# THE TECHNIC CONVEX-CONCAVE FAÇADE (*PARETE ONDULATA*) IN EUROPEAN ARCHITECTURE

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## Introduction

The concave-convex façade – *parete ondulata*, invented by Borromini basing on earlier baroque discoveries for adding a more dynamic, monumental and sculpted character to walls, was an ideal solution for small urban areas and thence its use in the tight streets of medieval cities, along squares and plazas where rigourous building laws applied, also in the narrow streets of central Rome. The concave-convex façade allowed the architect to endow both the building and the space it enclosed with the necessary consequence, fully realizing the baroque idea of variation and consistency of opposites – *complexio oppositorum*.

## Perspective and chiaroscuro as tools of architectural design

The new vision of the world, a different way of thinking and understanding of phenomena, which was begun by Mannerism and then consolidated by the Baroque, introduced new aesthetic categories. Visualizing the idea of *infinity through constant movement of matter* became a basic artistic objective[1]. In architecture continuity and infinity of space were ensured by appropriately arranged perspective views[2], while the undulating lines of facades created a dynamism of forms, as did transforming round or square places into ovals or oblongs. Just as religious spectacles and services taking place according to detailed and strictly arranged programmes[3] provoked intense emotions, so in architectural composition the final effect was planned according to the Baroque rule of *complexio oppositorum*[4]. The seeming freedom and lightness was achieved by using perfected geometric and mathematical principles and sophisticated calculations[5]. Designing space had to be combined with a knowledge and application of optical laws, especially of perspective, which only returned to design in architecture in the Renaissance owing to the work of Filippo Bruneleschi[6]. Knowledge of the principles of perspective explained foreshortenings in views of space and architecture. An early experiment in architectural illusion was the decoration of the lower façade of Scuola Grande di San Marco, adjacent to the Campo S. Giovani e Paolo in Venice (Fig. 1) executed by Pietro Lombardo (1488–1490). Bruneleschi used a similar method for the side chapels along the nave of the church of San Lorenzo in Florence[7] and Donato Bramante for the choir of the church of Santa Maria presso San Satiro in Milan[8].

The technique of simulating space is best illustrated by the Teatro Olimpico in Vicenza, designed by Andrea Palladia[9]. In the 17th and 18th centuries a knowledge of perspective and the ability to utilize it became the basic skill for architects, also owing to the development of illusionist painting and works which integrated all the arts.

How to use knowledge of perspective in architecture was explained by Andrea Pozzo[10], who showed how to draw fake domes, how to create the illusion of height and length in interiors and ways to increase the dynamics of foreshortenings of painted architecture. These techniques were perfected in the first half of the 18th century by F. Galli Bibiena and G. Fr. Costa[11]. Among the treatises were works

[1] E. A. Gutkind, *Urban development in Europe*, New York 1964 , vol.1, p. 136.
[2] S. Giedion, *Przestrzeń, czas, architektura*, Warszawa 1968, p. 103, Gutkind, vol. 1, p. 136.
[3] G. C. Argan, *Europa des Capitales*, Lussona 1964, p. 81–94.
[4] E. A. Gutkind, op. cit., vol. 1, p. 136.
[5] A good example are the designs of G. Guarini – a mathematician especially interested in descriptive geometry. P. Portoghesi, *Angelo della storia*, Roma 1982, p. 103 et seq.
[6] D. Gioseffi, *Perspective*, [in:] *Encyclopedia of World Art*, vol. XI, New York 1966, p. 216.
[7] Ibidem, p. 216; L. Benevolo, *Storia della architettura del rinascimento,* Bari 1973; P. Murray, *Architettura del Rinascimento*, Venezia 1971, p. 25–51.
[8] Ibidem, p. 122–139.
[9] D. Giosefi, op. cit., p. 212; P. Murray, op. cit., p. 316, Fig. 464–467.
[10] A. Pozzo, *Perspectivae pictorum at que architectorum*, Augsburg 1706.
[11] D. Giosefi, op. cit., p. 214, 215.

devoted to perspective architecture also known as *architettura obliqua*[12], in which foreshortenings played a special role.

