diagrams for constructing oval curves (Drawing in *L'Architettura*, book I "De Geometria")

The original hand drawing of the Verona amphitheatre by Peruzzi is mostly interesting and makes it possible for us to understand the author's analysis of the oval pattern. On Peruzzi's sketch, the holes made by the needle of the compass are clearly visible, together with the diagram lines, giving us some clues about the investigation conclusions.

While designing an amphitheatre, Roman designers of the imperial period were faced with tricky computation problems which consisted in the division of the external perimeter of the building in a given number of regular intervals on which to arrange the regular arches of the monumental façade. The perimeter of an oval is the sum of the four arcs that compose the curve. In order to simplify the regular division of the whole perimeter, each arc needs to be divisible into a round number of intervals of a given span. The length of each arc is proportional to its angle α and its radius R according to the equation:

$$A = 2 \times \pi \times R \times \alpha/360.$$

Since the four arcs of a symmetrical oval are equal two by two, the computation only deals with two equations with four variables: two radii R1 and R2 and two angles, $\alpha 1$ and $\alpha 2$. Peruzzi's drawing shows that in Verona, each arc of the amphitheatre façade comprises 18 arches, for a total of 72 arches for the whole perimeter. The façade is thus regularly composed of four arcs of equal lengths. We hence have:

$$2 \times \pi \times R_1 \times \alpha_1/360 = 2 \times \pi \times R_2 \times \alpha_2/360$$
$$\text{with } \alpha 1 + \alpha 2 = 180^\circ$$

or more simply:

$$R_1 \times \alpha_1 = R_2 \times \alpha_2,$$

which means that:

$$R_1/R_2 = \alpha_2/\alpha_1.$$

It thus appears that in order to obtain a curve made of four arcs of equal length, it is necessary and sufficient that the proportional ratio of the angles that subtend the arcs should be the exact inverse of the proportional ratio of the two radii. In the case study of the Verona amphitheatre, according to Peruzzi:

$$R_1/R_2 = \alpha_2/\alpha_1 = 5/3$$
$$(\text{with } \alpha 1 + \alpha 2 = 180^\circ)$$

5/3 is a classical proportional ratio named *superbipartiens tertias*.

More generally, in order to divide the perimeter of a symmetrical oval in a given even number of intervals, the following equation must be true:

$$R_1 \times \alpha_1 = N \times R_2 \times \alpha_2,$$

(with $\alpha 1 + \alpha 2 = 180^\circ$, and where N is the ratio between the numbers of intervals on each arc).

Peruzzi and Serlio were surely aware of the many ways to fulfil this requirement arithmetically, since Serlio says in his treatise, "there are many ways to draw oval forms but I will give the rule for four of them". The four patterns that he lists can be divided in two categories: diagrams one and four where $\alpha1 = 60°$ and $\alpha2 = 120°$, and diagrams two and three which both belong to a special case where $\alpha1 = \alpha2 = 90°$.

Diagram one is a general rule: the centres of the oval are set on the vertices of two paired equilateral triangles, and many concentric curves—of varying proportion—are drawn from these centres.

In diagram two, the centres are set on the vertices of an inscribed rotated square, with $R1 = (1 + \sqrt{2})\ R2$. Therefore the proportional ratio between the lengths of the arcs is also equal to $(1 + \sqrt{2})$, and the proportional ratio of the symmetry axes is $\sqrt{2}$: the classical irrational diagonal proportion.

Diagrams three and four are particularly interesting because the radii of the four arcs that compose the oval curve are in a simple ratio of 1:2. Diagram three is a variation of diagram two, with $R1 = 2\ R2$, therefore the length of the bigger arcs is double than that of the smaller ones, and the proportional ratio of the symmetry axes is 4/3: the classical *sesquitertia* proportion.

Diagram four is a special case of the general rule shown in diagram one, such that: $\alpha1 = 1/2\ \alpha2$; $R1 = 2\ R2$; and the proportional ratio between axes is 4/3 (similar to diagram three).

The comparison between diagrams three and four is particularly interesting because it shows that it is possible to draw, from different centres, oval curves that are very similar to each other, since their axes and radii are in precisely the same proportional ratios. The 4/3 proportion is not a random one. While discussing the Roman amphitheatre in his treatise De Re Aedificatoria, and more precisely speaking about its central arena, Leon Battista Alberti (1406–1472) asserts that "some of our ancestors would make the width seven eighths of the length, and some three quarters" (Alberti 1988, p. 278).

It is quite surprising that Serlio does not mention at all the possibility of drawing ovals by positioning the centres on the vertices of four paired Pythagorean triangles. This particular layout—which seems to have had a great impact on the design of amphitheatres in Roman times, and especially some of the later ones, including the Colosseum itself—appears to have been completely "forgotten" by Serlio, who never refers to it. It must be pointed out that one more oval curve, with the axes in proportion 4/3, and the radii in proportion 1/2, can be drawn from centres located on Pythagorean triangles in exactly the same way as Serlio draws them in diagrams three and four.

Ellipses and ovals recur in almost every book of Serlio's treatise, but as far as religious architecture is concerned, the most interesting discussions and illustrations are found in Book One, *De Geometria* (On Geometry, Paris, 1545), Book Three, *De le Antiquità* (On Antiquities), and Book Five, *De Diverse Forme dei Templi Sacri* (On Temples, Paris, 1547).

In Book One, Serlio addresses some classical mathematical problems: the duplication of the square, the duplication of the circle, and other questions; these, however, never go beyond the realm of plane geometry. He also addresses the question of the drawing of special curves such as the oval and the ellipse. Still, the world "ellipse" is never mentioned. We are told about this particular curve "of lesser height than the half circle which really pleases the eye". Masons trace it with a rope, whereas architects draw it by points with the help of inscribed and circumscribing circles. This geometrical shape, he says, can be used while designing bridges, arches, or vaults of lesser height than a half-circle. It is interesting to note that the three examples of applications mentioned by Serlio all concern the design of elevations or sections; in his mind the ellipse does not seem to be related to the design of plans or horizontal surfaces.

Immediately after Serlio, oval diagrams were regularly discussed in treatises ranging from architecture to military engineering to stone cutting (Cataneo 1567; Lorini 1596; Galli-Bibiena 2011). The figures that illustrate the discussions are, however, very similar to Serlio's: the basic diagrams are still those of the inscribed double square and the inscribed double equilateral triangle. No further discussions are present and no additions are made. It thus seems that Serlio was both the first and to some extent the last to discuss new geometrical figures in Renaissance architectural literature.

First Studies and Projects for Non-Built Oval Churches

Peruzzi was among the first to try to design a church with an oval plan. The freehand drawing conserved in Florence shows a study of his for a building of presumably quite large dimensions with a central double oval ring of columns enclosing an interior space and surrounded by an annular peripheral aisle.

