TWO VIOLIN FORMS:
COMMENTARY AND ANALYSES

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THE HISTORY OF VIOLIN DESIGN, A BRIEF INTRODUCTION

The two instruments whose outlines will be studied here were built by Stradivari and Guarneri del Gesú during the golden age of violin making which occurred between the years 1650 and 1750. The analysis of these two forms will also provide an opportunity to explain how this pinnacle era also fostered the decline of the geometrical approach.

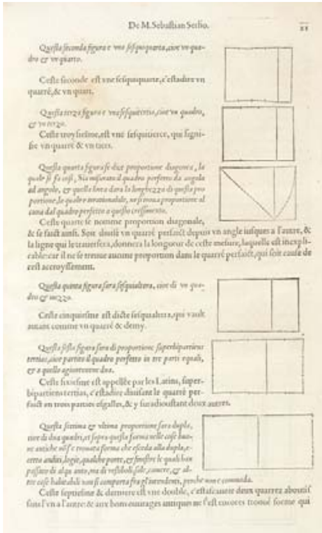
The acoustical and technical procedures involved in the birth of the violin are part of a creative evolution which, from Antiquity, blended contributions from East and West. These innovations were developed in the medieval Iberian Peninsula, where Greco-Arab, Greco-Latin and Jewish cultures[1] co-existed, and where even more ancient geometric principles were common knowledge. These older principles will be shortly introduced in this paper.

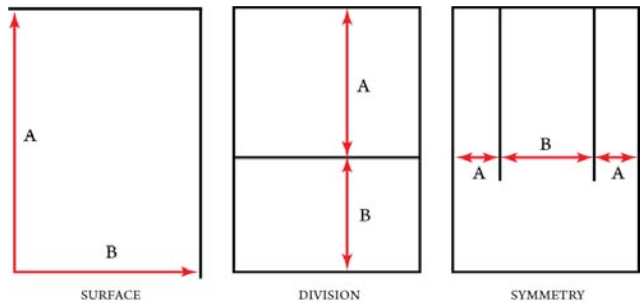
The archives of Toledo Cathedral in Spain provide us with unique information on the subject. Indeed, a notarized document from 1627 describes the content of the examination taken to obtain a Master's degree in musical instrument making. This document states that the candidate should know how to draw the patterns for a vihuela, a harp and all of the instruments of the violin family (soprano, tenor, contralto, and bass), using only "a compass, a ruler, and a t-square, the use of any template being prohibited." [2]

For a contemporary understanding of the nature of the procedures used by the master luthier candidates at that time, we must be aware of the essential points that separate us from them. A genuine archaeology of their construction methods is necessary if we want to understand the subject. This requires setting out some basic principles about ancient design procedures.

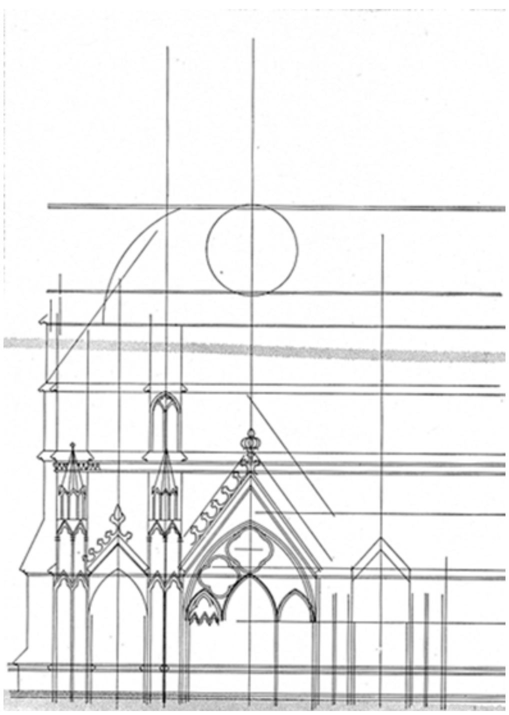
SOME DESIGN CONCEPTS RELATING TO MUSICAL INSTRUMENTS

When the use of the compass was still commonplace, designing an object consisted of defining in a pragmatic way the limits of what one calls "the whole and its parts." [3] The plan for creating a bowed or plucked stringed instrument is transcribed onto a single organized surface that we will call the framework. This layout, its divisions and its symmetry, rests on three types of relationships between two joined dimensions. [4]





Different types of surfaces.
(after S. Serlio)



The Rheims palimpsest is one of the few surviving plans of a mediæval cathedral. It clearly shows up a framework and should be read from right to left and from top to bottom. It shows the different stages of design, beginning with the most general relations and ending with details of the decoration. Rheims, City Library.