Studies of the rules of perspective were accompanied by investigations in the area of chiaroscuro. The use of perspective in drawing and painting, that is gaining a scientific method of presenting three-dimensional objects on a plane was possible only thanks to notation of volume using own shadow. The relation between objects was defined by cast shadow and mutual shadow. Already painters of the Italian Quattrocento, watching the way light describes the shapes of individual objects, noted that they take on and cast a specific shadow[13]. In the so-called chiaroscuro modelling the convex portions of presented objects were lightened while the concave were darkened, as described by the architect L. B. Alberti[14]. Also of importance for the development of the theory of light in painting were the observations contained in Leonardo's treatise. He first observed that shadows are also subject to the laws of perspective[15]. In the practice of painting it was quickly noticed that a suitable choice of light sources can affect the expression of the work.

Towards the end of the 16th century painting night scenes became popular (Titian, Tintoretto, the Bassanos). Light played a particular role in the works of Caravaggio. Sharp contrasts of light and shade, large parts of the picture plunged in darkness and, above all, sharp beams of light bringing out important fragments from the shadows are the most important ideas of the times. Light was of similar importance in the sculptures of Gian Lorenzo Bernini. It served to illuminate and distinguish a particular element of the sculpture and to stress its role. Streaks of light in the shaping of architectural interiors were used by Carlo Rainaldi who employed scenography lighting, based on the lack of continuity of space – where successive plans displayed the architecture of the interior. Guarino Guarini even introduced a kind of space-light unit – camera di luce. Francesco Borromini's architectural structures by the arrangement of light received tonal variations, subtly differentiating perspective plans.

## Perspective relief[16]

One of the methods of perspective illusion used in small urban interiors was the technique imitating *bassorilievo*[17], as a borrowing of methods used in relief sculpture, described and advocated in the publications of Girard Desargues (1591–1661)[18] and Abraham Bosse (ok. 1602/1604–1676)[19]. The raising of the figures in the foreground placed against flat backgrounds increased the optical depth of the reliefs. The Greeks were already using such effects, for instance when decorating the Parthenon[20]. The method became popular owing to the doors to the Florence Baptistery, the work of Ghiberti, where the artist applied Donatello's idea of *rilievo schiacciato*. The linear presentations of architecture shown in depth in geometric perspective created a special effect[21].

Using perspective relief in architecture, probably under the influence of Venetian architecture and the ideas of Michelangelo and knowledge of perspec-

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[12] J. C. di Lobkowicz, *Trattato di Architettura*, 3 vol., Vigevano 1678. Cf.: A. Guidoni Marino, *Il Colonnato di Piazza San Pietro: dall'architettura obliqua di Caramuel al "classicismo" berniniano*, "Palladio", XXIII, 1973; M. Brusatin, *Lo specchio obliquo*, *"L'arte della meraviglia",* Torino 1986; A. Rosa, G. D'Acunto, *L'inganno di pietra, in "La vertigine dello sguardo. Tre saggi sulla rappresentazione anamorfica*", Venezia 2002.

[13] M. Rzepińska, *Światło i mrok*, [in:] *Siedem wieków malarstwa europejskiego*, Wrocław 1979, p. 218.

[14] V. I. Stoichita, *Krótka historia cienia* [A Short History of the Shadow], transl. P. Nowakowski, Kraków 2001, p. 57 et seq.

[15] Ibidem, p. 59.

[16] The concept of the architectonic relief as a method of articulating a facade was introduced into critical writing by G. C. Argan. He used the term to describe multiplan compositions using elements protruding from the front of the building. That is how he defined the artistic means utilized by Pietro da Cortona in the arrangement of the facade of the small church od Santa Maria della Pace in Rome. Earlier Argan compared the facade designed by F. Bruneleschi to Donatello's *rilievo schiacciato*. The term had been used earlier to describe facades. For instance, the expression *rilievo schiacciato* was used by V. Constantini in his history of art to characterize the facades of the churches of S. Maria della Vittoria (1626) and S. Caterina da Siena (1630), designed by Giacomo della Porta. G. C. Argan, *Filippo Brunelleschi*, Milano 1955, p. 82; V. Constantini, *Storia dell'arte italiana: Dal Seicento alla contemporaneità,* Milano 1945, p. 24; G. C. Argan, *Il problema del Bramante*, [in:] *Studi e note. Dal Bramante al Canova*, Roma 1970, p. 16.

[17] D. Giosefi, op. cit., p. 213.

[18] G. Desargues, *Exemple de l'une des manières universelles du S.G.D.L. touchant la pratique de la perspective*, Paris 1636.

