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# Nineteenth Century Invention under Scrutiny: Louis Auguste Boileau's Frame Construction Systems of around 1850

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The article on Louis Auguste Boileau published in the *Grand Dictionnaire Universel du XIX<sup>e</sup> Siècle* by Pierre Larousse highlights the steps of a career that in 1863 already showed many points of interest (Larousse 1867, 876). First an artistic carpenter, then trained in architecture by Louis Piel, Boileau invented a “new architectural form” based on a personal interpretation of medieval architecture. Employer of the use of iron, he is the author of the Church of St. Eugène in Paris, and also of St. Marguerite in Le Vésinet and St. Paul in Montluçon. The importance given to Boileau in this article written on his lifetime, contrasts sharply with the little attention paid to his work.<sup>1</sup> It was not until Bruno Foucart's article in the *Revue de l'Art* that the theoretical aspect was extensively studied and compared with the finished product (Foucart 1969). Foucart traced the portrait of an inventive architect, occupying a special place in the history of architecture, on the fringe of mainstream style and doctrine.<sup>2</sup> More recently some research, which was concerned with the architectural field, also made reference to the figure of Boileau. Even if the architect does not occupy a central place in these studies, the developments they propose help to understand the links between Boileau and various social and intellectual contexts: the Social Art or the Saint-simonisme in particular (McWilliam 1993; Picon 2002). With their contact Boileau developed his own visions which fit very explicitly into a philosophy of history. The correlation between human progress and evolution of the architecture through its technical processes was the basis of many theories in the 19th century. But Boileau

is distinguished by the fertility of his imagination when it comes to giving substance to this process. The period of the 1850s is rich in this respect. The reflection about the architectural invention seems to come to a point of maturity. This resulted in a patent in 1851 with the title “Système de Construction ou forme Architecturale à voussures imbriquées et à nervures butantes” in the publication of the *Nouvelle Forme Architecturale* in 1853, and by a series of theoretical projects illustrating the possibilities of the principle (Boileau 1853). For the text, Boileau seeks not only to build an historical point of view, but also to legitimize its ability to become the architect of his invention. In this sense, the description of the principles is a prerequisite stage for future applications. However the analysis of this process suggests a much less direct path to the project intentions. The possible contradictions between these levels, as well as their respective interactions, complicate the distinction between the purely theoretical and the practical. It is interesting to identify where these continuities and differences happen. Both analysis of the theory and the graphical evidence allows a glimpse of the meaning given by Boileau in his constructive innovation.

## Syntheses and systems

In the first pages of the *Nouvelle Forme Architecturale*, Boileau established his method of deduction of the principles of his invention. In making a critical reading of history, he makes it possible to understand the progress, to diagnose

which valid part of the elements to preserve and to consider the reforms necessary to reach a new step. In its analysis, the medieval period occupies a privileged position. The construction system of the Gothic frame represents the most advanced end of a long evolutionary process that still continues through into the 19th century. The method is based largely on the *Introduction à la Science de l'Histoire* by Philippe Buchez (1833), who is one of the major references for the architect<sup>3</sup>. Buchez's approach is based on the belief in the existence of laws governing the historical process. The analysis of the human past should lead to identify the constants and variables in determining the mechanism of progression which will allow the prediction of the future. Celestin Hippeau remarks that such an approach is inspired by the natural sciences in his model of reasoning (1843, 321). It takes advantage of what a scientific domain can bring to his project. In his analysis, Buchez notes that the phenomenon of mutual dependence between men is one of the main "constants" in history. This ancestral solidarity leads men to share a "business purpose." The common orientation evolves through three great moments that characterize the progression of humanity. Originally, the first men face a nature hostile and mysterious. They require divine protection through sacrifice rites. At the top of pyramid constructions, the altar forms the most important part of the monument. Then comes the age of progress where the tribes are grouped into caste based, hierarchical societies. The temple, organized in successive enclosures, establishes the progression from the profane to the sacred. Finally, with monotheism and especially Christianity begins the last age which, unlike previous ones, is based on the principle of communion. The religious edifice was then, with the cathedral, a large covered area for the meeting of the faithful.

