The formal unity of aerial vault’s texture: The «trompes».
The role of traditional «trait géométrique» for trompes’ design in the perspective of the employ of modern CAD/CAM project/execution processes

Giuseppe Fallacara

This paper empathizes some theoretical/practical points connected to stereotomy, understood whether as a rigid rationalization of constructive method, or as an efficacious project/composition tool available for architects. This study follows the cooperated analysis of two works of Philibert de l’Orme; the 1st one, written 1536, is the juvenile one, the 2nd work is the one of the maturity written in the 1567.

The analysis has been made comparing the reasons of the classic stereotomy with the current cutting solids methods, pointing out conceptual continuity and affinity sure interesting for a researcher of the subject.

STUDY CASE. LION: PHILIBERT DE L’ORME AND LES TROMPES DE LA GALERIE DE L’HOTEL BULLIQUID

This case of study about the galerie de l’hôtel Bullioud 8 rue Juiverie built in Lyon in the 1536, is paradigmatic, considering stereotomy as the art of regulating.¹

A gallery between two cabinets supported from a trompe, should regulate a small irregular medieval court. (Fig I)

If the gallery concept is not new and is proper of the tradition of Lyon, everything in the processing of this program is new.

The Architect lets the power of his imagination go inside a rational universe.

I’ve done this work in the 1536, as soon as I came back from Rome and form my Italian journey.

There I attended my architectural study. The two trompes have made for the general of Bretagne, Monsieur Billau, in Rue de la in Lyon (P.de l’Orme 1568 L IV, c II, f 90)

Only recently, starting in the 1964, with the Malaux low of the 1962, that the vieux Lyon is
classify as one of the first sectors to safeguard in France. The Société d’Économie Mixte du Vieux Lyon starts projects for the restoring different buildings. The commune (municipalité) establishes in the 1977 a program for popular house that includes the «hotel Bullioud». From the 1983 to the 1986 Jean Gabriel Mortamet, main architect of historical monuments, and Michel Allemand (HLM Society), restored the Philibert de l’Orme’s gallery and 31 apartment houses more. (J. Salmon, J.L. Schefer 1989)

The trompes

Most of you are asking, what I mean when I speak about a trompe, this term is used only from the insiders and so, because of that it is, just known from a few person, and from nobody of the now constructors. So I want to be clear with the Reader, I would like to warn him that, probably the word trompe, the one that we use here, better, we abuse, comes perhaps from the similar structure of a trumpet. Because both are large in the front and close in its self like a vault. (P.de l’Orme 1568 L. IV, c 1, f 89 v)

In these sentences, the author compares formally the musical instrument, the trumpet, to explain the geometry of the architectonical element, which at that time was known only by a few master masons.

All vaults can be made as a trompe and all can be hang byair, without any support, except the two walls that create the angle; all this with a unique trait method. (P.de l’Orme 1568).

A. F. Frézier in his book (A.-F. Frézier 1754), for the term Trompe he writes: « normally is a semi conic vault that shows us its base (the talks about the sectioned solid, with a plane passing through the vertex)». There are different kinds of tromps and their names comes from their functions or from their forms. For what concerns forms, there are conic and spherical trompes . . . When the face of one of this two is convex the trompe is called en tur Ronde; if the face is concavo we will have a Trompe en tour creuse; in case we will find an interrupted front because of level surface, the name is trompe a pan; if springers have different high we’ll have a rampant Trompe; if we have got an undulated face and more a rampant springer the name is Trompe d’Anet. Taking a look to the main configuration, in case we have a cantilevered Trompe, we call it Trompesur le coin, on the contrary, if curve inwards Trompe dans l’Angle. When we find the name Trompillon: that is the beginning of a Trompe, which is placed, in the spherical trompes, on a cone’s vertex, in the conic Trompes and on a sphere’s pole. It is only stone ashlers that take the space of most of all the conic vertexes. These vertexes otherwise could be as sharp, as not to be possible to cut, avoiding the risk of break.