[19] A. Bosse, *La pratique du trait a preuves de Mr Desargues Lyonnois, pour la coupe des pierres en l'architecture par A. Bosse, graveur en taille douce, en l'Isle du Palais ; à la Roze rouge devant la Megisserie,* Paris 1643 ; G. Desargues, A. Bosse, *Maniere Universelle De Mr. Desargues pour praticquer la Perspective par petit pied Comme le Geometral*, Paris 1647.

[20] D. Giosefi, op. cit., p. 213.

[21] Ibidem, p. 213; G. C. Argan, *Storia dell'arte italiana*, v. 2, Firenze 1971, pp. 173–177.

tive and scenography[22], was something that interested Andrea Palladio. He used these skills when designing the system of overlapping and interweaving porticoes in the fronts of two Venetian churches, Il Redentore (1577–1580), (Fig. 2) and San Francesco della Vigna (1564)[23]. They formed side-wing illusory compositions, deepening the structure of the facade by employing strong chiaroscuro effects in the architectural elements. The method was used again by Jacopo Scamozzi when designing the facade of the Church of San Giorgio Maggiore (1597–1610). Experiments were continued by Mannerist and early Baroque architects, such as J. B. Vignola (Palazzo del Capitaniato, S. Maria dell'Orto, 1567)[24]. The technique, simplified to a modelled Giant order spread in Europe owing to the facade of the first Jesuit church of Il Gesù in Rome, designed by Giacomo Della Porta (1584), architect and sculpture, a pupil of Michelangelo and Vignola. It was also successfully employed by Carlo Maderna when he designed the facades of two churches in Rome, Saint Peter's Basilica (1603–1607), (Fig. 3) and Santa Susanna (1597–1603)[25]. Thanks to the strong effect of light and shade, the columns, pilasters and cornices, cut off from the shaded wall background, gave the impression of being more sculpted than in reality. In the 1620s and 1630s the principle was duplicated in the facades designed by G. B. Soria (the churches of Santa Maria della Vittoria 1624–1626, San Carlo ai Catinari 1636–1638). In Rome the technique of architectural relief was developed by such great Baroque architects as Bernini (Santa Bibiana, 1625), Martino Longhi il Giovane (Santi Vincenzo e Anastasio a Trevi, 1644–1650) and Borromini. The latter, in his design for the church of Santa Agnese in Agone (1653–1657) in the Piazza Navona also employed his own "invention" of the undulating facade. The full range of possibilities of creating perspective plans in architecture can be found in the designs of Carlo Rainaldi (Santa Maria in Portico in Campitelli, 1633–1667; the facade of Sant'Andrea della Valle, 1661–1665).

The technique of the architectonic relief spread in the mature Baroque. In the next generation it was employed by almost all European architects drawing on Italian models. In many cases they enriched the essence of the idea with regional aesthetic values[26]. At the beginning of the 18th century, returning somewhat to the Palladian convention, the same design method was continued by Domenico Rossi[27]. The best example of the technique of architectonic relief, successful in narrow streets and small squares, is the church of Santa Maria della Pace (1656–1667), renewed by Pietro da Cortona, architect, painter[28] and sculptor working in Rome[29] and the facade of the church of San Andrea al Quirinale (finished in 1670) designed by Bernini, sculptor, painter and architect, and author of theatrical scenery.

## The concave-convex façade

The discovery crowning Baroque architectural exploration was the *parete ondulata*, the concept of Borromini[30]. The idea was to shape the elevation along an undulating line, formed by an opposing, both horizontally and vertically, system of niches and avant-corps, faults or projecting cornices, which enriched the chiaroscuro effect and made the composition more dynamic[31]. The concept is attributed to Bramante but it gained its proper expression in Borromini's interpretation. The test was the design of Oratorio dei Filippini (1637–1650), (Fig. 4), built

[22] Cf. archival materials, after: *Basilica del Redentore*, http://it.wikipedia.org/wiki/Chiesa_del_Redentore [accessed: 24.03.2014].

[23] Below in the text dates and basic bibliographic data from generally available sources: it.wikipedia, en.wikipedia, de.wikipedia [accessed: 24.03.2014] and *Laboratorio Roma, Passeggiate romane, Le Chiese*, after: http://www.laboratorioroma.it/passeggiate%20romane/Le%20Chiese/Chiese%20Barocche/Chiese%20barocche.htm [accessed: 24.03.2014] and archINFORM http://eng.archinform.net [accessed: 24.04.2014].

[24] Already used by Alberti (basilica in Mantua, 1472), later by Michelangelo (Capitoline palace, 1564–1568), but popularized by Palladio, after: *Giant order*, https://en.wikipedia.org/wiki/Giant_order [accessed: 24.03.2014].