The historical scansion proposed by Boileau is identical. It outlines the main principles in the *Nouvelle Forme Architecturale*,<sup>4</sup> before going into more detail in the *Histoire Critique de l'Invention en Architecture* (Boileau 1886). From literature drawn from many sources, Boileau seeks to clarify the hallmarks of religious monuments of each era together with the leading principles of evolution. In the manner of a naturalist, he proposes a tree-branch

classification, a hierarchical array of architectural features.<sup>5</sup> The first order, the "syntheses," corresponds to the moral and religious ideas that shape each major period. They generate the creation of basic architectural types, the sacrifice altar, the temple, the cathedral, for the three ages established by Buchez. The second order consists of "systems," representing the material properties designed from the idea. They cover the technical field in particularly with the construction. The third order refers to "style," understood as the decorative element representing a historic moment. Chronologically, these three levels are in different time scales. The "syntheses" were established in the long term with the contemporary period still belonging to the third age as it is not yet finished. On the other hand, the "systems" together with the "styles" follow alternating cycles which are getting shorter and shorter. The table also describes a principle for the evolution of architectural forms resembling that of the approach of the naturalist. The sequence "type – constructive principle – style" evokes the progress of the composition plan, leading to the description of the internal organs, then finally to that of the surface envelope. This last example is only given as very circumstantial; a "habit" of adapted shapes, capable of multiple variations depending on the historical context.

Although distinctly separate, "syntheses" and "systems" are organized logically. Each age is indeed characterized by a "mother-invention" in terms of structure, closely linked with the developed architectural type. The pyramid shape of the first age, explained by the limited level of knowledge, is the simplest form of the laws of gravity and resistance to crushing of bodies resulting in a sloping arrangement. The contribution of the second age is due to the control through the structural portal systems. Composed of supports and monolithic plates, the upright solutions are still very basic in their static state or in their overabundant use of material. The third age is marked by the invention of the arch and the vault. Initially huge, they gradually lightened over time to become a thin "framework." The material saving is then correlated to intelligence and mastery of advanced solutions in "cantilever." The medieval period is the culmination of constructive invention. The Renaissance and the Classical

Age marked a break in the continuous process of progress. The imitation of antiquity forms replaced the inventive process. The architects abandoned their constructive skills for the benefit of artistic skills. The specialization of science had nevertheless a positive aspect, it allowed the industrialized 19th century to be taken advantage of. However, in architecture as in other areas, such development will only occur if a new relationship between art and technique is considered.

### Construction system

The system designed by Boileau is placed in prolongation of the concept of medieval framing. It is compared with the combination of arches and ribs characteristic of the 13th century. Boileau, however, intended to correct the faults he perceives in the Gothic system. His criticism focuses primarily on flying buttresses from the point of view of the aspect of construction. Exposed to the elements, they were, more likely than other covered parts, to suffer damage that eventually affected the stability of the building. Secondly, the author condemns the use of attic space in the structure over a masonry vault because this provision introduces too much difference between appearance and the reality of sheltered space. From the perspective of economy, the addition of such a structure is also an important additional cost. The solution devised by Boileau intended to solve these problems by protecting the entire structural frame and placing the cover directly on the upper vaults.

The invention was called “Système de Construction ou forme Architecturale à voussures imbriquées et à nervures butantes” and made the subject of a patent in 1851.<sup>6</sup> The accompanying notices and the three graphical boards allowed the understanding of the main principles of the system. The publication of the *Nouvelle Forme Architecturale* gives some details, particularly on the geometric construction and traces the original forms. The device consists of two separate entities that are to form either the nave or the aisles of the building. In each case, Boileau reasons on a repeated generic unit to form the roof coverage. In the aisles, the square plan vault is generated by the combination of several ribs in a quarter-circle

[or of neighboring proportion]. The arrangement resembles that of a portion of the vaulted arch cloister. At the level of the nave, the geometric base extends to a rectangle. The covering element is characterized by the asymmetry of the arches in segment of a circle at one end and pointed at the other. In the connection, the gap between the two arcs allows the input of light. Boileau bases the design on a series of operations where the geometric layout of lines produced both the shape of the diagram and the structural network of the ribs (Fig. 1). The relative abstraction of the process of the generation of forms was also identifiable in relation to the material. The patent of 1851 provided two versions of the same structure (Fig. 2 and 3); one in masonry, the other in metal. The documents that accompanied the patent instructions did not describe, strictly speaking, a complete architectural project. Limited to one plan and two sections, they explained the most general principles, outlining the dimensions of a building in their broad sense. The author does not give a specific example for his invention, saying it would be

