

Technicians and Master Builders for the Dome of St. Peter's in Vatican in the Eighteenth Century: The Contribution of Nicola Zabaglia (1664-1750)

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ABSTRACT: The works of Nicola Zabaglia, master mason of St. Peter's Fabbrica, may be considered an influential model of cohesion among architecture, building yard and applied mechanics. Zabaglia's work represents a basic milestone for the development of Roman building technology, as proved by his being deeply involved in the works for hooping of the St. Peter's dome, directed by Luigi Vanvitelli between 1743 and 1744. Nevertheless, the role of Nicola Zabaglia has remained not well known even today. Thanks to the information also provided by unpublished documents, this contribution highlights the working procedures, phases, technologies and organisational models adopted by Zabaglia and Vanvitelli for the restoration works of the Cupola. These works represent one of the most extraordinary examples of the capability achieved by the technicians of St. Peter's Fabbrica in the middle of the 18th century.

Between the Seventeenth and Eighteenth century the co-penetration between science and technology, and the new esteem assigned to technical knowledge translate into a lively dialogue between mathematics and mechanics. Mechanics correspondingly gained in dignity as a discipline: a presupposition for the scientific revolution of the 18th century, conceived as a radical and irreversible re-ordering of knowledge. There exists, however, an evident imbalance between ancient traditions and modern scientific practice, powerful enough to subvert the very concept of "revolution", as least as regards building mechanics (Shapin 1996). The latter long remained extraneous to mechanistic and experimental philosophy, nor was it informed by anything that could be assimilated to a "scientific method", i.e. a coherent, universal and effective sum of cognitive principles and procedures. Though this new theory of machines was increasingly known and appreciated, the attempt to mechanise cognitive processes through the formulation of certain prescriptive rules thus found no place in building sites. Here a consolidated empiricism, heir of imperial Roman technology and of the great building enterprises, renewed by the experience of Renaissance and Baroque greatest architects still continued to hold sway. This pragmatism rejected the reduction of natural phenomena to mathematical formulae and was exclusively based on the empirical knowledge handed down by experience and by the authority of the ancients: a body of knowledge perfected by centuries of application and by the gradual improvement of machinery and equipment for construction by technical experts. Among these is Nicola Zabaglia (1664-1750), who owes his success to the numerous scaffolds built during his long career and to the many restoration works in St. Peter's Basilica. The scaffoldings designed by Zabaglia share a constant care for the conservation of wall surfaces, the safety of workers and the reuse of materials; they represent such a remarkable progress in comparison with the usual building mechanical devices that they will be used without interruption up to the first half of the 20th century and abandoned only following the widespread introduction of modern metal scaffoldings. Zabaglia's devices, emblems of a knowledge based on the intuitive and pragmatic side of the human mind, are designed for the ordinary and extraordinary maintenance of St. Peter's, whose colossal size hinders even dusting. Therefore, they are not simple machines, but rather extraordinary temporary scaffoldings, designed to support at the dizzy heights of the basilica workers, equipment, materials and machines necessary for restoration works, for mosaic and painting decoration, for installation of statues, as well as for placing the iron hoops in the dome.

Zabaglia joined St. Peter's Fabbrica as a labourer in 1678 (Corbo 1999; Milizia 1999; Marino ed. 2008); in 1691 he figures among the seven labourers working for the architects Mattia De Rossi (1637-1695) and Carlo Fontana (1634-1714). During his career Zabaglia successfully completes several technical undertakings, characterised by the use of scaffolds composed of simple wooden elements that could be controlled by means of

a network of ropes driven by hoists operated by men and animals. Thanks to his incredible intuition and with apparent ease, Zabaglia brings to perfection these devices, improving their components, simplifying their warp and turning them into movable devices, that can be quickly placed where they are needed. Consequently, St. Peter's Fabbrica, the papal institution in charge of the financial and technical administration of the Basilica's building yard, can considerably reduce execution cost and time; moreover, downtime is also shortened, as it is no longer necessary to dismantle and reassemble all the components (Author 2004). Thus, timberings, scaffolds and machines become more effective, and even complex interventions can be carried out in a short time and saving lots of materials, as well as ensuring the successful completion of the work. Indeed, we owe to Zabaglia the improvement in the technique of struck joints for assembling considerably large scaffolds and machines.