In Book Five of his treatise Serlio proposes a smaller oval temple with an empty central space, free of columns, enclosed by a thick wall containing six peripheral chapels. Serlio draws both the plan and the section of the building, showing how the church is to be covered with an oval dome. Peruzzi's influence on Serlio's project shows clearly in the details of the design, especially in the shape of the peripheral chapels. The two studies may eventually be considered as two variations of a same concept, for small or large temples (Figs. 5, 6).

Vignola designed two oval churches that were never built: one upon his arrival in Rome in 1550 and the other towards the end of his career. Unlike Peruzzi's and Serlio's studies, Vignola's projects were proposals for actual commissions. The first design was a project for San Giovanni dei Fiorentini, the second for the Church of the Gesù, both in Rome. The project for San Giovanni dei Fiorentini is mainly known from drawings present in the codex by Vincenzo Casale (?–1593) now held in the National Library of Madrid, and from the sketchbook by Oreste Vannocci Biringucci (1558–1585) kept in the Municipal Library of Siena. The project for the Gesù, the mother church of the Society of Jesus, was commissioned of Vignola by Cardinal Alessandro Farnese. Vignola first designed a church with an oval plan. The project was appreciated by the cardinal but nonetheless rejected in favour of a more traditional solution based on a rectangular diagram. We know that the cardinal and the Jesuits argued about the orientation and the shape of the church. In particular, the Jesuits wanted a nave covered by a flat wooden ceiling, while the cardinal wanted a vaulted nave. Discussions between the two parties surely led to the quick dismissal of an oval shape. A letter written by the cardinal Alessandro Farnese on August 26, 1568, addressed to Vignola, clearly states that the church should not cost more than 25 thousands *scudi,* that it has to be well proportioned in length, width, and height, following the rules of good architecture; it has to have a single nave with

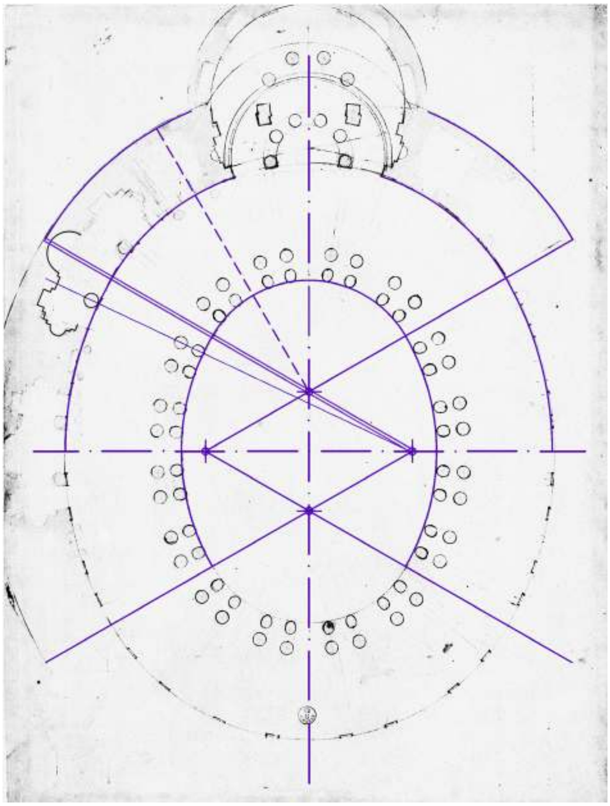

Fig. 5 Geometrical diagram overlaid on Baldassare Peruzzi's study for an oval church (Original drawing by Peruzzi: Museo degli Uffizi, Gabinetto dei Disegni e Stampe, Uffizi 4137A, Florence)

chapels on both sides but no aisles; it must face the square (today *Piazza del Gesù*) and be covered with a vault (Robertson 1992).[2]

The early studies by Peruzzi and Serlio, and the early projects by Vignola, show that in the mid XVIth century two main typologies for oval churches were being investigated. In the first typology the central space is enclosed by a ring of columns that supports the central dome, and, beyond the columns, an annular aisle dilates the architectural space. In the second typology, the empty oval central space is closed by a thick wall in which peripheral chapels are arranged and which supports the roof, presumably an oval dome. It is generally believed that the proposal by Vignola

[2] "…avendo voi l'occhio a la summa de la spesa che voglio far in tutta la fabbrica, cioè di 25 mila scudi, il dissegno de la Chiesa sia tale, che non excedendo la detta summa venghi ben proportionata ne le mesure di lunghezza, larghezza et altezza, secondo le regole buone de la architettura, e sia la chiesa non di tre navate, ma di una sola, con capelle da una banda et da l'altra. Il sito de la chiesa voglio in ogni modo che cada per diritto con la facciata dinnanzi verso la strada, et casa de Cesarini, et che si habbia da coprire di volta, et non altramente, se bene a questo fanno difficoltà per conto delle prediche…Pertanto servate queste cose che dico di sopra principalmente, cioè de la spesa, de la proportione, del sito, et de la volta, mi rimetto nel resto al giudizio et parer vostro…". Letter published in Clare Robertson, *Il Gran Cardinale-Alessandro Farnese, Patron of the Arts* (1992).

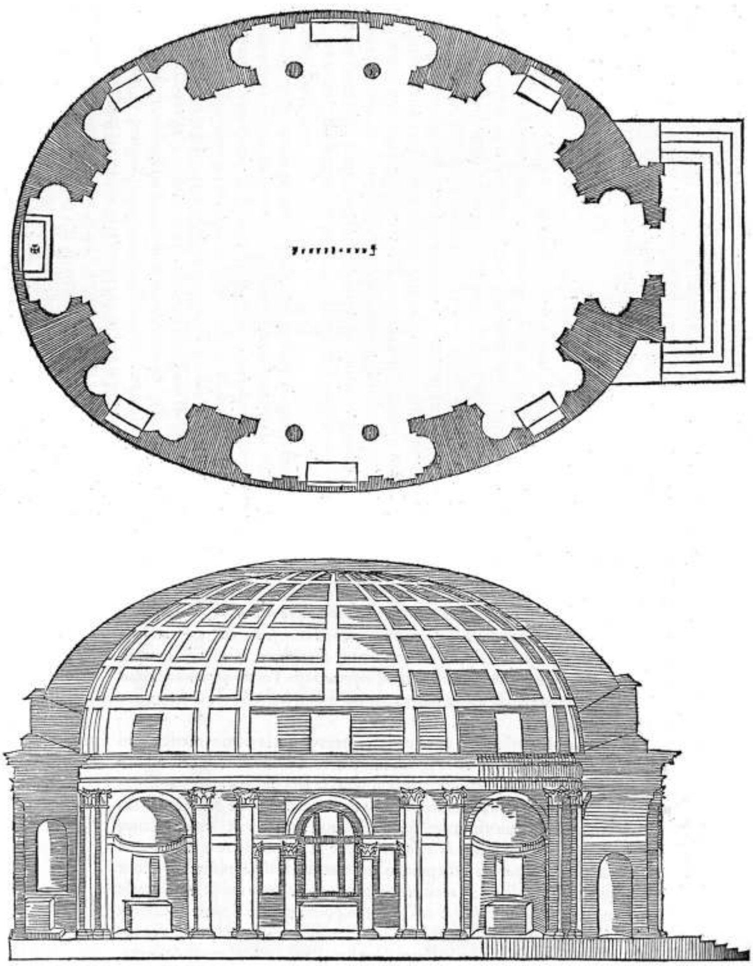

Fig. 6 Sebastiano Serlio, study for an oval church (Drawing in *L'Architettura*, book V "De Le Diverse Forme dei Templi Sacri")