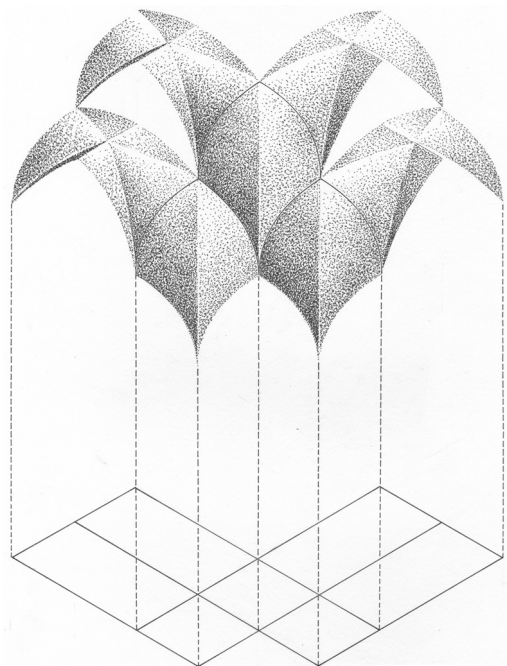


Fig. 1: Schema for the vaulting combination (by author).

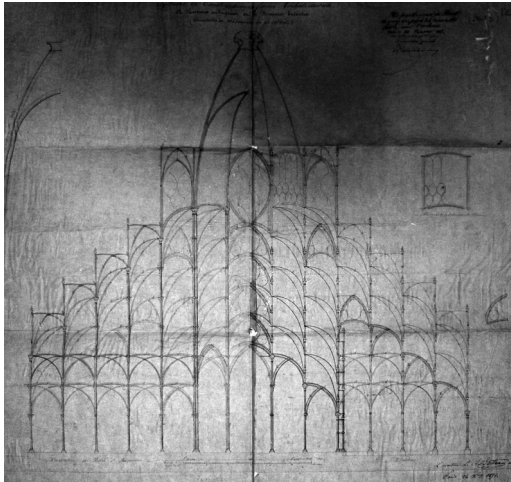


Fig. 2: Patent of 1851, metallic solution, section (Institut national de la propriété industrielle).

“applicable to all types of monuments and buildings” and provide “significant benefits for buildings, free of all physical internal separations, used for meetings or storage of any kind of product.”

Together with the versatility of use was the freedom to make the frame following a broad spectrum of materials ranging from stone or brick to cast iron and wrought iron. The main difference between these two versions lies in the design of columns and arches which were logically thicker when in masonry. However the overall layout is similar, equal spacing of the bays, with some techniques such as double bonded columns forming buttresses. Overall, Boileau gives very few details on the devices or the putting together. He seems, however, sensitive to the compactness of the shell roof by combining a thin arch, a thin layer of air insulation and a protective cover. Boileau designed a scheme structure essentially based on geometric reasoning where the practical construction is discussed very little. The specific combined system, however, directly affected the composition of the edifices. In the medieval intersecting ribs the forces sprang from the arcs and diagonal arches, combining to produce a resultant perpendicular to the nave. The principle devised by Boileau follows a different logic. The elements forming the nave are divided into two orthogonal axes. The coverage of the aisles accompanies

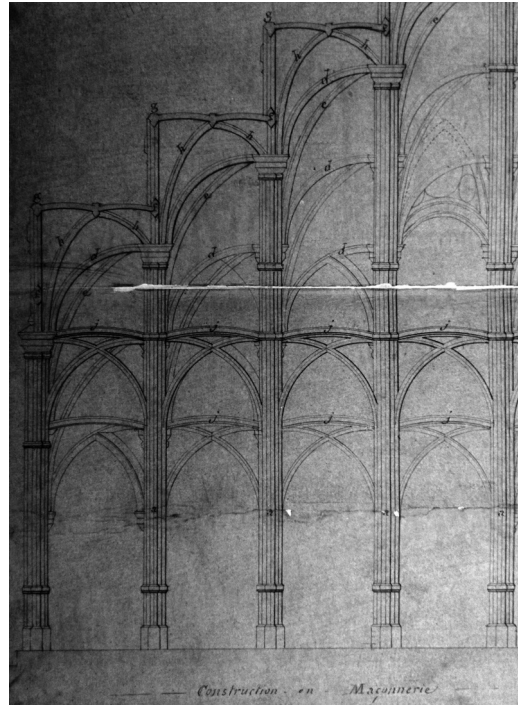


Fig. 3: Patent of 1851, masonry solution, section (Institut national de la propriété industrielle).

the crossing ribs of the nave and the generated volume resembles a pyramid. The gravitational forces were spread out from the top of a “tree structure” through the edges and surfaces to the ground. Although visualized in reference to the medieval architecture, the proposition by Boileau is actually quite far from the Gothic model. The return of the pyramid is perhaps not foreign to the idea of an ultimate synthesis of the first monumental forms and the latest advances in construction science.