Zabaglia's career begins in 1695-1696, when he accomplishes the transport of the porphyry stone for Ottone II's tomb from the foundry to the Chapel of the Blessed Sacrament. To this end, Zabaglia employs metal levers, hoists and tackles whose dimensions are proportional to the huge weight to be lifted. The success of the enterprise wins him the assignment of other important jobs, such in 1737 as the transfer of the 7.37-metre high and 2.24-metre wide Domenichino's fresco representing St. Sebastian's martyrdom to the Mosaic Studio (AFSP, 27, E, 431, f.22v); the construction of the magnificent scaffold, "touching neither the floor nor the walls", that was used to restore the friezes in the vault of the tribune in the church of St. Paul within the walls (1735); the improvement of the pole crane that was used to set up the statues on the sides of the colonnade in the square (1703); as well as several other transports of statues, huge tombstones and dedicatory monoliths. However, his undisputed masterpieces are the scaffold to restore the friezes in the great dome of St. Peter's and the one built for the restoration of the stucco works, made by Giuseppe Lironi between 1731 and 1734, in the nave. In the same year Zabaglia supervises the transport of the Sallustian obelisk (62.25-span, that is about 14-metre high) from Villa Ludovisi to S. Giovanni in Laterano square. According to an unsatisfied wish of Pope Clemente XII Corsini (1730-1740), the obelisk should have risen in front of the basilica façade (D'Onofrio 1992; Felici 1952). The scaffolds invented by Zabaglia consist of two broad groups: the scaffolds designed to assist in their work painters, stucco and mosaic decorators, as well as masons, carpenters and stone-cutters, and the ones aimed to support more complex jobs, often carried out also outside the Vatican. Scaffolds can be divided in ground and suspension framework. Ground scaffolds, based on principles of simplicity, reversibility and strength, should be solid enough to support the stress produced by lifting materials; therefore, they are anchored to short chestnut beams embedded right in the wall structure and blocked in their slots by wooden wedges. The multi-storey scaffold built by Zabaglia in 1735 belongs to this type, though improved in some of its components; it was used in the tribune of the church of St. Paul within the walls for the restoration of the vault (Zabaglia 1743, pl. XX). It stands out for Zabaglia's mastery in reaching the height of the tribune up to the cornice "by means of large trestles", surmounted by several tiers up to the top of the vault (AFSP, 12, D, 4b, 29, f.1030).

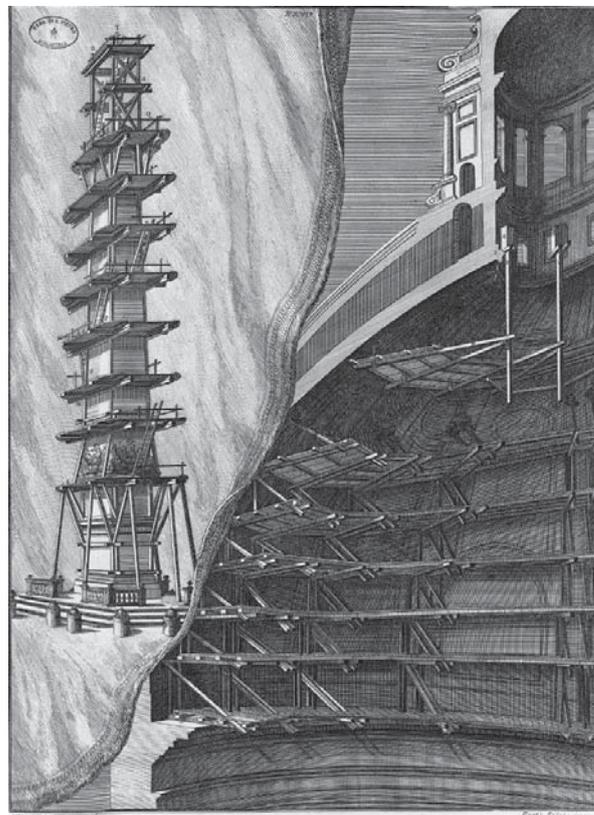


Figure 1: Zabaglia's scaffolds for the restoration works of the Vatican Obelisk and St. Peter's Dome in the Eighteenth century; (from *Castelli e Ponti* 1824, pl. XXVI)

Among the so-called suspension scaffolds is the big planking erected by Zabaglia for the restoration of the mosaic friezes in the main dome that was acrobatically laid down on the cornice up to the point allowed by the curvature of the dome. Such complex though not invasive scaffolding was designed with the utmost respect for the structure of the dome. Safety, respect for the structure, simplicity and reversible assembly are confirmed as the guidelines for Zabaglia's inventions; he, as a real engineer, once established some chief ideas, can apply them in any given case. Thanks to the crucial improvements made by Zabaglia, flexible use and adaptability to various contexts become the main features of scaffolds and timberings, that are characterised by versatility, convenience, safety and economy. In order to assist his precious talent as a "mechanic", Zabaglia is relieved of the daily tasks assigned to the other workers in the Fabbrica and is granted the use of a studio where he can test the mechanical prototypes he invents by making working scale models (AFSP, 12, D, 4b, 29, f. 974v). His inventions put the empiricism of the building technology in competition with the advances in theoretical research, and thus call for being sanctioned by publishing. This occurs in 1743, when a book entitled *Castelli e Ponti di Maestro Nicola Zabaglia* is published under the patronage of high Vatican officials, Ludovico Sergardi (1660-1726) and Lelio Cosatti (1677-1748); they intend to show to the entire world the talent of the technicians in St. Peter's Fabbrica and the leading role of the Fabbrica for the Roman building industry. The book collects 55 plates depicting Zabaglia's inventions, as well as tools and devices of everyday use (Author 2008a; Author 2008b; Author, in press). It represents a real compendium of know-how, which rehabilitates the old pragmatism over the new and pressing scientific progress (Zabaglia 1743; Zabaglia 1824).