Jean-Marie Pérouse de Montclos (J-M P. de Montclos 2001): in the chapter dedicated to the Trompes, remind that this kind of structure has been developed in European architecture in the 2nd part of the XV cent. It means that Philibert de l’Orme was not the first to use it (trompe de l’hôtel Pincé a Angers, or hotel Cluny in Paris). But surely was him to create a theory about them. When (P.d l’Orme) he writes about, and when he creates the «trait» on the maison Buillion yard, he talks about the geometrical tracing that gives the possibility to . . . on les peut faire toutes . . . this is the reason for which le trompes are prototypes.

Time ago, in Lyon, I project and 1 superintended works for two trompes, they were really big and complicated, because of the narrow space where they had to be

Figure 2
Drawing by the author (June 2002)
The formal unity of aerial vault's texture

construct; more, if one of these is rampant, sagged and curved on the front, the other on the opposite corner, is round on the front and of vast dimension. On both the trompes was erected some cabinets, connected by joining gallery from a trompe to the other: this all was hang by air, to give a possibility to connect one part of edify with the other, obtaining so cabinets for rooms. This job let this space became comfortable and strong; otherwise it would be uncomfortable, because of the that is too long and narrow. (P.de l'Orme 1568 L IV, c I, f 90)

The two trompes supporting the cabinets (the south one and the north one, on the left and on the right of who looks at those, by the front) are the tur Ronde kind. The south one is the already known from the freemason's corporations, de Montpellier (fig2), the north one is the one that has got more variants, Philippe Poité: (1536), notices that this is invention of the trompe of the Hotel Bollioud. Philbert gave a variant only for the curve, in the vertical plane, defining the cones generatrix. This in place of the semicircle will be described from a sagged and rampant arch.

The trompe de Montpellier, writes Jean-Marie Pérouse de Montclos (J.M. Pérouse de Monclos 2001, p125), is a famous variant of the trompe en tour-ronde. The archetype lain in rue de l'Herberie in Montpellier. The name comes out for the first time, without any comment, in Chereau.


About the first kind he says:

A trompe is called en Tour ronde, when on the vault is possible to built a cabinet, or something that could be assimilated at a round form.

About the third he write:

This Trompe is called de Mon-pellier, because in the town of Mon-pellier exists a trompe like this, is beautiful and known among masons for its beauties and elegance.

Jean Baptiste De La Rue, Traité de la coupe des pierres, Imprimerie Royale, Paris 1728. trompe di Montpellier tav. XLV (there is nothing as difficult as get round the tops of ashlers, the one typical of la tour ronde, I hope with this words a to explain it.), he explains properly how to proportionate the different parts.

This specimen is finalized to:

1) Rising the ideal/geometrical model or the mathematical one of the trompes in the galerie de l'hôtel Bullioud, voicing with different traits géométriques belonging to the trait method of the trompe d’Anet showed from P. de l’Orme.
2) Erection of the prototype of a trompe, lain on the south of the gallery of Lyon, this with the CAD/CAM process (virtual/real model) with the intention to use a quantitative/qualitative verifying program method.
3) Make the tension-computerized analysis of the geometrical model, verifying format compatibility of exchange data, making a quantitative/qualitative analysis of the architectonical element.

From the relief to the theoretical model: numerical model and mathematical model

Informatics models can be united in two families: the numerical models (point clouds of laser scanning, manual relief), and than the mathematical models (or theoretical) (R.Migliari 2002).

«More: is necessary to start the relief's study with regular geometrical solids . . . » (C. Boito 1881 pp16, 22)

The relief of the southern trompe of the gallery of the hôtel Bullioud 8 in rue Juiverie in Lyon, has been made following a particular methodology aimed to the retrieval of point in the space, these points were referable to the Cartesian coordinate through opportune triangulation. Tanking this method we obtain the numerical model of the intrados of the trompe, made by a discrete model «iron wire», that interpolates the different point relieved through a connection with a line segment.

This model moving from the idea to the realization, loses the original pureness of its planning conception, keeping construcitive deformations.

One of the most common theoretical/practical points in architecture is the distance between the
designer engineer and the executants. This obliges to considerate all the variables during the realization . . . how match this distances reduces its self, as match will determinate the condition for the realization on the work (C. D’Amato 2002).3

The author do not describe the rule of the project, but the condition of the realized work, so this is first way to rise to the pure scheme of the project and its theory (geometric model or mathematical model), to get it realize.

The relief has been made on forms of the architeconical elements seen before, the trompe, has been compared to a semi conic vault.