for San Giovanni dei Fiorentini referred to the first typology while his original project for the church of the Gesù referred to the second one. (Tuttle et al. 2002, pp. 60–71, 247). The first typology can be seen as the elongated deformation of the ancient model, such as the temple of Bacchus, for use in round churches and baptisteries, which both Serlio and Palladio include in their treatises. The second type can be read as a derivation of the archetypal form represented by the Roman Pantheon, in which the circular diagram is elongated into an oval. The second pattern will turn out to be the successful one, and most oval churches will be designed as a variation of this type, not least because this kind of spatial organization makes it possible to host larger congregations of worshippers.

The Oval Churches of the Late Sixteenth Century and Early Seventeenth Century

The Renaissance studies of oval geometry for centrally planned churches finally came to fruition when Vignola designed and built the church of Santa Anna dei Palafrenieri for the confraternity of the papal *palafrenieri*, or "pontifical grooms". Located at the border between the Vatican City and the city of Rome, Santa Anna was the first oval church to be built in Rome. Vignola himself did not live long enough to see it completed: the building operations began in 1572 (a year before he died) and were directed by his son, Giacinto Barozzi, from 1573 on (Fig. 7).

The church is rather small: the length of the nave is just under sixteen metres; the width less than thirteen. Vignola's project emphasizes the plan's two axes of symmetry. The major axis connects the entrance door to the altar, and the minor axis connects two side chapels, shaped as wide and shallow niches. The oval liturgical space is inserted inside a rectangular building, and the somewhat triangular residual spaces in the corners between the oval and the rectangle are used as passageways from the church to other rooms used by the confraternity. As we will see below, this design solution will be echoed several times later on by architects influenced by this innovative church. Santa Anna dei Palafrenieri, with its new and elegant shape, spawned a new typology of religious architecture that would spread all over Europe in the two centuries that followed.

Many churches were constructed, enlarged or remodelled during the sixteenth and seventeenth centuries in Italy. This building effervescence is directly related to the number of new religious orders that were founded in the same period: nine important new orders were approved—in Italy alone—over the course of a single century. Some of these were very active in building their own new churches as they expanded in number and power.[3] This intense activity of church building prompted by the growth of many religious orders provided the necessary favourable context to encourage formal innovation in church design.

The second oval church built in Rome, San Giacomo degli Incurabili, was designed soon after 1590 by a disciple of Vignola, Francesco Capriani da Volterra (1535–1594). The church is part of the Hospital of San Giacomo degli Incurabili, the very hospital in which Camillo de Lellis was cured for war injuries and where a religious conversion led him to found the order of the Camillians, dedicated to curing the sick (see note 4). In 1579 Cardinal Anton Maria Salviati promoted the

[3] The Theatines founded in 1524 by Saint Gaetano dei Conti di Tiene and Giovan Pietro Carafa (the future Pope Paul IV); the Barnabites founded in 1530 by Saint Antonio Maria Zaccaria; the Society of Jesus founded in 1534 by Saint Ignatius of Loyola (approved in 1540); the Somaschi Fathers founded in 1540 by Saint Girolamo Emiliani; the Oratorians, founded by Saint Filippo Neri (approved in 1575); the Clerics Regular Minor, also called *Caracciolini* after their founder Saint Francesco Caracciolo of Naples (approved in 1588); the Clerks Regular Ministers to the Sick, called *Camillians* after their founder Saint Camillo de Lellis (approved in 1591); the congregation of the Clerks Regular of the Mother of God of Lucca, founded by Saint Giovanni Leonardi (approved in 1595); the Clerks Regular of the Pious Schools, known in Italian as the *Scolopi*, and in English as the *Piarists*, founded by Saint Giuseppe Calasanzio (approved in 1621). Some orders had their own architects. Andrea Pozzo and Orazio Grassi were Jesuits, Guarino Guarini and Francesco Grimaldi were Theatines, Lorenzo Binago, Giovanni Amgrogio mazenta were Barbabites.

Fig. 7 Jacopo Barozzi da Vignola, Santa Anna dei Palafrenieri, Rome 1575 (Photo: Sylvie Duvernoy)

renovation of the hospital, and in 1592 the construction of the new church started. It is a much larger church than Santa Anna dei Palafrenieri: the area of the central space is more than double, and it is surrounded by six deep chapels. Like Vignola, Francesco Capriani died before the end of the construction, and the church was completed by Carlo Maderno (1556–1629) (Fig. 8).

Other oval churches were then constructed outside Rome. Between 1609 and 1621 Giovan Battista Aleotti (1546–1636) built two oval churches almost simultaneously, the first, Santa Maria della Celletta, in his hometown of Argenta, near Ferrara, and the second, San Carlo, in the centre of Ferrara (Cavicchi et al. 2003). Santa Maria della Celletta is a freestanding building, a sanctuary dedicated to the Virgin Mary erected in the countryside, while San Carlo is an urban church, built for the confraternity of San Carlo Borromeo. Aleotti is mostly known for his works in hydraulic engineering and for his studies for the fortifications of Ferrara, but his designs for the two oval churches show that he was also involved in the artistic innovation of his time, if not as a form giver, at least as a designer closely in tune to the architectural research of his time (Fig. 9).

Fig. 8 Francesco Capriani da Volterra, San Giacomo degli Incurabili, Rome 1590 (Photo: Sylvie Duvernoy)

Other examples of early oval churches are found in Naples. Around 1626, Frà Giuseppe Nuvolo built the church of San Carlo all'Arena, thus starting the series of Neapolitan oval churches that were built in the city until the mid eighteenth century. An exhaustive inventory of the oval churches erected in Italy and outside during the seventeenth century is beyond the scope of this paper, which focuses on the study of the first samples of this new typology that had such a strong and long-lasting influence on Baroque architecture in all Europe.

In 1634 Francesco Borromini (1599–1667) started to design the famous church of San Carlo alle Quattro Fontane in Rome (also known as San Carlino because of its small size). The church, together with the whole monastic ensemble, was his first independent commission, which he received from the Spanish Trinitarians. The project site was on the Quirinal Hill at the intersection of the Strada Pia and the Strada Felice (today Via del Quirinale and Via delle Quattro Fontane), an urban

Fig. 9 Giovan Battista Aleotti, San Carlo, Ferrara 1621 (Photo: Sylvie Duvernoy)

intersection that was marked by the presence of four fountains at the four corners. As Joseph Connors explains, for this project Borromini "packed 'all he knew', to produce 'an extraordinary design, with nothing copied or borrowed from any architect, but founded on the antique and on the best architectural authors'" (Connors 1995) (Fig. 10).