This refined publication, unusual in its genre and definitely innovative even for the Vatican editorial tradition, proves as a very effective media operation, cleverly aiming at stating the papal supremacy, and not just in the building field. Abbé Lelio Cosatti takes care of the diffusion in print of "*Macchine e Ponti del Zabaglia*"; he writes the text and edits the page layout. Cosatti is a valued mathematician, mechanic and architect. In 1719 he is invited, together with Filippo Juvarra, Nicola Michetti, Domenico Paradisi, Antonio Canevari and Antonio Valeri, to take part to the competition called by Pope Clement XI Albani (1700-1721) to design the new Sacristy of the Vatican Basilica. Having an interest also in the issue of the consolidation of St. Peter's dome, in 1743 Cosatti publishes a memoir on the "suffering and restoring of St. Peter's big dome" (Cosatti, 1743). The story is common knowledge. Since 1636 the dome had been showing a serious cracking pattern, which in the following century had been getting worse and worse. The concern of the Popes translates into getting the scientific community involved: the most authoritative representatives are called to verify the statics of the monument (Benvenuto 1981; Di Stefano 1980; Como 1997; Como 2008). The issue becomes critical under Pope Benedict XIV Lambertini (1740-1758), who sets up several committees in order to avert the danger and to keep under control the negative judgements expressed by the European public opinion. The first committee, chaired by Giovan Francesco Olivieri, treasurer of the Fabbrica, does not achieve any result; a second committee is then entrusted with the inspection of the pillars sustaining the dome, but does not detect any sign of movement. This latter committee is composed by architects Pietro Hostini [Hostini], Nicola Salvi, Ferdinando Fuga, Domenico Gregorini and Giuseppe Sardi, by Father Domenico Sante Santini, member of the Camillian Attendants of the Sick from Maddalena's convent, and by the Fabbrica's master mason Nicola Giobbe. The experts who are consulted come from different contexts and institutions, but are all well known for expertise and professionalism: Ferdinando Fuga and Nicola Salvi come from the Apostolic Palace, Nicola Michetti and Luigi Vanvitelli are from the Apostolic Chamber; while Pietro Hostini and Domenico Gregorini from the Congregation of Good Government. The manuscript by Saverio Brunetti entitled *Discorso intorno ai pericoli che minacciano la Cupola di San Pietro* (Poleni 1748, pp. 225-228) reports the inspection carried out by the committee on the 22nd of September 1742, to which Zabaglia very likely takes part too. However, no conclusion is drawn. The Pope then sets up a third commission, including three outstanding mathematicians, Tommaso Le Seur e Francesco Jacquier, from the Third Order of St. Francis, and the Jesuit Ruggero Giuseppe Boscovich (Glatigny Dubourg, Le Blanc 2005; Niglio 2007). Their research, reported in the famous *Parere* published in 1743, divide the experts into two factions (Boscovich, Le Seur, Jaquier 1743). The three mathematicians substantially agree with Vanvitelli, Salvi and Hostini, while are at variance with Fuga, Gregorini together with three Neapolitan mathematicians, Bartolomeo Intieri, Pietro di Martino and Giuseppe Orlandi, who are also called to give their opinion on the dome. In the attempt to cast some light in such an intricate maze of discordant opinions, in 1743 Pope Benedict XIV appoints as members of the committee also Pier Leone Ghezzi, Filippo Barigioni, architect of St. Peter's Fabbrica at the time, marquis Girolamo Theodoli and Monsignor Giovanni Bottari, a Florentine theologian and librarian for the Corsini family, who was a prestigious intellectual in the Roman society of the Eighteenth century. Nevertheless, neither is this initiative successful. Therefore, as a final and decisive measure, the Pope appoints the famous Paduan mathematician, marquis Giovanni Poleni (1683-1761), to verify the statics of the dome. Poleni had been member of the London Royal Society introduced by Newton since 1710, and in 1715 he had become member of the Berlin Royal Academy introduced by Leibniz. In 1740, following the example of the Anglosaxon lecture-demonstrations, he founded the first experimental laboratory in physics in an Italian university. He had long been interested in mechanics, taking part to the research on "live forces" and proposing a revolutionary experiment that anticipated the resolution of the problem (Saladin, Tallas 2000; pp. 85-91; Soppelsa ed. 1988). In 1743, assisted by Luigi Vanvitelli, Poleni performs an accurate inspection of the dome, the attic, the drum and the buttresses. The findings of this inspection are collected in *Memorie storiche della Gran Cupola del Tempio Vaticano*, published in Padua in 1748, which represents a historical research as well as a review of the structural behaviour. In the appendices are also reported the opinions by the other experts involved, including Lelio Cosatti and an anonymous master mason, author of a "short note in defence of St. Peter's dome" dated 1744. The latter opinion seems to be greatly esteemed by Poleni, which

demonstrates that practical experience is still an authoritative element of knowledge (Poleni 1748, pp. 314-321).