Properly the stereotomic6 element is comparable to a slantwise conic surface,7 generated from a semi circumference direttrix (defined in a second moment of the relief), and from a segment line generator, this is the vertex of the element. All these lies in the perpendicular plane at semicircumference direttrix (that is the base). The conic area lain on the way in which the semicircumference direttrix extremes and the vertex line on the same horizontal plane. It means, for what we’ve written above, that the base is perpendicular to the aforesaid surface.

The monument intrados (the conic surface) shows the connecting joints of the ashlars of the trompe, which can be comparable to the generator segments of the conic surface.

The Cartesian area to find the points is made of:

- A horizontal plane passing from the vertex of its conic surface and the base’s semicircumference extremes.
- A conic discretized surfaces (underlined from the ashlars contact joints).

As it is shown in the figure, the point A (characteristic for the intersection curve between conic surface and cylinder), in this method there is a double triangulation AVB, BVD, c/o AVB, BVC. (fig. 3)

The data table to find the numbers of the contour points of the trompe (intersection curve) is composed by 3 columns (to locate the point, the vertical triangulation, horizontal triangulation), and 17 lines (for the numbers of the ashlars of the trompe).

For a proper geometrical analysis (tomomorphologic) of the monument, the numerical coordinates, the one in the table, have been converted in a digital three-dimensional model, easy to analyze.

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The Delormian method: trait geometrique of the trompe d’anet, codified in le premier tome de l’architecture

On the trompe vault that I project and that I make erect in the Anet castle, to connect a cabinet to the room where took Hers journey, Her Majesty King Henry. (P. de l’Orme 1568 L IV, c l, f 88 r)

And it seems to me a good idea to create an aerial vault, to find comfortbably the place were to locate the cabinet. (P. de l’Orme 1568)

In the trait géométrique we find the geometrical model of the trompe, better, of all trompes, the same method already known from the hands of that age, and so is possible to combine in an infinitive way the three basic elements of the trait geometique: two horizontal sections, and a vertical section.

The novelty dwells in the attitude of de l’Orme, to figure out forms and architeconical characters in the pre-realization phase; now the attention moves on the project and on the control of it, match more than on the graphic strategy finalized on solving the practical problem.

In this tome we find the most charming treaties of
the 1522, about the creation of the trompe of the cabinet for King Henry in the castle of Anet (fig 4) (so we will not find the trait géométrique of the 1536).

The project / composition kind, is evident in the three sections shown in the graphic. Changing these is possible to have infinitive configurations of trompes (fig 5). The first section is the horizontal one, between the two walls, with a recto angle springer (not properly, because of walls deformations caused during the building) of the trompe. The second section is the horizontal of the building (cabinet du roi), which should be erected by the trompe, and particularly talking is a mix-line. He changes the way to draw, to design in that age. He employs his Italian culture. He changes the normal circular or squared plant typical of the age. The employing of these models is reserved to the sacred architecture; the trompe has on it the cabinet of Henry the II, sanctuary of his reflection (P.Potié, pp99–100).

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To rise now to the geometrical rule that preside the construction of the trompe, we’ve written about, we have to suppose to follow a deductive process for which the trait of Lyon trompe is structured as the back of the trait d’Anet, so: decrypting the geometrical model of the second one (existent the trait, inexistent do the monument), the numerical model of the first one could be interpreted in a proper way (inexistent the trait, exist the monument).

We finalized this compare to the analysis of these two models: The theoretical one and the physic one. The first one has got an opportune critic interpretation; the second one instead has got a right critic.

Analyzing the trait géométrique of le trompe d’Anet is possible to make an hypothesis about the method that Philibert de l’Orme proposed. With it de l’Orme hoped to decrypt the graphic. The intention was to have a punctual comprehension of the all parts that took part to the project/realization of the trompe.

We can finally find a triple kind of the trait:

- Project / composition kind
- Static / constructive kind
- Graphic / operative kind

Project / composition kind

Static / constructive kind

Graphic / operative kind

The third section is the vertical one (overturned on the horizontal plane), the one of the intrados of the conic vault, which could be compared to the directrix curve of the conic surface. Correctly talking is an oval arch turned to vertical plane to become rampant.