[25] S. Giedion, op. cit., pp. 148–150, 166; T. Tołwiński, *Urbanistyka*, Warszawa 1948 (ed. 1–1932), p. 240; Ch. Norberg-Schulz, *Architettura Barocca*, Venezia 1998, pp. 66, 175.

[26] Eg. the facade of the church of Santa Maria di Nazareth in Venice, by Giuseppe Sardi (1672–1680) combines the composition of the Il Gesù facade with the structural solutions based on Palladio's idea.

[27] *Domenico Rossi*, after: http://www.novarchitectura.com/2011/12/28/e-successo-oggi-28-dicembre/ [access: 24.03.2014].

[28] He was also a quadratura painter – Chiesa Nuova, pallazo Doria, pallazzo Barberini.

[29] G. C. Argan, *Retorica*, [in:] *Dal Bramante*, p. 187–189, R. Arnheim, *The dynamics of architectural form,* Berkeley 1977, p. 81.

[30] G. C. Argan, *Retorica*, p. 209 et seq.; idem, *Storia*, p. 321; L. Benevolo, *Storia della architettura*, p. 707; S. Giedion, op. cit., p. 150; P. Portoghesi, *Roma barocca,* Roma 1966, p. 170–172.

[31] These variaties of architectural relief became especially popular owing to the already mentioned publications of G. Desargues and Abraham Bosse. In the German countries A. Pozzo's book played an enormous role.

in a small closed square. The facade follows a concave curve, divided into two stories of Giant order and crowned with a dynamically shaped cornice. The middle part of the ground floor and semicircularly projecting part of the portal is opposed to the deep niche of the second story, which distinguishes the facade of the Oratorio from adjacent buildings. A similar principle of contrasting convex and concave elements is found in the facade of the College of Propaganda Fide (Borromini, 1646–1667) (Fig. 5) located in a narrow street. The floor built in Giant Ionic order with a strongly concentrated rythm has a concave central axis, plunged into deep shadow. Against its background stands a pilaster portal, semicircularly projecting from the wall, and above it a semicircular aedicula. The building is crowned with an extensive bracketed cornice, and over it is the flat mezzanine floor subordinated to the line of the street.

The *parete ondulata* method in the facade of the church of San Carlino (1634–1667), (Fig. 6) was used by Borromini to provide specific spatial effects and underscore the rank of the building. The undulating line of the facade reflects the interior layout. The central projecting part corresponds to the nave, and the two concave parts at the sides correspond to the recessed chapel and staircase of the tower. The facade is higher than the wall of the church and hides the dome, suggesting a much larger structure. The two-storey scheme of the facade is formed by columns on diagonal plinths which carry the tall and projecting "flowing" entablature. The Giant order with elongated proportions, monumentalizes the building[32]. The concentration of the vertical elements and emphasis on the middle part highlights the verticalism of the composition. The upper floor seems to be lighter because of the three niches. From the middle emerges the aedicula of the window corresponding to the protrusion of the entrance on the ground floor. The ground floor plunged in deep shadow seems to be heavier while the upper storey, reflecting light, passes smoothly by way of the openwork balustrade to the background of the sky. Opposing concave and convex surfaces and rich chiaroscuro work together to add dynamics to the facade both horizontally and vertically.

Borromini's design method, which only became popular in the 18th century, can be found in the Sicilian churches of G. Guarini (Santissima Annunziata, San Filippo Neri in Messina, 1660–1662)[33]. Since the beginning of the 18th century, this type of concept with rococo detail was used in Rome by Giuseppe Sardi, for instance in the design of the facade of the church of Santa Maria Maddalena di Roma (1735). On these models were based the designs for new churches in Sicily, rebuilt after the great earthquake of 1693[34], using a curved line, concave or convex and deep architectonic relief, avoiding alternating and opposing elements. The Jesuit church of San Carlo al Corso in Noto designed by Rosario Gagliardi (1730), dedicated to Charles Borromeo, though clearly inspired by the Roman example, yet has a facade where on all three floors the line follows the same concave curve. And the facade of the church of San Domenico (1703–1727), by the same architect, has a strongly projecting semi-circular central avant-corps. This was repeated in several of his designs (San Giuseppe in Ragusa, San Giorgio in Modica). Similar solutions were applied by Giovanni Battista Vaccarini (church and abbey of Santa Agata, from 1735, San Giuliano, 1740 to 1748 in Catania).