Analogously to the manuscript by Poleni, Cosatti's *Riflessioni* also aim at refuting in part the opinion by the three mathematicians, and thus proving the lack of foundation of the alert for the stability of St. Peter's dome. Such convictions are discussed with an articulate line of argument on the real contribution of the lantern to the statics and the cracking pattern of the dome. In fact, in the introduction to its *Ragionamento*, Cosatti maintains that "the damage suffered from the dome is to be ascribed not just to the various external accidents, but even more to the widespread lesion that, rising from the foundations of the temple and continuing its openings, causes the most part of the damage itself" (Cosatti 1743, p. III). On the basis of a series of well-constructed hypotheses, Cosatti wonders whether the weight of the lantern, pressing on the two shells and on the ribs, has been able to remove the common support, that is the drum with the buttresses and the common base" (Cosatti 1743, p. VII), thereby refuting the expert report by the three mathematicians. In the Pope's opinion, the famous Poleni is the only one who can settle the question, by virtue of a sort of divine investiture. Thus Cosatti, to ingratiate himself with Poleni and persuade him of the correctness of his own reasoning, donates him a "model of St. Peter's dome for his study made with a tasteful architectural sense, a great accuracy and an excellent similarity to the real parts of the Fabbrica and their composition" (Poleni 1748, p. 134). Luigi Vanvitelli also intervenes on the issue with a *Parere* which dates back to the 20th of September 1742, which is mentioned by Poleni himself in the fourth book of *Memorie istoriche* (Poleni 1748, pp. 334-339). In short, the experts called by the Pope are divided into two opposite schools of thought: the one represented by the three mathematicians maintains that the collapse of the dome is imminent and the urgent and necessary restoration would require major modifications of the architectonic structure; the other group of experts, led by Poleni, have a less catastrophic vision, and are convinced that the faults of the dome can be fixed with a less invasive intervention (Como 2008, p.982). Poleni's firm belief relies on an accurate static analysis of the dome. This is an ogival structure with a double shell, stiffened by 16 big ribs and laid down on the cylindrical drum having a 3-metre-thick wall, which in turn is stabilised by 16 buttresses. During the construction of the dome, carried out between 1589 and 1592 by Giacomo Della Porta (Bellini 2006; Bellini in press), three iron hoops were walled in the internal shell. They were set up between April and October 1589. The first massive chain, that is walled in the solid portion of the dome, is composed of 16 iron rods joined by small poles and weights overall 18,255 pounds (6,190 kg). Between May and June 1590, in addition to these first three chains, two further hoops are set up at the base of the lantern, at the level of the intersections with the two shells (Bellini 2007, p.191).