As is easily possible to understand, the three section’s interpolation, defining the monument d’Anet, are at the same time the exemplifications of the main method to construct a trompe.
The static / constructive kind is evident, in the structural section of the rampant arch. Here the structure is more stressed part and, is possible to notice the ashlar thickness, this sections corresponds to the larger structural span, beyond which level surface the vault is cantilevered. De l'Orme in this section draws the ashlar (7 for Anet), whit joints that probably were perpendicular to the tangent to the sub-divisional points of the rampant arch. Is interesting to notice how to set the graphical elements of a trope, this section could have made on all intermediate vertical levels, present between the vertex and our section, without giving any problems to the structure of the trompe. Statically the element increases its value, noting that this structural section has been built where there was the largest distance between the vault’s supports. Verified the thickness hypothesis of the vault, is possible to verify all the static system. These proportions do not absolve all the static problems; we still can not have the condition to verify the cantilever of the trompe; in fact they have no empirical relation with the proportions of the elements.

The graphic / operative kind is clear from graphical traces of rotation and overturning of the line segments (that are the generators of the conic surfaces), with the aim to determinate the lengths of these.

Is possible to observe that the vertical section of the rampant arch is essential to the erection of the center’s trusses. These support the ashlars during the vault assembly.

To permit a good construction of the vault the wood trusses, need to follow the directorix curve of the vault.

Now to have a unique trompe of Lyon, whit the Delormian method, «the three sections interpolation», we can rise to the only data not reliavble on the monument. The vertical section of the intrados:

1) Horizontal section of walls springer: from the relief
2) Horizontal section of the cabinet: from the relief
3) Vertical section of the vault's intrados: indirectly drown

This last work has been made making sections from the discrete model that we obtain from the architectonical relief. This section almost correspond to a discretized semi circle, we suppose that in the ideal project this section would have be a semi circle.

All these data give us the possibility make hypothesis about the traits géométriques the two trompes of Lyon (fig 6) Is precious to note a similitude of the trait of the south trompe with the trait of a pechina tore ridonda enbiaje, illustrate in the manuscript of (A. de Vandelvira, 1575–1590. f. 11 v).

Figure 6
Drawing by the author (June 2002)

Now we continue with the graphical modeling of the trompes and with the error analysis between ideal model and the model of the work construct.

The overlying of these models show us how those two are really similar, underlining the coincidence between the theory of the project and the perfect execution of the stereotomic architecture.

Informatics modeling process and CAD/CAM prototypes and CNC* machine. Lyon; South Trompe

On the BF line you will do a rampant arch as it is possible to see from the figure, it has to be made of seven pieces, identified by numbers. In any case you could do the arch
of as many pieces as you would like, because as much will be the number of these pieces as resistant will the vault of the trompe and sweeter will be its line. (P.de l’Orme 1568 IV, III, 92r)

The method, that de l’Orme suggests, for the trompe erection needs for the aerial vault a discrete method of the intrados conic area. This condition is clear: «as much will be the number of these pieces and as much will the resistant at the same time will be the vault of the trompe and sweeter in its line». Tracing of the vertical section, the rampant arch, follows the involutional time for what concern the theoretical point of view: the moving from continuous to discrete. This section is sub-divided in a finite points numbers with the consequence the sweetness of the intrados area of the vault is proportional to the points quantity. Even the static resistance enhances with the increasing of ashlers subdivisions. Is evident that in this way there is a better resistance of the ashlers with smaller dimension.

We can distinguish two different theoretical/practical informatics elaboration: a discrete one and a continues one (mesh e nurbs) the first one is subdivided in triangular faces of the conic vault; the second one has no continuing solution on the vault surface. (fig 7).

More: the first get approximate to the geometrical place of the second.

In the manual execution of the trompe ashlers, we follows the first method, but in informatics is easy to work with both methods, to see what the limits are at the discrete model, and how those limits are accepted by human eyes.

In any case the three-dimensional CAD can define the geometrical model that is on the base of the following actions.

To create the south trompe prototype with CAD/CAM techniques and with the CNC machine, we operate with the discrete modality according to the delormian method, with the aim to verify the esthetic quality.