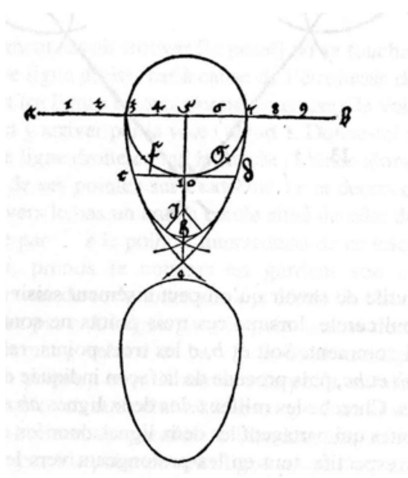
Every manipulation of the ruler or the compass brought into being one of these three relationships, so that the combination of dimensions was the expression of an operative logical order. These are the various procedures that the ancients called "measuring."

Remark:

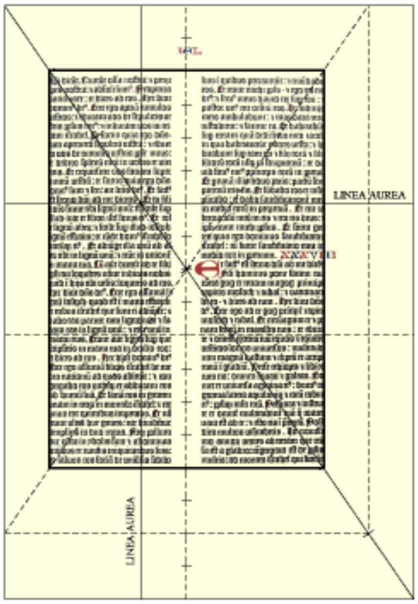
The vitality of these geometrical processes reflects the constraints imposed by oral transmission of knowledge and, therefore, they would not have long survived its disappearance. At the end of the Middle Ages, two events would shake the foundations of seemingly solid concepts. This first blow was delivered by the invention of the printing press, which caused a significant decline in oral communication. The second blow came from a small number of scientists who began to question the restrictive nature of the philosophical principles in their disciplines. In the Renaissance, the relevance of certain principles relating to the concepts of measure and proportion came under scrutiny. These developments came first to the intellectual classes, while craftsmen (such as luthiers) were spared their effects until some decades prior to the industrial revolution. The geometry of the violin must be seen as the ultimate extension of certain ancient principles. The depth of these roots partly explains our difficulties in reaching them.

NOTIONS ABOUT THE DRAWING OF CONTOURS

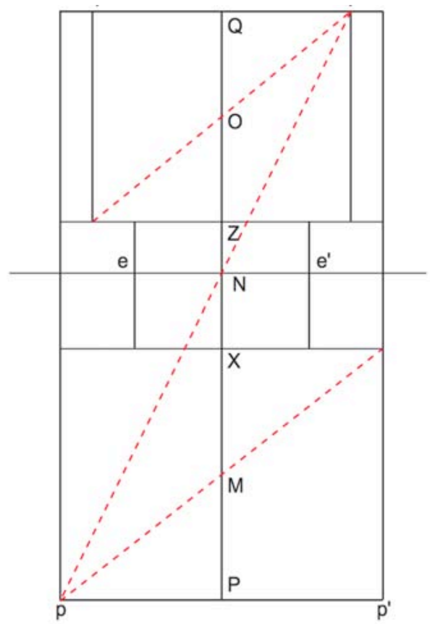
With the exception of the lute, which has a particular elliptical shape, the contours of stringed instruments are composed of a series of circles. The values of the radii of these circles correspond to the distances between the divisions on the axes, and the limits of the contour are naturally those of the surface on which the drawing was made. In the documentation that has come down to us, this technique is usually illustrated with the drawing of the ovum (egg shape).