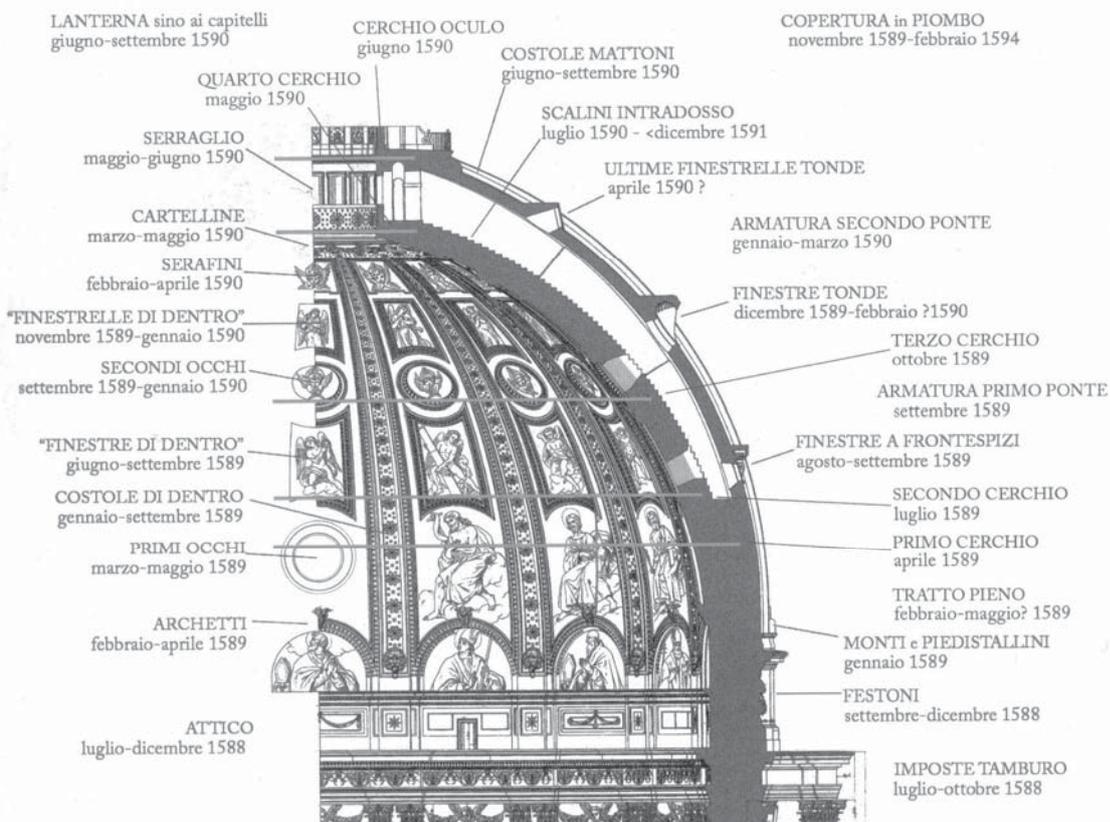


Figure 2: Steps in the construction of St. Peter's dome under Giacomo Della Porta's direction and position of the five original iron hoops; (Bellini 2007, p. 191)

The masonry of the two shells and of the ribs, made of bricks or travertine blocks kept together with lime mortar, was carried out by Della Porta on a massive arch centre made of oak wood. The weight of the dome has therefore pressed on a single two-shell structural system stiffened by ribs (Di Stefano 1980). Eventually, the static conditions of the dome got worse and worse. Towards the mid 18th century, it presented with a diffusely and severely disrupted state which, because of the progress of the cracks, was transforming the dome in a pressing structure divided into segments by the large meridional lesions. The cracking pattern of the dome intrados is specifically surveyed between 1742 and 1743 by Vanvitelli, whose drawings are enclosed to the second book of Poleni's *Memorie*: "a detailed description of the faults of the Vatican dome was made by architect Vanvitelli [...] His Holiness kept the book and two copies were made by the Reverenda Fabbrica" (AFSP, 12, D, 4b, 29, f.1003g). The documents held by the Archives of St. Peter's Fabbrica confirm the findings of the inspection: a file entitled *Difetti della Cupola Vaticana e disegni di Luigi Vanvitelli. Copia manoscritta in tutto conforme all'originale e autenticata dagli architetti Nicola Salvi e Pietro Hostino* reports on the condition of the dome and its lesions (AFSP, 17, C, 256). Analogously, the record on *Stato dei difetti trovati da Poleni nella visita fatta al fabbricato della gran cupola nell'anno 1743 e raffronto con la visita fatta nell'anno 1794* specifies position and size of the lesions for each section of the dome, from the base to the lantern (AFSP, 64a, C, 1, *Visite degli architetti alla Cupola, 1743-1800*). The position of the cracks is made clear graphically by Vanvitelli's drawings, though some of the cracks in the upper shells where the lantern is laid down, that had been already described by Poleni in his *Memorie* "could not be measured" (Poleni 1748, pl. XVI, XV). Thus, the cracks run from the drum nearly up to the impost of the lantern, while no ring cracks are detected in the inner shell. However, one of the two iron hoops walled in the inner shell by Della Porta during the construction is broken. The cracking pattern is highly complex, quite similar to that arising in brickwork domes, which tend to divide into segments due to the substantial failure of the brickwork to absorb the tractions existing in the parallels of inferior sections (Como 2008, p.984).

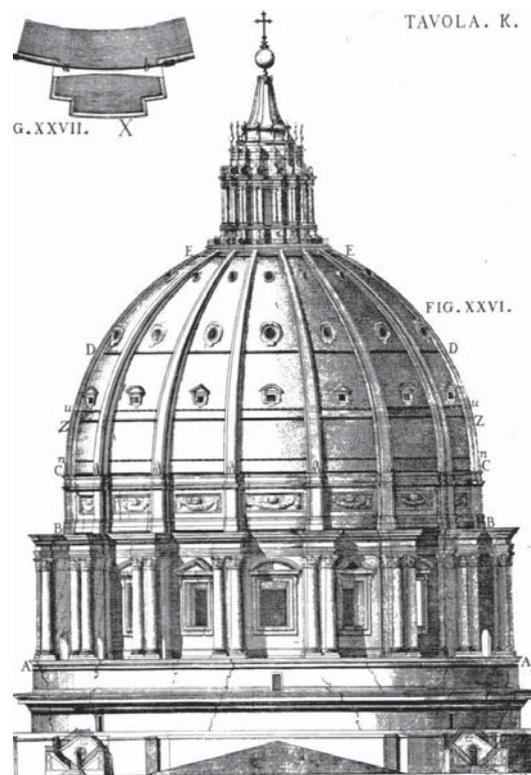


Figure 3: Position of the five new iron hoops set up by Poleni (A-E) and of the replaced one (Z); (Poleni 1748, pl. K)