### “Composition synthétique” and the halls projects

To illustrate the possible applications of his system, Boileau designs a series of architectural compositions of different scales. The project “Composition synthétique” published in 1853 in the *Nouvelle Forme Architecturale*, is similar to the stone version of the patent. This is a proposal

for a “monument of the religious significance of St. Peter’s in Rome,” which Boileau makes a model that he exposes and photographs (Fig. 4).<sup>7</sup> Unlike the patent plan which was a Greek cross, the layout follows a Latin cross. This raises the question of the capability of the pyramidal system of “voissures imbriquées” on an axial composition. The contradiction is resolved by a duplication of domes: one large, covering the transept, the other, more modest, providing the necessary development in the nave. The result of this association is perceived in the undulating silhouette of the building. The proposed solution for the dome also differs from that of the patent. Boileau’s proposition here is built in the form of an ellipse



Fig. 4: Composition synthétique, model (Ecole nationale supérieure des beaux-arts).

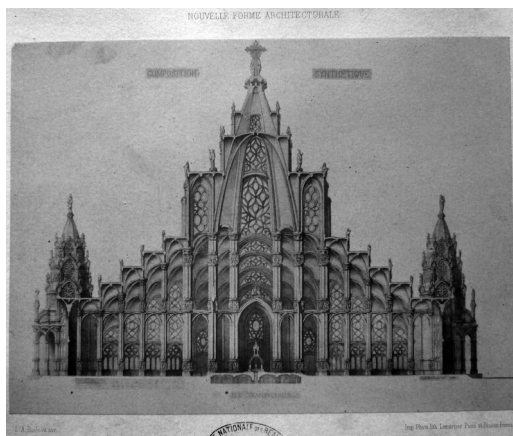


Fig. 5: Composition synthétique, section (Ecole nationale supérieure des beaux-arts).

or parabola (Fig. 5). This choice may reflect the influence of the architectural theories which considered the future evolution of the arc towards this type of geometry. At the time of Boileau’s designs, the *Revue Générale de l’Architecture* of Cesar Daly was particularly receptive to these ideas. It showed in particular, as an example of application of the elliptical arc, the parish church projects of Pierre Joseph Dubel, Francis Edouard Dainville, and Jean Eugène Fromageau (Daly 1847-1848). The solution devised by Boileau is however more complex. Its combination of an internal dome and a conical shape construction points, despite the style difference, to the system used by Christopher Wren in St Paul’s in London. In the 19th century, Auguste Ricard de Montferrand proposed, for the building of St. Isaac’s Cathedral in St. Petersburg, a metallic adaptation of this arrangement (Ricard de Montferrand 1842). Using an elliptical path allowed Boileau to influence the proportion of this device in the vertical direction to establish a unit in relation to its overall composition. With this combination, did Boileau hope that the weight of the conical shape construction could influence the lateral thrust in order to be channeled to the foundations? This order of solution is however revealing that Boileau tried here again, to exceed the comprehensive reference to the medieval architecture, to attempt a blend of many constructive traditions.

Following the instructions of the patent, the versatility of the system could address different types of programs. In preparation for the Universal Exposition of 1855, Boileau designed in collaboration with Albert Lenoir a “Palais pour les expositions des beaux-arts et de l’industrie” (Fig. 6)<sup>8</sup>. The project, whose drawings are dated July 1852,<sup>9</sup> again revealed a tension between the principle of generation of the structure and the axial dimension of the building. The composition proceeded by the assembly of pyramidal units, the result of which hold both the nave and the dome. Following this first project, rejected, perhaps in part because of the shape of the cover,<sup>10</sup> the architects design a second proposal (Fig. 7). The building, located along the Seine, responded this time to the request for a gallery annex to the Palace.<sup>11</sup> If again, the approach was not successful, it nevertheless offered an opportunity to improve