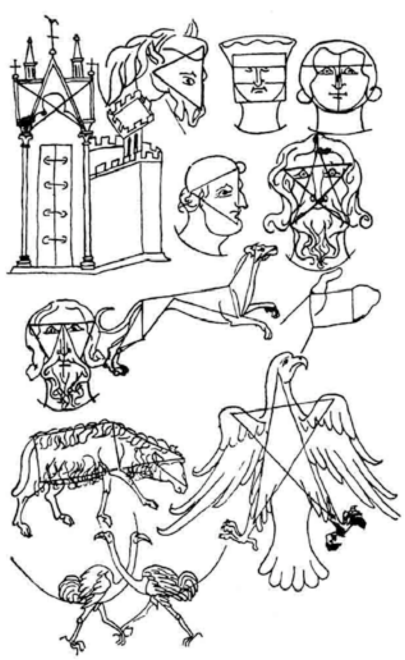
Both Dürer and Serlio introduce the principle of drawing arcs taking the ovum as an example. The construction begins with the divisions of an orthogonal frame. The radii measurements are based on the approximations of the harmonic section.



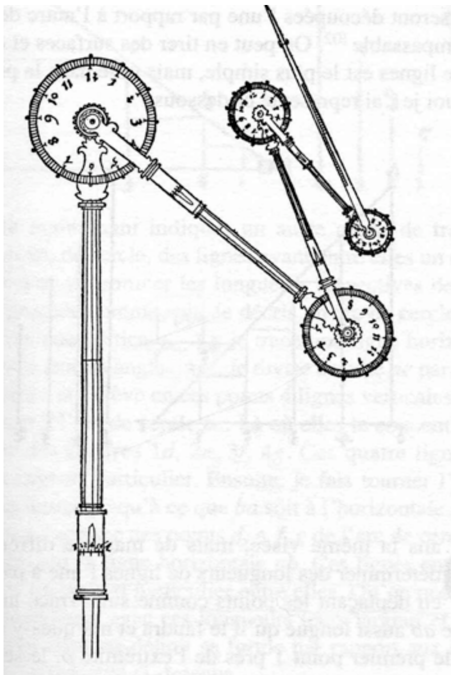
It is known that diagonals were used to set type in the earliest days of printing. This page of the Gutenberg Bible illustrates this principle. (after Adolf Wild, Cahiers de GUTenberg no. 22, 09/1995)



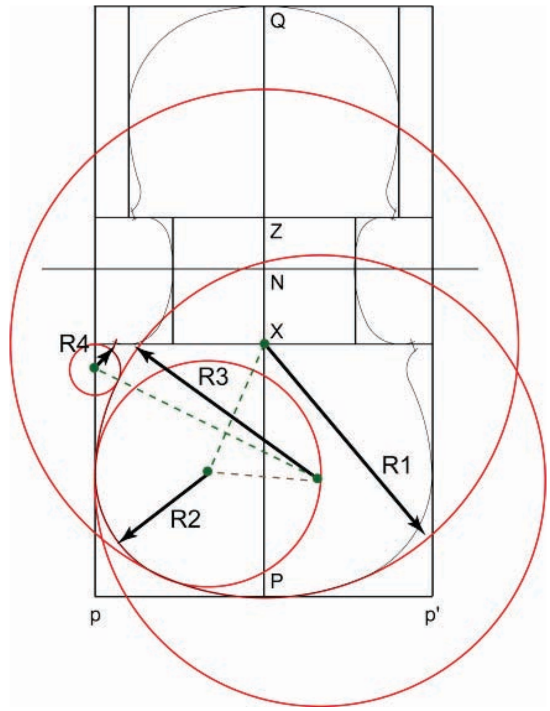
Example of Maggini's framework. The principal widths of the form (points M, N, O) are set by diagonals following a process met also in the Biblical page layout (see to the left). Brescian instrument's proportions clearly apply to the exterior contours rather than to the molds as in Cremona. Nonetheless, the guiding geometric principles are the same.[5]



Example of the use of diagonals to apply proportion to figures.
(After Villard de Honnecourt, 13th century)



Articulated tool used for tracing curves.
(from Dürer's Geometry*)*



The framework can be broken down into a series of segments made up of the radii measurements (ex: R1=XP). These radii are linked together by their centers, in the same fashion as an articulated arm (illustrated to the left). The geometry of the outline is understood as a trajectory for which parameters have been defined by the framework. A possible link to the armillary sphere of the archaic astronomy (skeletal celestial sphere) would be interesting to explore further

"THE TITIAN" BY ANTONIO STRADIVARI (1715)