The church is indeed innovative, even in the context of the intense architectural activity of the sixteenth and seventeenth centuries. In San Carlo alle Quattro Fontane the entrance, the symmetrical side chapels, and the main altar recess do not appear as additions external to the oval central space: they are part of it. In earlier oval churches the wall surrounding the nave followed a strict oval curve that was interrupted or opened where it intersected the geometrical axes in order to insert the side altars or chapels. Instead, Borromini designed a sinuous wall whose alternating concavities and convexities enclose both the nave and its niches. The oval pattern acts as a starting diagram that is then deliberately deformed to produce a more dynamic space. The upper architrave supported by sixteen columns is thus not oval in plan: it is alternatively straight and bowed. The building obviously pleased the commissioners. It is interesting to notice that a later church of another branch of the

Fig. 10 Francesco Borromini, San Carlo alle Quattro Fontane, Rome 1634 (Photo: Sylvie Duvernoy)

same Spanish Trinitarian Order, located in Rome along the Via Condotti, constructed between 1741 and 1746 by the Portuguese architect Emanuele Rodriguez dos Santos together with Giuseppe Sardi (1621–1699), was also laid out on the basis of an oval diagram. Borromini was asked for copies of his plans by several illustrious visitors who admired his work, but so far only one copy of San Carlo is known: the church of Santa Maria del Prato, close to Gubbio, in Umbria (Connors 1995).

Gianlorenzo Bernini's most famous church, Sant'Andrea al Quirinale, is only a short distance away from San Carlo along the Via del Quirinale. The church was commissioned of Bernini in 1658 by Cardinal Camillo Pamphili for the novitiate of the Society of Jesus. Sant'Andrea was the third Jesuit church built in Rome, after the "Santissimo Nome di Gesù" by Vignola and Sant'Ignazio by Orazio Grassi. While Vignola's initial oval design of 1565 for the Gesù had not been accepted, Bernini's oval project—designed almost a century later—was approved by the Society of Jesus, and built. In Sant'Andrea Bernini proposed a new kind of elongated centrality. The oval nave is oriented transversally to the entrance direction: the path from the door to the main altar follows the minor axis of the central space. This lack

Fig. 11 Gianlorenzo Bernini, Sant'Andrea al Quirinale, Rome 1658 (Photo: Sylvie Duvernoy)

of longitudinality—partly due to the shape of the allotted land—is balanced by the fact that the major transversal axis does not open on to side chapels but is "closed" by piers. The church had to have five altars, dedicated to five different Saints; it had to be connected to the novitiate, the sacristy, and had to be provided with confessional booths. Bernini thus designed an oval church with a total of ten surrounding niches and chapels. The central space can be read as an elongated decagon. The geometrical figure of the decagon is rarely adopted when double symmetry is required precisely because it cannot be divided into four equal quarters. Here Bernini takes advantage of this property in order to stress the visual perspective along the minor axis, blocking the elongation of the major axis. The central space is quite simple in shape and volume: it is covered by a large oval dome resting on the strong entablature supported by pilasters (Fig. 11).

Another church worth mentioning in this short list of oval examples is Santa Maria in Montesanto, the twin church of Santa Maria dei Miracoli, both of them built simultaneously by Carlo Rainaldi (1611–1691) between 1662 and 1679. The purpose of the construction of those two churches, flanking each other at the entrance of the Via del Corso, was to monumentalize the Piazza del Popolo, the northern entryway to the city of Rome. Viewed from the exterior, the two churches look similar, but while Santa Maria dei Miracoli has a circular plan, its twin sister Santa Maria in Montesanto is oval. This variation in geometry is a response to the different width of the two sites (Norberg-Schulz 2003). As a pair, though, the two buildings gracefully illustrate the concept of elongated centrality and the symbolic equivalence of circle and oval.

Architectural Features of Oval Churches

Although every church is unique in its layout, design, features, and decoration, all oval churches propose similar challenges to their designer, the most important of which are the choice of the geometrical pattern of the plan, the dome, and the façade.

The Plan

Each oval layout is characterized by the proportional ratio between the axes of symmetry of the curve (that is, the ratio of width to length) and the position of the centres of the paired arcs. An overview and comparison of some of the diagrams of the main churches of the seventeenth century show both the differences and the similarities between the layouts. No two churches are alike, but like variations on a single theme, they all refer to the same design principles.

Vignola seems to have drawn the plan of Santa Anna dei Palafrenieri on the basis of an oval constructed from four Pythagorean triangles.[4] The proportional ratio between width and length is 5/4, which generates a rather rounded shape for the central space. In contrast, the diagram chosen by Vignola's disciple, Francesco Capriani, for the design of San Giacomo degli Incurabili is an oval drawn from two paired equilateral triangles. The designer's intent is revealed thanks to a drawing dating to 1590 attributed to Capriani himself, which is kept today in the National Museum of Stockholm. The actual church differs in some details from this initial project but the drawing is correct as far as the proportions and the layout of the plan are concerned. Furthermore, it clearly shows the projection of the oval dome that covers the central space. This oval, drawn by the designer himself, belongs to the family of curves shown in Serlio's diagram one: the centres of the four arcs are located on the vertices of two paired equilateral triangles. If from these centres we draw the oval that Serlio describes in his fourth diagram (a special case of diagram one), we find that it falls precisely at mid-width of the perimeter wall. This coincidence suggests that this specific curve was the original starting pattern on which both the aesthetic and the structural designs were based. The rectangular side chapels are centred on the minor axis of the oval and the round chapels are centred on the diagonal axes that are the extensions of the sides of the central equilateral

[4] The analysis of the plan was carried out on the basis of the recent drawings by Francesca Billiani and Claudia Caratelli, published in Bruno Adorni, *Jacopo Barozzi da Vignola* (2008, p. 162).

triangles. The entire composition is symmetrical with respect to both the minor and major axes of the church (Figs. 12, 13).

It is possible to understand the pattern of the church of San Carlo in Ferrara thanks to another original sketch, a plan drawn by Giovan Battista Aleotti himself, kept in Ferrara's Biblioteca Ariostea, which clearly shows the geometry of the project. The oval pattern, whose centres lie on the vertices of two equilateral triangles, belongs to the family of curves shown in Serlio's first diagram, and therefore recalls San Giacomo degli Incurabili. The proportions of the church are nonetheless quite different. The limited width of the site led the architect to plan a quite elongated church, and two out of the four centres of the curve are outside the curve itself, in the outermost possible position, on the back wall of the chapels located on the minor axis of the building.