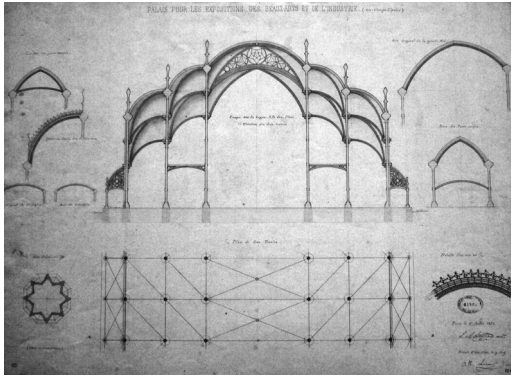


Fig. 6: Palais pour les expositions des beaux-arts et de l'industrie, 1852, section and details (Ecole nationale supérieure des beaux-arts).

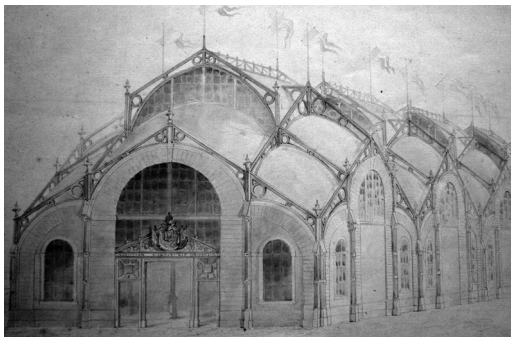


Fig. 7: Exposition hall project, 1854, perspective view (Ecole nationale supérieure des beaux-arts).

the system. The change seemed substantial enough for Boileau to consider it necessary to file a protecting addendum to his patent dated December 1854 (Fig. 8).<sup>12</sup>

The new part lies in a set of metal rods connecting the upper ends of the columns. These elements provide sufficient rigidity to resist thrusts of the vaults. Outside, they are reminiscent of the decorative cutouts that accompany the hips and valleys of previous projects. Their ornamental effect was coupled with a symbolic significance in that their design was also the structure hidden under the roof. In the improved proposal, the ornamental element was associated more closely to the structure. The strengthening of the system was certainly the reactions to objections against the general stability. It also marked a more personal concern of

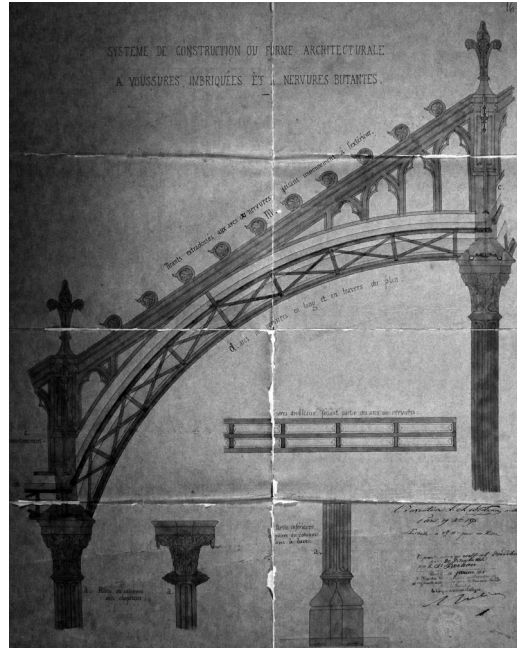


Fig. 8: Addition to the patent, 1854, construction details (Institut national de la propriété industrielle).

the architect in search of a vaulted roof, free of lateral forces. The emerging theme was still in relative contradiction with the idea of the “nervures butantes.” However, the question would still be raised and developed later in the system called “pendentifs à nervure.” Used in the construction of Sainte-Marguerite in Le Vésinet and Saint-Paul in Montluçon, the principle had little in common with the addendum of 1854. If not assigned to the structure, it was placed above the arches, having an important role in the neutralization of lateral thrust.