A study of the outline of this Stradivari violin shows that it was built from the "P" Ms 44 pattern, currently housed in the Civic Museum of Cremona. The history of this mould was explored in detail in another publication [6], the principal elements of which will be reviewed here briefly. There is reason to believe that Stradivari created his models from geometric archetypes inherited from the 16th century. Thus, there came about a series of patterns that bear the letter of the archetype from which they were conceived. The archetype in question here is the "P", whose construction is shown in Figure 1, as it might have been transmitted to the master by Nicola Amati. It has been asserted that the "P" pattern shown in Figure 3 corresponds very closely to this theoretical proportional model. The few differences are attributable to replacing some geometric measurements with metrological ones (using a standart of measurement rather than proportions).[7]

THE DESIGN OF THE “P” ARCHETYPE

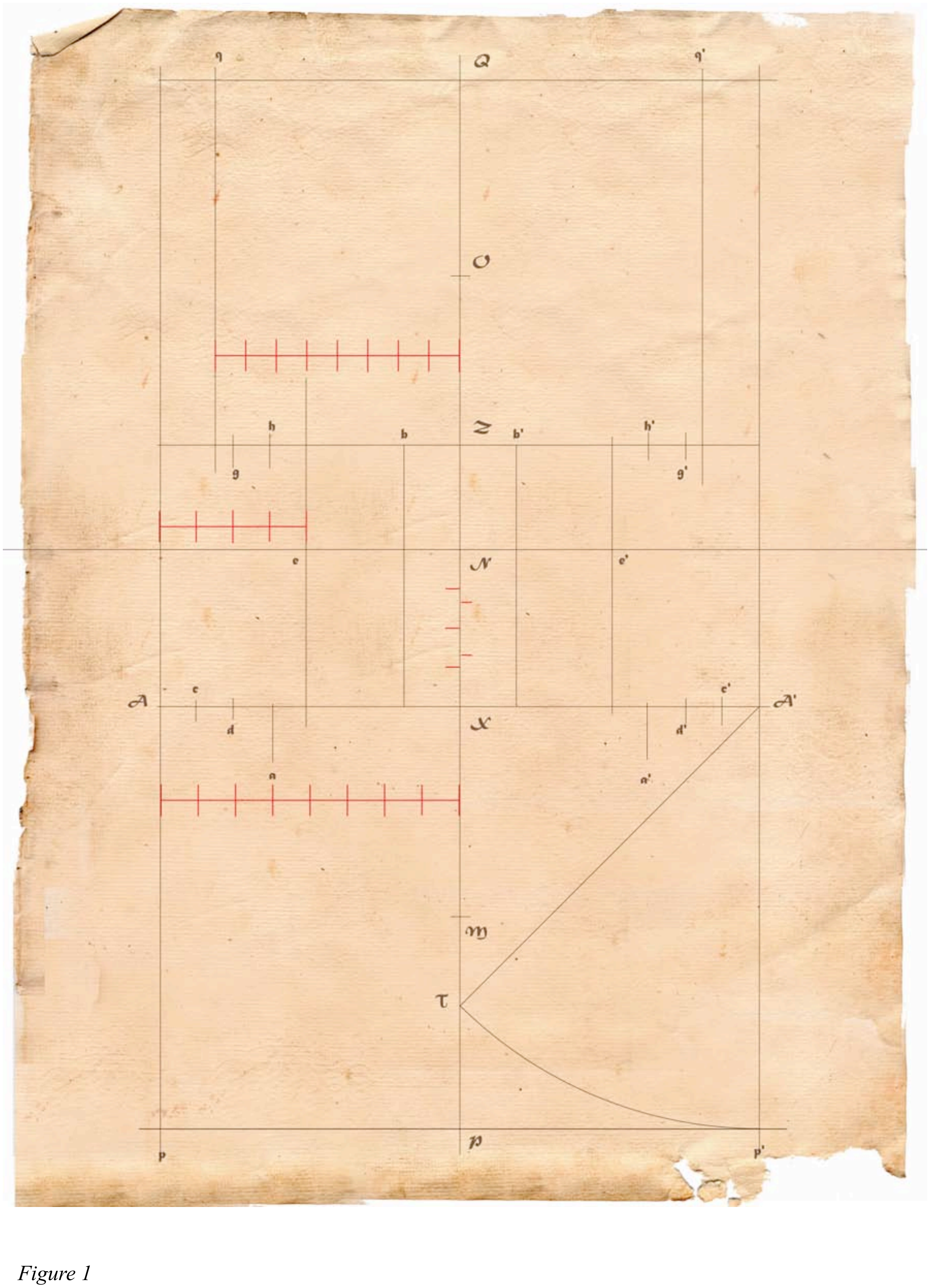
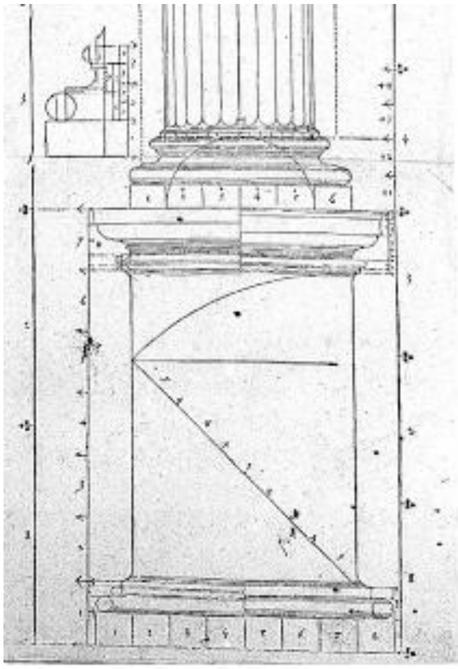