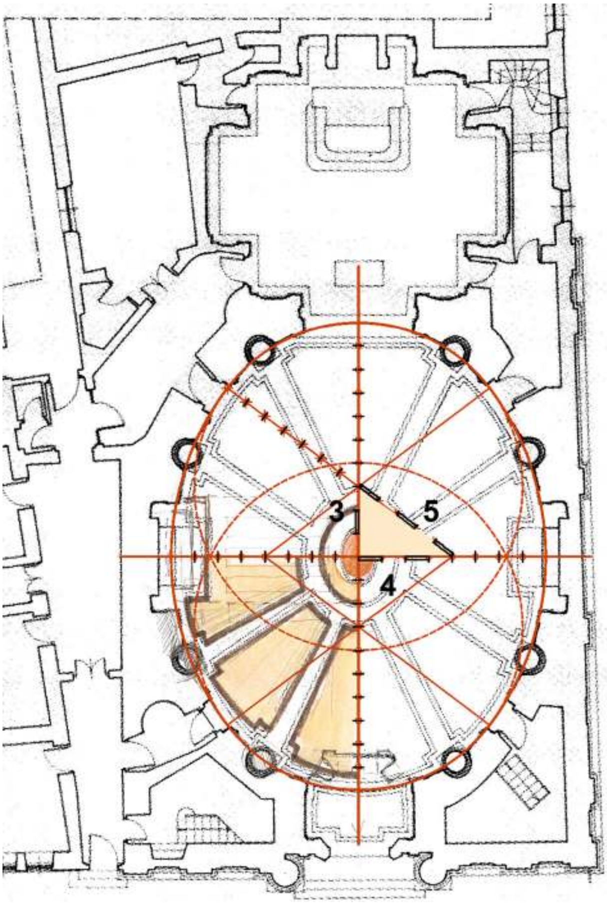

Fig. 12 Geometrical diagram and modular analysis of the plan of Santa Anna dei Palafrenieri by Jacopo Barozzi da Vignola, Rome 1575 (Measured survey and original drawing: Francesca Billiani and Claudia Caratelli in Adorni B., *Jacopo Barozzi da Vignola*, Skira, Milano 2008,162)

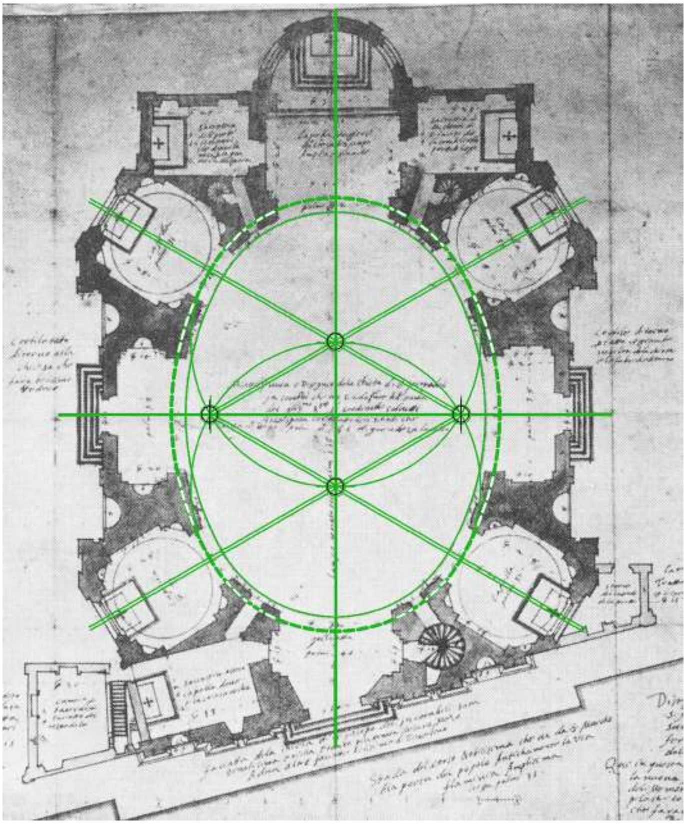

Fig. 13 Geometrical diagram of the plan of San Giacomo degli Incurabili by Francesco Capriani da Volterra, Rome 1590, from a drawing kept in the Stockholm National Museum, inv. CC 2071

The surviving drawings by Francesco Borromini unveiling the geometrical underpinnings of the project of San Carlo alle Quattro Fontane were all redone by Borromini himself after 1660, when the construction of the church body was completed. The drawings show an oval curve, most probably the projection of the dome above the nave, drawn from four centres located on the vertices of two equilateral triangles. The curve is tangent to (and partly formed by) two adjacent circles that are in turn inscribed in two larger paired equilateral triangles. This means that, like San Carlo in Ferrara, two of the centres are outside the curve itself, but inside the church. The axes connecting the centres of curvature determine the position and orientation of the peripheral chapels and passageways to other rooms. The vertices of the two big triangles mark the depths of the side niches on the minor axis, and the overall distance between entrance and main altar recess on the major axis (Fig. 14).

The geometrical pattern of Sant'Andrea al Quirinale is not so straightforward. Two surviving original drawings, kept in Rome, show the plan of the church at an early and at a late design phase. Neither of the two drawings bears evidence of the

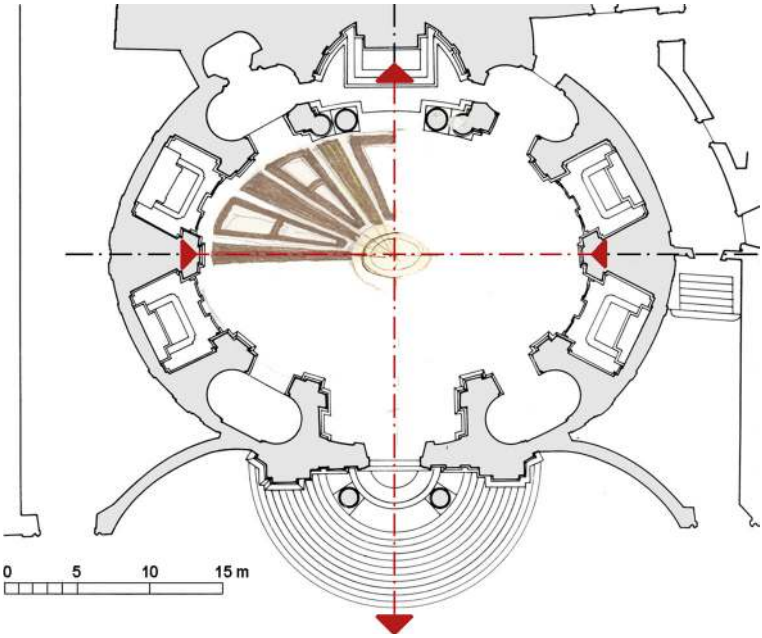

Fig. 14 Gianlorenzo Bernini, Sant'Andrea al Quirinale, Rome 1658 (Drawing: Sylvie Duvernoy)

pattern that governs the geometrical order of the plan. Attempts at unveiling the pattern have already been made, but so far the results mostly testify to the difficulties of such an investigation (Smyth-Pinney 1989).