After examining the dome and analysing its statics by applying the theorem on the equilibrium of the arch by Robert Hooke (1675), Poleni tells the Pope his conviction that the state of the dome is in fact less dangerous than the picture envisaged by the three mathematicians. Although the dome was not in imminent danger of collapsing, its state was yet fated to get worse eventually. Having won the Pope's assent, Poleni defines the criteria and methodologies for intervention in collaboration with Vanvitelli (Mainstone 2003). The work to consolidate the statics consists in setting up five iron hoops around the dome and in performing a dense network of patches in the brickwork, done with the so-called technique of "cuci-scuci" (sew-unsew). A sixth hoop will be added in 1748, when Vanvitelli, while work is in progress, realises that one of the two sixteenth-century hoops had broken up. Overall, the six hoops ensure additional strength and rigidity to the entire dome, thereby preserving it from further deformations and contributing to bring its static condition back to full safety. In order to determine the section of the hoops, Poleni does not rely uniquely on theoretical calculations, but takes also advantage of practical experiments aiming at identify the strength of the iron rods as a function of

their thickness. The breaking load and the hoop section are determined by Poleni by means of the "macchina divulsoria" (tearing machine), which allows to evaluate the relationship between the section of a sample iron rod and its traction strength (Gargiani, 2003).

On the basis of Poleni's guidelines, the consolidation work begins, under Vanvitelli's direction between 1743 and 1744. To Vanvitelli himself is dubiously ascribed the invention of a special system to join the metal components of the chains, based on the use of a lock consisting in two wedges with trapezoidal section, whose profile ensures the blockage of each component, preventing the hoops from losing the right tension (Poleni 1743, p. 415, n. 579). In *Memorie degli architetti antichi e moderni* (Milizia 1785, II, pp. 265-266), Francesco Milizia describes in detail such device: each hoop is composed by 32 iron rods; at their ends are elongated rings in which an iron wedge is fixed by hammering, "so that each part of the hoop is equally pressed". Once walled in, the hoops are covered with travertine panes and mortar to protect them from inclement weather.

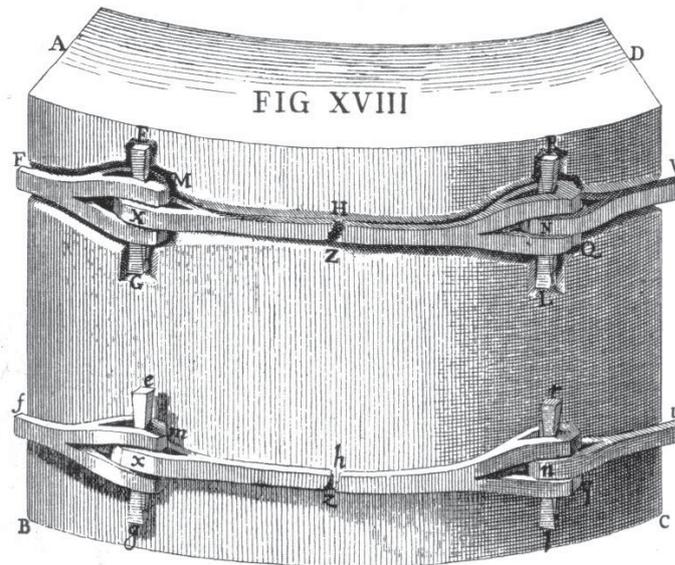


Figure 4: Device for joining the components of the iron hoops, tightened by means of the wedges hammered into the eyelets at the end of the rods; (Poleni 1748, pl. F)

Up to this point the restoration of the dome is widely documented in historical and technical historiography. The actual execution of the consolidation works is less known, and in part still obscure. The works are entrusted with 79-year-old Nicola Zabaglia, master mason of St. Peter's Fabbrica, who is about to see his professional activity sanctioned by the publication of *Castelli e Ponti*, exactly in 1743. The controversy between Vanvitelli and Zabaglia, reported by Milizia and concerning the invention of the "concave scaffold used inside the Vatican dome to fill the fissures" (Milizia 1785, p. 266), makes apparent the authoritativeness won on the field by the "illiterate St. Peter's master mason". Such acknowledgement leads competent professionals such as Vanvitelli to misappropriate his extraordinary inventions, but to be disproved by Milizia and Bottari, who accredit again the invention of the scaffold to master Nicola, well-known and beloved by Roman common people. A series of unpublished documents from the Archives of St. Peter's Fabbrica reaffirm the authorship and define modality and procedure chosen by Zabaglia for the difficult hooping of the dome. Zabaglia performs the work under the supervision of the Fabbrica's treasurer, Monsignor Olivieri, the chief architect Filippo Barigioni, the reviser architect Luigi Vanvitelli and the "fattore", Filippo Valeri, that is the person in charge for managing staff and materials. The first undertaking accomplished and ascribed to Zabaglia is the construction, dated 1743, of the scaffolding around the abutment arches and at the height of the cornice of the attic in the dome intrados, "so that marquis Poleni could inspect the cracks" (AFSP, 12, D, 4b, 29, f. 1003b). The scaffold features are likely to resemble those depicted in figures XXIV and XXII in *Castelli e Ponti*, which was built "without disfiguring the walls with holes and with no damage to the ornaments [...], and can well serve as a model for analogous needs" (Zabaglia 1824, p.18).