We passed from discrete model of the intradossal/ extradosal conic surfaces to subdivide the trompe ashlers. (fig 8)

Working with different informatics modelers is possible to read, through the format (for ex: IGES = Initial Graphics Exchange Specification) the three-dimensional geometrical conformation and than going on.

As first; reshape and locate ashlers on the machine.

The proportional reshape of the trompe has been
made considering the largest dimension connected to the working limits of the CNC machine: 5 axes EASY 11\textsuperscript{13}.

Considering this the best scale ratio results 1:4.7.
It means that the prototype is five times littler of the original, having consequence on the material choice\textsuperscript{14}; the prototype's scale has to follow the scale reduction to verify the esthetic and the quality of the work.

During the CAM project, we meet the first problem when we had to fix the row material on the machine. In this context an important role has the under-piece. The under-piece can have different conformations especially in the case in which the prototype element hasn't any support level surface. In this case is possible to analyze a trompe ashlar modeled whether with the discrete modality or the continuous one: conic Intradosal /extradosal surfaces with continuous modality, leveled areas with discrete modality, contact beds for leveled joints of both modalities.

It is evident that working with a continuous modality is more complex, especially conforming the under-piece as a conic surface (even a changing one) in the upper part of the support.

Working with discrete modality the Intradosal /extradosal surfaces of the vault reduces its self to level surface, positioned on a parallelepiped form under-piece. To optimize the process the under-piece was 76.75 × 27 × 5 cm to let, all the 17 ashlars of the trompe be anchorage (the dimension –the length- of these is 32.43 cm < 1 < 60.86).

The blocking method is given by an air pump; this is the most flexible method, in this way is possible to use rows of different size, with the only condition of a level surface.

Then we choose proper cutters,\textsuperscript{15} for this program: the geometrical kind of the object, the processing method, the materials used, the velocity of the cutter rotation.

The processing method

1) Flattering of the 3 axes row piece to have the ashlar’s thickness
2) 5 axes Processing for cylindrical surfaces of ashlar’s top
3) Versor rotation for the ashlars contact bed processing, and for the bordering process with cylindrical cutter.

To find all parameter of the CAM we create a file postscript NC, readable from the machine controller 5 axes EASY 11, we used for processing.

Each ashlar has been processed at the velocity of 40° each; 25° to assemble it; 15° for shaving removing. (fig 9)

All the ashlars have been assembled in the trait géométrique, and then reported on forex support as horizontal springer of the vault aims to compose again the formal unity of the vaulted system. (fig 10)

In this way the trompe is analyzable under different points of view, geometrical / formal /static.

Figure 9
CNC Work phases for the prototype’s realization of the Trompe (Laboratorio Cad-cam, Dipartimento ICAR, Scienze dell’Ingegneria Civile e dell’Architettura, Politecnico di Bari, June 2002)

Scale ratio and tensional analysis

If these walls gave me enough trust, I would have build as long as the line AD was, instead ten or twelve feet, I would have done it twenty or twenty-four . . . So, on it I erect a cabinet, I am really proud if it nowadays is not possible to see cantilevered overhang that big. (P.de l’Orme 1568 IV, II, f 90–91)

Thanking these data is possible to rise to a real dimension of the trompe d’Anet, so is possible to
I notice that no one of the masons had heard about trompe like the one I project in Lyon, reduced, undulated rampant, with almost three quarter of the circumference overhangs. (P.de l’Orme 1568 IV, II, 91r)

Is necessary to observe that for what concern the trompe d’Anet the longest ashlar on the generatrix AD, has got more of the haft of is length out of the projection of the wall’s springer. (Fig 11)

With opportune vectorial data conversion techniques is possible to read the geometry of the Lyon trompe and so apply a tensional analysis.16

The trompe model has been analyzed, with the aim to individualize the global static of the monument, having the help of the analysis software.

We did an accurate static analysis of the three-dimensional structure. We used as first the discrete method for shell quadrangular elements, with linear elastic behavior. This kind of behavior for stone elements is justify by a low tensional state of those.

The theoretical base of this software is based on matrix analysis of the structures, using bi-dimensional elements «shell kind» under superficial force actions, coming from perfect joint of elements.