Sant'Andrea is often shown as a unique example of an oval church whose main axis is parallel to the street, with entrance on the minor axis. However both San Celso and Giuliano built by Carlo De Dominicis in 1735 under pope Clement XII, and the church of the "Santissimo Nome di Maria" built in Rome by the French Antoine Dérizet in 1736, have a similar layout.

The comparison of the various geometrical patterns of the early oval churches highlights the diversity of all the projects. The analysis of the various diagrams also calls attention to the relationship between written texts (architectural treatises) and actual monuments (built architecture), in other words between theory and contemporary practice. While there are many oval churches, Serlio is the main Renaissance textual reference on oval geometry, and so it was in the first half of the seventeenth century. It seems clear that Serlio's colleagues did not take his book as a reference manual of ready-made solutions, but rather drew inspiration from the architectural research that he helped to initiate, and that he was the first one to put down in writing. Since Serlio's book anticipated the burst of oval design, the evolution of the architectural research itself shows the limits (and incompleteness) of his words and illustrations. The oval curves having centres on the vertices of a square (Serlio's diagrams two and three) seem to have rarely been applied in actual practice. On the other hand, the ancient "Pythagorean" diagram (in which the centres lay on the vertices of two pairs of "3-4-5" triangles) was used on occasion, though it is not listed by Serlio. The most popular pattern, however, seems to have been the oval whose centres are on the vertices of two equilateral triangles. The reason for such success surely derives from the arithmetical convenience. In classical antiquity, the concept of beauty in mathematics was related to the achievement of perfect harmony between geometry and arithmetic. Vitruvius used to recommend the research of perfect *symmetry*, a quality intended as an arithmetical property of modularity and commensurability of all the dimensions of the building, expressed in natural integers. In the "Pythagorean" oval diagram, the angles subtending the four arcs are not expressible in round numbers, even though the basic triangle itself is perfectly commensurable. Similarly, the "square diagrams" may involve the irrational quantity of the square root of two. Serlio's fourth diagram, with its simple ratios of 1:2 and 2:1 for the arcs and angles, is indeed likely to become the favourite. Later architects gave it the name of *ovato tondo* (rounded oval) (Galli-Bibiena 2011, note 10). The lines connecting the centres of the arcs can be used as diagonal axes on which to align peripheral chapels in a more regular way than with other patterns. This possibility had already been noticed by Peruzzi and Serlio in their studies, though it was not applied by Vignola in Santa Anna dei Palafrenieri. The figure of the two circles circumscribing the two equilateral triangles is furthermore very familiar to any mathematician, or any architect, who studied the basics of mathematics using Euclid as a guide, since it contains and develops the first illustration of the first proposition of the first book of the *Elements* explaining "how to draw an equilateral triangle."

The Dome

Assuming that the Roman amphitheatre, an open-air structure, provided the inspiration for Renaissance oval churches, the architects of the sixteenth and seventeenth centuries had to devise a way to cover their churches. The answer was indisputable: oval churches are covered with oval domes. Serlio himself shows the way. In his proposal for an oval temple, the longitudinal section of the temple vault is oval in shape, and corresponds to half the curve of the ground plan. Consequently, the oval dome covers the whole nave, enhancing the centrality of the space. As Santiago Huerta explains:

The geometry of an oval dome is much more complex than that of the usual dome with a central vertical axis of symmetry… the architect would have to think first in a general way of parameters which define the overall form of the intrados of the dome: the relationship between the two axes of the oval plan, the relation between the height and the span, and the profile of the dome. All these parameters must have a certain relation with one another (Huerta 2007) (Fig. 15).

On the drawings resulting from the measured survey of Vignola's first oval dome, built for Sant'Andrea in Via Flaminia, we can see that the cross section on the minor axis is semi circular (Adorni 2008, pp. 68–69]. The height thus corresponds to half the minor axis, the most straightforward option. This kind of oval dome perfectly illustrates the concept of the "elongated centrality:" its form results from the stretching of the hemisphere along the main axis. The intrados of Sant'Andrea's dome is smooth. Complications occur when windows must be opened in the dome to bring sunlight inside the building. In Sant'Andrea, a freestanding building, the windows are located below the dome, in the vertical and rectilinear walls, but in Santa Anna, where natural light could only come from above, Vignola had to design another structure. The dome has eight ribs, each one resting on one of the eight columns that support the oval architrave. Between the ribs, seven windows (of different widths) are inserted (Figs. 16, 17).

In San Giacomo degli Incurabili, the dome rests on a drum that is broken at both ends of the long axis (that is, at the entrance and towards the main altar) by tall arches that reach up into the zone of the vaulting, so as to stress the longitudinal axis. Here too, six windows are inserted in the dome; however the structural ribs are not highlighted and the intrados is fully decorated with paintings.

In San Carlo alle Quattro Fontane, the dome does not rest directly on the peripheral entablature; it is further elevated and rests on pendentives that connect it with the vaults covering the entrance, the sides, and the main altar. A lantern tops the dome, the open sides of which allow light to flood in.

The oldest description of the geometry of oval domes is contained in the *Tratado de Arquitectura* (Treatise of Architecture), written around 1580 by the Spanish architect Alonso de Vandelvira (1544–1626). This first Spanish scientific theorization testifies to the intense cultural and scientific exchanges between Italy and Spain in the late sixteenth century and early seventeenth century. In fact, the construction of the oval church of the Convent of Las Bernardas in Alcalá de Henares (Madrid), designed by Sebastian de la Plaza, began in 1617, a few years before Borromini designed San Carlo alle Quattro Fontane for the Spanish Trinitarians. Later on, around 1650, Diego Martinez Ponce de Urrane built the oval church of the Virgen de los Desamparados in Valencia. Two important oval domes had already been constructed in Spain by then: the dome above the crossing of the cathedral of Cordoba and the dome of the Sala Capitular of the Cathedral of Seville, both in the second half of the sixteenth century (Baldrich 1996). Also, the oval Oratory of San Filippo Neri was built in Cadiz by the architect Blas Diaz at the end of the