In the 1860s, the system of “voûtures imbriquées” was used a few more times. The project of a large covered room, exposed to the class of Fine Arts at the Universal Exhibition of 1867, was a very logical application of the principle.<sup>13</sup> The square plan was arranged diagonally, providing a perfect base to form the geometric pyramid dome. This unconventional provision also allowed the perspective effect to be amplified in the simultaneous dimensions of width and height. A variant of this proposal was also one of the few examples where the system avoids the use of columns, the roof

supporting itself by successive consoles.<sup>14</sup> A church project of the same period revealed the simplification of geometric plans.<sup>15</sup> In the nave, the pointed arc is replaced by semicircular and straight lines, reducing the number of ribs. Beyond the stylistic connotation which seemed to be changing, the project also reflects the experience of the architect in the field of steel construction. The combination of the parts becomes more complex, the principles of assembly are more precise, specific details of metalwork appear. If, in its early formulations, the system has a generic dimension applicable to both metal and stone, it became specific over time. The modularity of geometric forms presented from the beginning became suitable for industrial production of architectural elements.

For Boileau, inventing a new principle of construction came from the reading of history. Starting from the first ages and tracing the major steps of evolution, the author identifies the principles – in particular, the gradual reduction of structure – enabling him to understand the direction of architecture to come. In this process, the medieval period was strategically located, providing an end point as a new beginning. Although wanting to

retake, beyond the Renaissance and the Classical Age, the principle of the Gothic structure, Boileau's relationship to its source of inspiration was complex. If the system of “vousures imbriquées” was part of this relationship, it also went further away. In addition to the improvements put forward by the author, the principle found its originality in the organization of downward forces. Boileau replaced the medieval span with a modular combination where efforts followed a crisscross network of supporting ribs. From this followed the domed pyramid. The morphology of the structure must accommodate different pivotal axes when required by the program. This contradiction may explain the later subsequent search for other devices which were more appropriate to longitudinal arrangements. In the 1850s Boileau considered the implementation of his principles in iron or in masonry. The equal position he gave to the material reveals that the effort to systematize the forms does not fall solely in the context of industrialized building. His interest also lied in the resource of the compositional geometry, which could also determine the spacing of the structure as much as the symbolism of form.

## NOTES

1. In *Bauen in Frankreich: Eisen, Eisenbeton* (1928), Sigfried Giedion considers Boileau a “tireless champion of the introduction of iron” yet without developing any real arguments to his accusation. *L'Histoire de l'Architecture Classique en France* (1957) by Louis Hautecœur, does not show any more interest. The architect appears certainly a precursor to Baltard in Saint-Augustin, but without possessing its qualities of composition.

2. Patricia de Fougerolle devoted a major study on the successive careers of Louis Auguste, Louis Charles and Louis Hyppolyte Boileau (De Fougerolle 1993). The debate between Boileau and Viollet-le-Duc was presented by Bernard Marrey (Marrey 2002).

3. Boileau is said to have drawn in Buchez “most general principles” that he sought to apply. For the set of books written by people close to the philosopher, Boileau cites the *Manuel d'Histoire Universelle* by Auguste Ott (1840-42) or the work of Dr Laurent Cerise (Boileau 1853, 71-72).

4. Upon the publication of the *Nouvelle Forme Architecturale*, Boileau outlines the book he is preparing.

At this moment, the book is named *Du Progrès dans l'Art Monumental* and should be published by subscription.

5. “Table synoptique” in *Histoire Critique de l'Invention en Architecture*.

6. Patent under government guarantee no. 12778 filed 24 December 1851 and recorded 24 January 1852. Archives de l'Institut National de la Propriété Industrielle.

7. A detail drawing that appears to relate to this project is dated 1850. Fonds Boileau à l'École Nationale Supérieure des beaux-Arts de Paris, Catalogue n° 3286.

8. In 1852 it was decided to build on the Champs-Élysées a permanent building to house national exhibitions as well as various festivals and events.

9. Fonds Boileau, Catalogue n° 3372, 3373, 3374, 3375, 3376, 3377, 3378.

10. So says the report of the Conseil général des bâtiments civils cited in the *Nouvelle Forme Architecturale*.

11. Fonds Boileau, Catalogue n° 3379, 3380, 3381, the perspective sketches are dated June 1854.



12. The addition consists of a short one-page leaflet and a board. Archives de l'Institut National de la Propriété Industrielle.
13. Fonds Boileau, Catalogue n° 3289 et 3290, documents dated 1864.
14. Fonds Boileau, Catalogue n° 3291, 3292 et 3293, published in l'*Histoire Critique*.
15. Fonds Boileau, Catalogue n° 3294, 3295, 3296, 3297, 3298, 3299 (1866), 3300 (1866), 3001 (1866), partially published in l'*Histoire Critique*.

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