<table>
<thead>
<tr>
<th></th>
<th>Trompe d’Anet intrados (we deduct from the treaties)</th>
<th>Trompe south Lyon Intrados (from relief)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longest ashlar</td>
<td>3,90 m</td>
<td>2,94 m</td>
</tr>
<tr>
<td>Longest ashlar out of the wall sprinter</td>
<td>2,14 m</td>
<td>1,00 m</td>
</tr>
<tr>
<td>max h from the wall sprinter</td>
<td>3,15 m</td>
<td>1,95 m</td>
</tr>
</tbody>
</table>

make a physical compare with the south trompe of Lyon.

We now that: a French top = 1,949 meter = 6 feet (16)
A French foot 0,3248 meter
The variation of the ashlar length (AD 10 – 12 feet) is 3,248 m < 1 < 3,90 m
Considering AD = 12 feet = 3,90 m; is all the weight and the forces unload oneself on the corner, even tipping on, without collapse, if everything has been well done. (P.de l’Orme 1568 IV, II, 90r)

Figure 10
Prototypes of the Trompe (Laboratorio Cad-cam, Dipartimento ICAR, Scienze dell’Ingegneria Civile e dell’Architettura, Politecnico di Bari, June 2002)

Figure 11
Drawing by the author (June 2002)
To better understand the elastic characteristic of elements, we took as reference stones with coefficient of elasticity $E = 200,000$ Kg/cm², weight $P = 2800$ Kg/m³.

The model has been developed on a bound hypothesis of a perfect joint on the terminal section of the vault. The statically analysis, done automatically, determinates the calculus and the assemblage of the rigidity matrix of every elements on the memory available on the computer.

From the tensional diagrams is possible to observe two different effects:

In the radial direction the normal tensions are related to the overhanging behavior that brings tractions to the trompe extrados (these are at the maximum in the central area near the joint).

In the direction of the circumference is evident the oblique inflexed effect. The system give the possibility to unload some of the load, that otherwise would remain only in the radial direction, increasing the traction solicitation. In this way is created an arch effect that moves the load on the extern part of the vertical supports. In the case in which there is a load concentrated on a extern side of a trompe, these benefit reduce (fig. 12)

**Critical Observations and Final Considerations**

**Biuniqueness relation between trait geometrique method and prospective representation**

Is possible to think how the kind of the trait can have a so strange develop. (P. de l’Orme 1568 IV, I, 88 v)

I wanted to make it more difficult and with a strange form to let it have nicer a form to see. (P.de l’Orme 1568 IV, II, 89 v)

The prospective representation (P. de l’Orme 1568 IV, II, 89 r) of the cabinet du roi illustrated by Philibert de l’Orme give as the possibility to make some consideration on the relation between the trait geometrique (P.de l’Orme 1568 IV, II, 92-93) and the architectonical composition of the monument. First of all he thinks or not if the bi-dimensional rule of the trait is on the base of the project of the monument of vice versa if this is just a consequence of a rationalization of the control rules during the executive phases of the work.

Considering that the draw illustrated in the treatise is successive to the cabinets realization, is possible to think on some hypothesis:

1) The representation, refers to a draw of the cabinet, in which the formal intentions of the designer engineer are evident, and this before the editing of the trait geometrique

2) The prospective representation was made on the site, when the work was complete, so it describe the monument in all his parts, from the theoretical/constructive elaboration of the trait geometrique

3) The prospective representation has been made from an engraver, that didn’t now the trait geometrique and finalized his draw to a representation the work for the treatise

In the first hypothesis the trait geometrique would follow the spatial disposition of the designer engineer, being so the rational means of the executive control of the work.

In the second hypothesis, it should admit that, even if the prospective representation is perfect, there is not correspondence between trait geometrique and reality. This hypothesis contrasts the one of de l’Orme but agrees with this paper.
The third hypothesis there is no intention to finalize the graphic method of \textit{trait géométrique} to the project/creation of architectural stereotomic form, the homological passage would have be evident between the \textit{trait} and the prospective representation; and it doesn’t happen. (T. Maldonado 1998 p. 101)

Reminding what Camillo Trevisan wrote, that in the f. 106v of his treatise de l’Orme complains about the modest quality of the draws, giving the guilt to the engravers.