Once Poleni and Vanvitelli have defined the type of intervention and the kind of chains to set up to consolidate the dome, St. Peter's Fabbrica makes provision for materials and equipment needed to execute the work. On the 3rd of August 1743 from the papal foundry in Conca, nowadays known as Borgo Montello, near Nettuno, arrive to St. Peter's the first 35 iron components of the hoops. They consist in iron rods 24-span (5.5 m) long, cast in high-quality iron and with well-made eyelets at their ends. The section of the rods is 5,6 x 9,6 cm (Poleni 1748, pp. 412-414). During 1743 to the Fabbrica also arrives all the iron needed for making the first "two hoops of the dome, one around the drum, the other around the attic", that is weighted as usual to appraise its price correctly (AFSP, 12, D, 4b, 29, f.1003g).

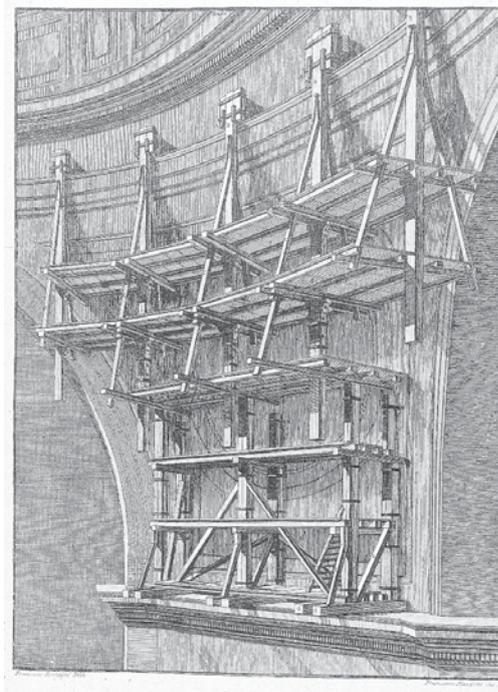


Figure 5: Zabaglia's scaffolds for pendentives of St. Peter's dome; (from *Castelli e Ponti* 1824, pl. XXIV)

Between December 1743 and March 1744, helped by 17 labourers and by using 400 wooden boards made of *albuccio* (*Populus alba* or white poplar) and several tiers of trestles, Zabaglia builds the scaffolds around the drum and the attic of the dome "so that the stonemasons can work and draw the outline to set up the iron hoop". The labourers also help "the plumbers to remove some lead panes from the dome to set up the hoop" (AFSP, 27, E, 431, f. 31r). Each of the first two hoops that are set up is composed by 24 elements joined according to the system invented by Vanvitelli. The assembly of the components following the right geometric curvature of the dome circumference is verified on an outline drawn in mortar and paint on the pavement of St. Peter's square in order to give them the right centring and on the drawing were the hoops composed" (AFSP, 12, D, 4b, 29, f.1003g). Thus any possible fault in the geometric conformation of the pieces can be quickly corrected in the nearby foundry of St. Peter's. The pieces are then carried inside the basilica and are brought to the roof terrace through the spiral staircase known as St. Michael's, which is in the North transept, by means of hoists and burtons. In the meantime Zabaglia and his labourers build the scaffolds around the dome attic and drum, on which are set up several blocks and tackles. The hoop components are then raised from the terrace onto the scaffolds by means of pulls and burtons driven by winches. Now that the hoops have arrived to the working height, they can be mounted in their housing, made by the masons in the body of the shell, and are tightened by fixing the components by means of the wedges hammered into the eyelets at the end of the rods (AFSP, 27, E, 431, f.31v; AFSP, 12, D, 4b, 29, f.1003c). Once the assembly is done, masons and hodmen take care of filling the housing and covering it with travertine panes to protect the iron. The same hodmen also build the scaffolds for the plumber, the glassworker and the stonemason who are in charge for the finishing works.

Between the 23rd of March and the 25th of July 1744 the third and fourth hoops are set up. Fifteen hodmen from St. Peter's Fabbrica in Zabaglia's service construct the scaffolds around the main part of the dome under the supervision of Filippo Valeri, the Fabbrica's "fattore", and the architect Filippo Barigioni (AFSP, 27, E, 431, f.31v). At the same time are erected the 50-span-(11.2 m)-long scaffolds contiguous with the big arch of the "Vultone" (near the main entrance of the Basilica), the big arch of the Chair and the so-called St. Simon and Jude's big arch, that are necessary to fill and restore the cracks and lesions (AFSP, arm. 12, rip. D, vol. 4b, fasc. 29, f.1003c). While the construction of the scaffolds goes on, the components of the third and fourth hoops are carried to the dome terrace in a similar way to that employed for the first two hoops. The methods used to assembly and set up the hoops are also similar: "any piece of the hoops is weighted, and all the pieces are laid in St. Peter's square, and arranged so to have the right centring, and then carried to the Church and pulled through the spiral staircase up to the terrace of the dome and put onto scaffolds, and laid down, and finally, once the work is finished, the scaffolds are undone" (AFSP, 27, E, 431, f.31v; AFSP, 12, D, 4b, 29, f.1003g). A contemporary account reports on that expedient: "on Friday the 7th of September His Holiness goes and sees the big iron hoops that are worked under the colonnade of the Vatican Basilica on the side of Our Lady of the Furnaces" (Chracas 1744, n. 4074). A few days later the Pope goes and admires the scaffold that "the famous engineer Zabaglia" has built in the Vatican Basilica (Chracas 1744, n. 4233).