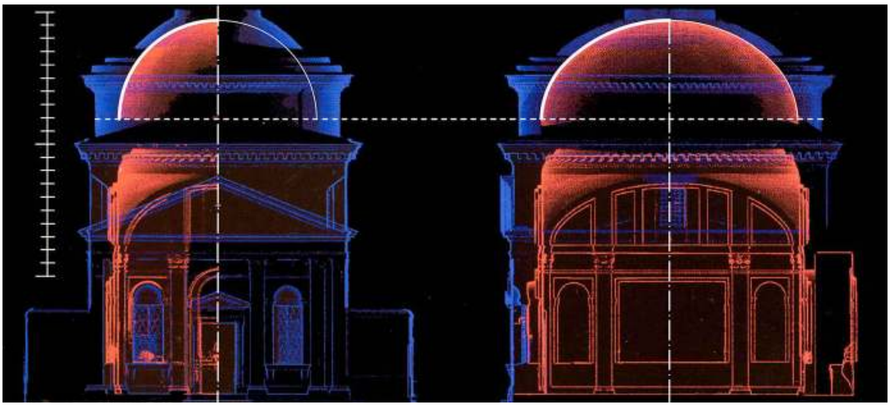

Fig. 15 Jacopo Barozzi da Vignola, Sant'Andrea in via Flaminia, Rome 1550–51 (Measured survey and drawing: Lorenzo Pio and Massimo Martino in Adorni 2008, pp. 68–69)

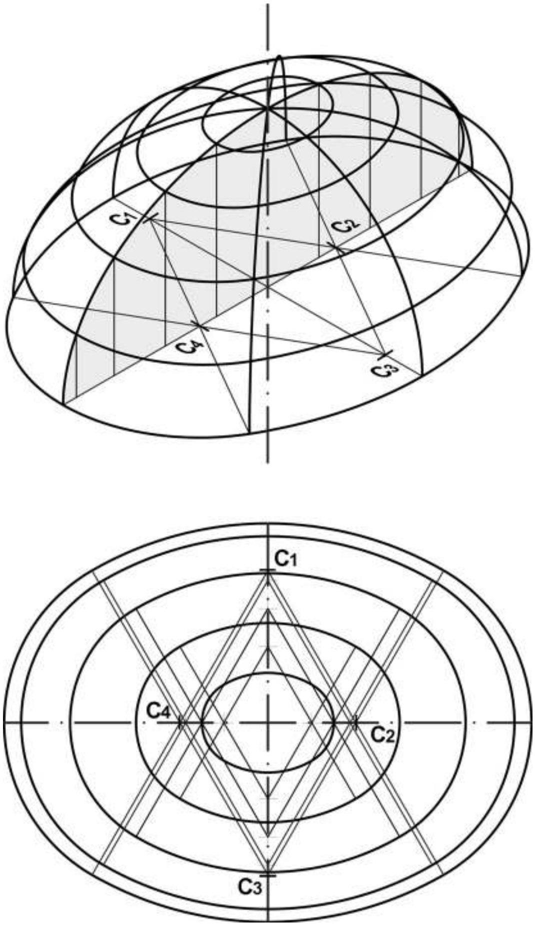

Fig. 16 Geometrical properties of an oval dome (Drawing: Sylvie Duvernoy)

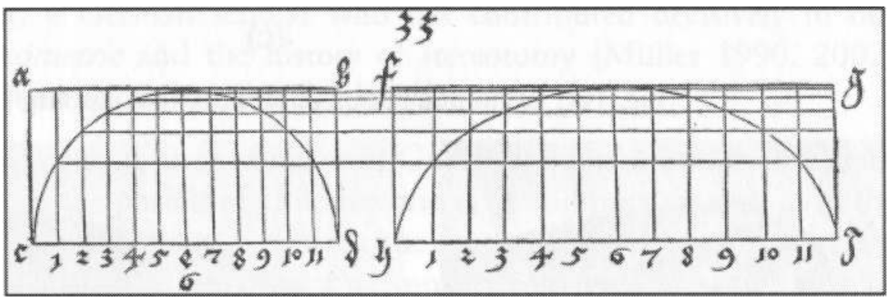

Fig. 17 Albrecht Dürer, the elongation of the semi circle into a semi ellipse (Drawing in Dürer 1525)

seventeenth century, in roughly the same years in which Mattia de Rossi (1637–1695, a disciple of Bernini's) was building the church of Santa Maria dell'Assunta in Valmontone, near Rome.

Vandelvira discusses six different kinds of oval domes in his treatise. The theoretical—and practical—problem was to define the geometry of the "meridian" and "parallel" ribs of the domes. When the cross section of the dome is a semicircle and the longitudinal section is an oval (Vandelvira's case study three), or when the longitudinal section is a semicircle and the cross section is an oval (case study four), what is the shape of a meridian rib? Vandelvira drew the curves point by point with the help of the combined orthogonal projections.

The question of the geometrical shape of the dome's ribs brings us back to the question of the mathematical difference between the ellipse and the oval. Many Italian oval domes have semi-circular cross sections. If the longitudinal section of the dome is a semi-oval, in order to match the geometry of the plan, then the dome intrados is a surface of revolution around the major axis. Any cross section is thus a semicircle, "and by placing semi-circular transverse centring the dome may be easily built by successive rings, until it is closed" (Huerta 2007).

But if the longitudinal section is drawn as an "elongated" semicircle as prescribed by the traditional method explained both by Leonardo da Vinci (c. 1510, fol. 318) and Albrecht Dürer (1471–1528) (Dürer 1525), the resulting curve is an ellipse, and any meridian rib of such a dome is elliptic. Conversely, its parallel ribs (that is, the horizontal sections) are ovals of the same nature as the pattern of the plan, but they are not concentric: the quadrilateral formed by the centres shrinks regularly with the curve itself, as the section reaches to the top of the dome.

Solid geometry raises mathematical problems that were solved graphically and empirically by architects and builders before being theorized by mathematicians in the seventeenth century. It was the Swiss mathematician Paul Guldin (1577–1643) in 1640 who discovered the elliptic nature of the elongated semicircle. The combination of oval sections in plan and vertical elliptic sections in the same volume clarifies why the mathematical indistinctness between ellipse and oval is so persistent in architectural literature, from Serlio on.

The largest oval dome in Italy covers the sanctuary of Vicoforte di Mondovì (near Cuneo), the construction of which began in 1596, soon after San Giacomo degli Incurabili, under the direction of Ascanio Vitozzi da Orvieto (1539–1615), another disciple of Vignola's. The commissioner was Duke Carlo Emanuele I of Savoy, who specified that the sanctuary should also be the funerary church of the house of Savoy. Because of difficulties regarding structural stability, construction was interrupted 4 years after it had begun, when the construction had risen up to the level of the impost of the supporting arches. The dome and its lantern were completed only in 1733, thanks to the architect Francesco Gallo (1672–1750).