J. M. Perouse de Montclos: «le graveur dont de l’Orme se plaint, n’a pas su représenter l’ouvrage».

Philippe Potié underline that the delormian project hypothesis has got an anticipation rule on d’épure, comparing it to the spatial project. (P. Poiré, insc.101)

The form of the projected object is the consequence of choices made on the épure constructive tracing.

Now the pre-figurative intuition of a spatial curve, as the result of intersections of surfaces and different solids is difficult: the method assures a rational answer about the execution/realization of the work, but not on the aesthetic control of the form; because is not possible to have a three-dimensional vision of the work but only the bi-dimensional one. Is not difficult to believe the figurative capacity, of spatial curves, increase proportionally using the \textit{trait géométrique} method, in this way is possible to get under control forms in the spaces, at the same time using parametrical/variational modeling techniques effects are amplified.

The analogy between the delormian method and the solid parametric modeling techniques, based on feature\textsuperscript{9}, applied on stereotomic elements, assure the novelty and the continuity of results. (fig 13)

The deep synergy between techniques, processing and theoretical/applied instruments, leads us to think about the way to project and to analyze a planned work.

This is my contribute\textsuperscript{10}.

\textbf{NOTES}

1. Regulating; or accomodare, from latin \textit{commodus}: adapt.

2. For what concerns la cupe de pierres, and generally all draws that define a vault, could they be on plant, prospect, section or developed. This term has a largest meaning than épure, because we mean the draw whether on a natural scale (1: 1),or with reductions. Normally the épure is only on natural scale. A.F.Frezier 1754.


6. The geometrical conformation of the trompe is given from the intersection of a particular recto cylinder and from a particular slantwise cone.

7. References to the «trompe réglée» the flated trompe A. ch. D’Aviler, \textit{Dictionnaire}, article trompe

8. Two horizontal levels lying on a surfaces and a vertical overturned on the horizontal level.

9. Infinitive antichill three, for how many parameter there are in the function/\textit{trait}

Is possible to individualize 5 graphic methods for drawing a rampant arch, to have harmonic proportion between parts. *Tratado práctico de Estereotomia, aplicaciones al corte de piedras, maderas y hierros.* Por Francisco Ponte y Blanco, *La Coruna, 1921*

12. CAD = Computer Aided Design, CAM = Computer Aided Manufacturing, CNC = computerized numerical control

13. EASY 11 (E = Opened structure, moving desk 30° inclined, l = single desk, l = processing unity. Different kind of movements, m. longitudinal (axes X), m. transversal (axes Y), m. vertical (axes Z). Length of axes: X = 1000mm; Y = 1200mm; Z = 650mm; C45°; B = +/- 160°; max velocity 24000 gir/min.

14. To construct the Lyon gallery Philibert chooses a local stone, Oolitic limestone, better known as the lucenay stone. The caves situated near Lyon had always been used for elegant building construction. The material used for the prototype is polystyrene, with a density of 30 Kg/cm.

15. Tools kinds: 1) cutter for forms; 2) cilindric; 3) spheric. Normally cutters are used at the end of a work and working on borer an on engraves

16. My regard goes to the eng. Giuseppina Uva researcher at the Politecnico di Bari Facoltà d’Architettura, and to the eng. Girolamo Fallacara expert in geometrical modeling finalized to the structural calculation.

17. French foot = 0,3248 m, Vineies foot = 0,3161 m, Spanish foot = 0,2786 m, roman foot = 0,297 m, roman palm = 0,223 m.

18. Is necessary to observe that the Boolean operation of union, subtraction and intersection between solids, the one that has nothing to compare with the intuition is the third. Because the point in common with the solids are inner within the solids.

19. This processing method changes the boolean operations in primitive. A feature is a solid processing event, and it doesn’t lose ever its intrinsic characteristics. Dipartimento di Meccanica e Tecnologie Industriali - Università degli Studi di Firenze

20. The paper summarises some aspects of the on-going Doctorate dissertation the author is carrying out at the Politecnico di Bari, and titled *L’unità formale nell’apparecchiatura di sistemi lapidei. Dalla natura sineretica della modellazione digitale alla progettazione/costruzione di elementi architettonici di pietra.* Tutor: Prof. Claudio D’Amato Guerrieri, Politecnico di Bari. PhD Course in Progettazione Architettonica per i Paesi del Mediterraneo, ciclo XVI.

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