The last hoop, the fifth one, is set up in December 1744: "the scaffolds for the fifth iron hoop were built, and it was pulled up the spiral staircase to the cornice and carried onto the scaffolds" (AFSP, 12, D, 4b, 29, f.1003g). Overall, the iron used for setting up the hoops weights 124,468 pounds, equal to about 14.5 tons. From *Ristretto*

delle spese occorse per il modello, i 5 cerchioni, la catena e per il riattamento della Cupola anno 1743 (AFSP, 27, D, 412, ff.576- 607) we learn that the purchase of the iron needed for the five hoops implied that St. Peter's Fabbrica spent the total amount of 7355.55 scudi (AFSP, 27, D, 412, f. 588; AFSP, 27, E, 424, f. 114; AFSP, 12, D, 3, ff. 338-368).

Between the 27th of July and the 14th of December 1744 two carpenters prepare the boards made of *albuccio* and the trestles needed to build the scaffolds, as well as the wooden arch centres necessary to the masons (AFSP, 27, E, 431, f.33v). Once the scaffold around the dome is assembled, the metal components of the hoops are once again "laid in St. Peter's square to give them the right curvature", but this time it has to be modified. The pieces are brought to the forge and adjusted, and then moved to the basilica and pulled up through the spiral staircase up to the Fabbrica's roofing". When the blocks and tackles are placed, the iron pieces are raised up to the balustrade and then "let down piece by piece and set up and hammered onto the dome" (AFSP, 27, E, 431, f. 33v). To finish up, the lesions in the dome intrados are mended and filled; the records attest that to perform this intervention 15 hodmen built suitable scaffolds, once again designed by Zabaglia (AFSP, 12, D, 4b, 29, f.1003c; AFSP, 27, E, 431, f.33v). When the work is done, the scaffolds are carefully disassembled and their components (timber, ropes and metal tools) are put away in the warehouse known as St. Peter's "munizioni", as the storehouse for materials and work equipment is called (AFSP, 27, E, 431, f.33v; Author 2004, pp. 30-37, 139-230).

Zabaglia is now eighty years old, but his extraordinary skilfulness is far from waning; the Pope, greatly admiring the perfect way he conducted the work, awards him and his collaborators a reward: "100 scudi were given to master Nicola Zabaglia and his collaborators by order of Benedict XIV as a reward for the machines and scaffolds built inside and outside the big dome to set up the iron hoops and to restore the cracks" (AFSP, 12, D, 4b, 29, f.1003g). Work goes on during the following years, as proven by several invoices dated 1746 (AFSP, 27, E, 431, f. 28). In 1748 a new pull is set up on the top of the lantern to replace the damaged hoop (AFSP, 12, D, 4b, 29, f.1013r). Its circumference is 650 span long (about 145 m) and it is composed by 32 metal elements. The scaffold serving this part of the intervention is fixed to the main part of the dome; its housing is made in the brickwork section. Once again the hoop metal components are first assembled in St. Peter's square to check their geometric conformation, and then moved through the Gregorian spiral staircase up to the various heights of the dome. From here, once the blocks and tackles are fixed to the scaffolds and a supporting "bilancia", that is a lifting machine, is constructed, all the parts of the sixth hoop are raised, assembled and tightened by hammering the metal wedges into the end eyelets. When the work is done, the scaffold is disassembled and its parts are stored in the warehouse of the Basilica.

The restoration is completed. The six hoops have been inserted in the massive body of the dome, whose stability is thus rescued, and so is the papal prestige. In 1748, when the work is finished, Poleni will see his success sanctioned by the publication of *Memorie storiche della Gran Cupola del Tempio Vaticano*, whose copper plates are engraved by Pietro Monaco and printed by Antonio Peroni, which costs overall 997 scudi (AFSP, 52, A, 88). In May 1743 Pope Benedict XIV presents marquis Poleni, who is about to go back to Padua, with a precious golden box, a few crowns and golden and silver medals, an annual 150-scudi pension to the episcopate of his priest son (Chracas 1744, n. 4044), and a reward amounting to 1000 scudi, for the prints and as a personal thank you from the Pope (AFSP, 43, D, 84, f.131). Such a conspicuous amount of money is not even comparable to the sum of 100 scudi that Zabaglia and his collaborators have to share. These extremely skilful workers, the real executors of such a renowned exploit, will be given their due only by the publication of *Castelli e Ponti*: thank to this book their work will be divulged and handed down to posterity.

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