The Façade

Many oval city churches are totally enclosed inside larger blocks that also comprise either a monastery or a hospital (like San Giacomo degli Incurabili). Others are squeezed between buildings on either side within a dense historical urban fabric. However, there are cases in which the church is located on a street corner, or is freestanding. To be sure, designing a façade for an oval volume was a difficult challenge for Renaissance architects. The model of San Pietro in Montorio was too classical a reference to be useful for solving this kind of innovative problem. Nor could inspiration come from the model of the façade of the Roman amphitheatre, which was both too monumental and too uniform, in the sense that it did not stress the entrances to the monument in any way, not even the four main gates located on the symmetry axes of the building. A church, the house of God, requires a monumental façade that frames the entrance door. In the compromise between centrality and linearity expressed by the oval geometry, the inner space and its dome enhance the centrality, while the front façade emphasizes the linearity: the path towards the altar. In the Renaissance, the design of the façade represented a special chapter in the whole process of church design, quite separate from the design of the interior space. Like dessert after the main course, the project for the façade was often approached and solved autonomously in a late design phase. In some cases, final decisions about the façade had not yet been made by the end of the construction of the building, and furthermore, funding for this last operation was sometimes lacking, so that there are many famous examples of churches that lack their stone or marble façade veneer.[5] There are also many examples of church façades realized by a second designer, after the first architect had passed away before the completion of the construction.

How to design a façade on a convex wall was a new problem that had no easy solution. In the case of Santa Anna dei Palafrenieri, the problem was solved (or perhaps eliminated) by Vignola by inserting the oval church inside a rectangular box, and since the church is located at the intersection of two streets, he thus created two street façades: a front and a side meeting at right angles. The front is actually in the Vatican City, and the side is along a street in the city of Rome. The volume of the edifice as a whole has no relation to the shape of the interior liturgical space. As Wolfgang Lotz explains:

The two fronts—they are, after all, the sides of a rectangle—have, in spite of the difference of length, five bays each. The disposition of these bays differs as much as that in the interior. Thus in this centrally planned building, not only is the interior unrelated to the exterior, but the system of the main façade is also unrelated to that of the side façade (Lotz 1995, p. 120).

The shape of the dome alone, which is visible above the main body and clearly does not have a circular base, suggests the existence of an elongated space beneath, but at eye level, no innovation in the exterior aspect and façade design matches the innovative form of the central space (Figs. 18, 19).

The urban context of San Carlo alle Quattro Fontane is somewhat similar to Santa Anna. The whole Trinitarian monastery to which the church belongs stands on a street corner. However the church itself only faces the Via del Quirinale, since Borromini located the oval nave between the cloister and other liturgical spaces. A long and narrow sacristy, followed by a thin corridor, is aligned along the Via delle Quattro Fontane, thus orienting the church towards a unique and precise direction heading to the Via del Quirinale. Consequently, the church has a single narrow front, which stands beside and beyond the corner fountain. However, the relation

[5] Among others: San Lorenzo in Florence, the Medici family church; Santo Spirito in Florence, remodelled by Filippo Brunelleschi, Santa Maria del Carmine in Florence, etc.

Fig. 18 Jacopo Barozzi da Vignola, Santa Anna dei Palafrenieri, Rome 1575 (Photo: Sylvie Duvernoy)

between the church nave and its front façade is quite different here with respect to Santa Anna dei Palafrenieri. Architects of the mid-seventeenth century were no longer pioneering a new typology and thus they could refer to the initial experiments and realizations to propose new solutions. More than 80 years of research in oval design allowed Francesco Borromini to express his personal talent fully by designing a curved street front, whose flowing lines echo and extend the sinuosity of the interior walls. It is the inner volume of the oval nave itself (lacking any intermediate entrance space) that pushes the façade wall out on the street, and shapes its peculiar undulation. When Borromini died, the façade had risen up to the cornice of the first level. The second level was completed by his nephew, Bernardo Borromini (Figs. 20, 21).

Although in a different way, the façade of Sant'Andrea al Quirinale is also a play of curves and counter-curves. Sant'Andrea is almost a freestanding building. The volume of the church is only partly enclosed in the Jesuit novitiate buildings, so that the outside wall of the masonry shell is visible along three-quarters of its perimeter, making evident its convex oval shape. In order to design a solemn entrance to the church Bernini transformed the awkward convex shape into a concave curve. Semi-circular steps, covered by a semi-circular porch, lead from the street to the main door, and the convex protrusion of the porch itself is framed and enclosed by two symmetrical, curved, concave walls, extending sideways. The outline of the curved walls and the urban space that they shape, ideally containing an entrance parvis, evoke the oval nave that is to be found beyond the church door. The façade design is

Fig. 19 Francesco Capriani da Volterra, San Giacomo degli Incurabili, Rome 1590 (Photo: Sylvie Duvernoy)

dated to 1669, some 10 years after the design of the church itself, and the entrance ensemble was built after 1676 (Frommel 1983, p. 227). To a certain extent this urban arrangement may be seen as a small-scale imitation of his own design for the monumental Piazza San Pietro, in Rome.

Oval, Ellipse, and Cosmos

The sixteenth-century rebirth of oval patterns and their application to sacred architecture has often been cast in parallel with the progress of scientific knowledge in astronomy and the new discoveries about the planetary motion reported by Johannes Kepler (1571–1630) in his book *Astronomia Nova* (New Astronomy,

Fig. 20 Francesco Borromini, San Carlo alle Quattro Fontane, Rome 1634 (Photo: Sylvie Duvernoy)

1609 - Kepler 1992).[6] However, historical chronology shows that Kepler was not even born at the time when Vignola designed Sant'Andrea in Via Flaminia around 1550, and was an infant when the later Santa Anna dei Palafrenieri was designed in 1572. In his revolutionary treatise Kepler states that the path of the planets orbiting around the sun is elliptic and that the Sun is located at one focus. The irregularities noticed in the movement of Mars led contemporary scientists to inquire into the reasons for this apparent disorder in the cosmos, but it took Kepler years of hard work before reaching the final discovery. For our purposes, it is mostly interesting to note that he first tried calculations based on oval models before stating that the ellipse was the true shape described by the motion of Mars. The oval, visually similar to the ellipse, is after all a multiplicity of circles and the structure of the universe that he himself had described in his previous book *Mysterium Cosmographicum* (The Cosmographic Mystery, 1597) was formed by multiple concentric spheres.

Kepler came to the conclusion that the orbit must be some kind of oval, rather than a perfect circle… The task of determining exactly which oval was appropriate

[6] In English, the full title of his work is *New Astronomy, Based upon Causes, or Celestial Physics, Treated by Means of Commentaries on the Motions of the Star Mars, from the Observations of Tycho Brahe*. See the new English edition, Johannes Kepler, *New Astronomy* (1992).

Fig. 21 Gianlorenzo Bernini, Sant'Andrea al Quirinale, Rome 1658 (Photo: Sylvie Duvernoy)

and how to generate it was a torturously complex process that took all of 1604. Kepler wrote to Longomontanus that he had tried in twenty different ways. Eventually he resorted to using an ellipse as an approximation of a likely oval orbit (Voelkel 1999).

At the turn of the sixteenth century the figure of the circle still represented divine perfection and its multiplication in concentric and/or eccentric diagrams was ideally suitable both for sacred architecture and astronomical models. Therefore, while the newly discovered elliptic geometry of the planetary motion cannot have provided the origin of the new type of oval churches, it may have led to the continuity and persistence of this geometrical pattern in church design during the following centuries.

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