The place where Borromini's ideas aroused especial interest was among Viennese architects working at the imperial court and performing commissions for lay and clerical investors associated with the emperor. Johann Lucas von Hildebrandt, a pupil of Carl Fontana, before his moving to Vienna was designing the facades of churches on an undulating plan, for instance in the Church of sv. Vavřince and sv. Zdislavy in Jablonné, Gabel, 1699–1702 (Fig. 7) or the Piarist Church from the years 1698–1718. In both cases, the author applied a convex in the middle and partially broken line in the facade, in Jablonné two-storey, in Vienna a very high single order. In the designs for which Hildebrandt became famous, in the great palace buildings, he did not use concave-convex facades and undulating lines appeared only in the cornices of portals (eg. Daun-Kinsky Palace in Vienna, 1713–1716). The artist who took up the technique of liquid line was Johann Dientzenhofer. As a pupil and collaborator of Carl

[32] Cf.: H. Sedlmayr, *Die Architektur Borrominis*, Munchen 1947 (1st ed.–1930), p. XII.

[33] H. A. Meek, *Guarino Guarini*, Milano 1991, p. 21

[34] A. Blunt, *Barocco siciliano*, Roma 1968, passim; *Barocco_siciliano* http://it.wikipedia.org/wiki/ Barocco_siciliano [accessed: 18.06.2014].

Luragi and J. B. Mathey, he designed facades in the form of distinctive architectonic relief (cathedral in Fulda, 1704–1712). Only in the final period of his work, after 1710, did he begin to design facades on the plan of a concave or convex arc (facade of Neumünster Abbey in Wurzburg[35], 1711–1716; monastery church in Banz[36], 1707–1719). Similar solutions were applied by his brother Christoph (church at the Pauline monastery in Obořištu from the years 1702–1711, the castle church in Smiřicach, 1702–1712; St. Clare's in Cheb, 1708–1711.), In contrast to Johann's designs, he preferred a concave central part and employed pilastres not half-columns in the orders, arranged slanting to the face of the facade. Convex-concave structures were used by J. B. Santini Aichel, known for adapting Gothic forms to the dynamic compositions of the Baroque, who in his travels met Borromini and was fascinated by his work (the church of the Holy Trinity in Rychnov nad Kněžnou, 1713). But it was only in the late works that he combined concave and convex elements on the principle of mutual opposition. Borromini's technique also inspired Kilian Ignatius Dientzenhofer, a continuator of his father's work, as evidenced by the facades of the courtyard of the monastery in Broumov (1728–1738, the upper storey of a deep balcony niche, crowned by a repeatedly broken cornice (Fig. 8). The principle of contrasting convex and concave elements was applied on the facade of the church of St. Nicholas in the Lesser Town of Prague (1732–1735), (Fig. 9). crowned with a massive repeatedly broken and undulating entablature and reduced in the upper tier by a frieze (as in Broumov). In the facade of the church of St. Nicholas there is a wealth of architectural techniques used, based on structural modeling in accordance with the principle of contrasting concave and convex elements. Using a relatively simple form of architectural detail, very modest ornamentation, restricted to decorations of the capitals and window tympanums, as well as small, when compared to the scale of the building, sculptures, a monumental work was composed, rich with chiaroscuro and dynamics. In other designs of church facades Kilian Ignac used the same basic method of projecting or retracting the central part of the facade, as in the Church of Saint John Nepomucene on the Rock in Prague's New Town, 1730–1739, (Fig. 10); Saint Magdalene in Karlovy Vary, 1729–1730, a copy of the Broumov avant-corps (Fig. 11).

This type of dynamics can also be seen in Catholic and Orthodox churches in the eastern borderlands of Poland. The principle of an undulating line of the facade plan with a concave or convex middle part was accompanied by the introduction of concentrated perspective structures of pilaster divisions determining the vertical arrangement of the composition of the facades. Such solutions were equally popular in Spain and Portugal, where monumental architecture was abundantly ornamented (Fig. 12).

## Conclusion

Borromini's idea for the design method applied to the concave-convex facade was a difficult concept both architecturally and aesthetically. It required great skill from the designer in shaping the composition of the facade and knowledge of construction techniques. Predicting what would be the final effect of the architecture on its the urban setting had to arise from extensive knowledge of perspective or great design practice. Recipients often probably did not understand the essence of the chosen solution. This explains the relatively low prevalence of the *parete ondulata* technique in its full form, contrasting concave and convex elements arranged both horizontally and vertically, in spite of the great opportunities the method provided for creating distinct facades with an illusion of monumentalism. The method was usually limited to the use of an undulating line of cornices or entire façades, which currently, in the general view, is associated with Baroque architecture. This perception often obscures the tremendous intellectual contribution of this period to the field of design.

Translated by A. Petrus-Zagroba

[35] Ch. Antz, *Sacrum Theatrum Romanum, das Würzburger Neumünster und die katholische Baukunst in Deutschland zwischen 1680 und 1720*, Weimar 1997, p. 71; J. Emminger, *Die Neumünsterfassade in Würzburg,* München 1978, p. 67, opinie zebrane, [in:] R. Held, *Die Fassade der Neumünster-Kirche in Würzburg*, 2007, http://www.rudis-kunstgeschichten.de/Neumuenster.htm [accessed: 18.06.2014].

[36] H. G. Franz, *Dientzenhofer, Johann,* [in:] *Neue Deutsche Biographie*, Band 3, Berlin 1957, p. 649; *Johann Dientzenhofer*, http://de.wikipedia.org/wiki/Johann_Dientzenhofer [accessed: 18.06.2014].

## Bibliography


Ch. Antz, *Sacrum Theatrum Romanum, das Würzburger Neumünster und die katholische Baukunst in Deutschland zwischen 1680 und 1720*, Weimar 1997.

G. C. Argan , *Europa des Capitales*, Lussona 1964.

G. C. Argan, *Filippo Brunelleschi*, Milano 1955.

G. C. Argan, *Storia del arte italiana*, v. 2, v. 3, Firenze 1968.

G. C. Argan, *Studi e note, dal Bramante al Canova*, Roma 1970.

R. Arnheim, *The dynamics of architectural form*, Berkelay 1977.

*Barocco_siciliano*; http://it.wikipedia.org/wiki/Barocco_siciliano [18.06.2014].

*Basilica del Redentore*; http://it.wikipedia.org/wiki/Chiesa_del_Redentore [24.03.2014].

L. Benevolo, *Storia del architettura del rinascimento*, Bari 1973.

A. Blunt, *Barocco siciliano*, Roma 1968.

V. Constantini, *Storia dell'arte italiana: Dal Seicento alla contemporaneità*, Milano 1945.

G. Dehio, *Handbuch der deutschen Kunstdenkmaeler*, Berlin 1924.

*Domenico Rossi*; http://www.novarchitectura.com/2011/12/28/e-successo-oggi-28-dicembre/ [24.03.2014].

J. Emminger, *Die Neumünsterfassade in Würzburg*, München 1978.

H. G. Franz, *Dientzenhofer, Johann,* [in:] *Neue Deutsche Biographie* (NDB). Band 3, Berlin 1957, p. 649.

*Giant order*; http://en.wikipedia.org/wiki/Giant_order [24.03.2014].

S. Giedon, *Przestrzeń, czas, architektura. Narodziny nowej tradycji*, Warszawa 1968.

D. Giosefi, *Perspective*, [in:] *Encyclopedy of World Art*, v. XI, New York 1966, p. 183-215.

R. Held, *Die Fassade der Neumünster-Kirche in Würzburg*, 2007; http://www.rudis-kunstgeschichten.de/Neumuenster.htm [18.06.2014].

*Johann Dientzenhofer*; http://de.wikipedia.org/wiki/Johann_Dientzenhofer [18.06.2014].

H. A. Meek, *Guarino Guarini*, Milano 1991.

P. Murray, *Architettura del Rinascimento*, Venezia 1971.

P. Portoghesi, *L'angelo della storia*, Roma 1982.

P. Portoghesi, *Roma barocca*, Roma 1966.

P. Portoghesi, M. Tabarrini, *Storia di San Carlino alle Quattro Fontane*, Roma 2001.

A. Pozzo, *Perspectivae pictorum at que architectorum*, Augsburg 1706.

M. Rzepińska, *Siedem wieków malarstwa europejskiego*, Wrocław 1979.

H. Sedlmayr, *Die Architektur Borrominis*, München 1947.

H. Sedlmayr, *Johann Bernhard Fischer von Erlach*, München 1976.

V. I. Stoichita, *Krótka historia cienia*, transl. P. Nowakowski, Kraków 2001.

T. Tołwiński, *Urbanistyka*, Warszawa 1948, (ed. 1–1932).



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