Figure 1

Construction of the framework

- Draw two axes which intersect in X.
- Draw two vertical lines passing through A and A' (with AA' = 199 mm)[8].
- Draw a diagonal through A', intersecting the vertical line through X at T. Set a compass to length A' T and with one leg of the compass remaining at A', mark point p' at distance A' T below A' on the vertical line through A'
- Draw a horizontal passing through p' and position the points P and p on the vertical lines passing through X and A.
  - pp' is the width of the wooden form.
  - PX is the height of the lower part of the shape.
- Divide pp 'into 4 parts and give 7 of them to PQ. Draw a horizontal line passing through Q. PQ is the length of the wooden form.
- Divide pP into 8 parts and give:
  - 10 of these units to aa', the largest width of the f-holes.
  - 3 of these units to bb', the smallest width of the f-holes.
  - 8 of these units to qq', the largest width of the upper part.
- Divide qQ into 8 parts and give 10 of these parts to ee' the smallest width of the medium part.
- Position N at the quarter of XQ and draw a horizontal line passing through this point.
- Divide XN into 3 parts and place Z at 2 of these parts over N.
- Divide XN into 4 parts and place O at 5 parts below Q.
- Position M in the middle of PX.
- Divide the space between the vertical lines passing through p and e into 4 parts. Place c and d on the horizontal line passing through X, respectively at 1 and 2 parts away from the vertical line passing through A. Place g and h on the horizontal line passing through Z, respectively at 1 and 2 parts over the vertical line passing through e. Proceed symmetrically to place c', d', h' and g'.
- -cc' and dd' are the limits of the blocks of the bottom corners.
- -gg' and hh' are the limits of the blocks of the top corners.



Remark:

The sketch of this framework is based on a type of surface, frequently denoted in the Renaissance as a "drawing by diagonals". The secret of the proportions given by the diagonals of the square and the double square is associated for good reason with the practice of medieval builders. Yet these notable proportions, reflecting a wide range of interests and practices, were developed much earlier and were already mentioned in Antiquity. They are probably a Pythagorean legacy.

In 1550 the German Hans Blum published one of the numerous architectural treatises of this time. The drawings of columns appear to be made on the same basic geometry as the violin.

Drawing of the outline:

The borders and various surfaces of the shape being thus defined, the next step is to draw the outline using arc radii fixed by the framework. The measurements of these radii are:

- *For the lower part :*[9]

R1 = ZP (arc from the bottom block, of center Z)

R2 = PX / 2 (tangential arcs to arcs R1 and vertical lines passing through p and p' and of centers m and m').

R3 = XZ (tangential arcs to arcs R2 and to vertical lines passing through p and p ', and of centers m1 and m1').

R4 = XN / 2 (corner arcs tangential to the arcs R3 and passing through the points c and c').

- *For the middle part.*

R1 = pp'/ 2 (tangential arcs to the vertical lines passing through e and e' with their centers on the horizontal line passing through N).

R2 = XN / 2 (tangential arcs to arcs R1 passing through points d and d ').

R3 = NZ / 2 (tangential arcs to arcs R1 passing through points h and h ').

R4 = NZ / 2 (arcs passing through h and g to the left and h' and g' to the right) [10].

- *For the upper part.*

R1 = NQ (arc from the top block, of center N).

R2 = OQ (tangential arcs to arcs R1 and vertical lines passing through q and q', of centers o and o').

R3 = NZ / 2 (corner arcs tangential to arcs R2 and passing through points g and g').

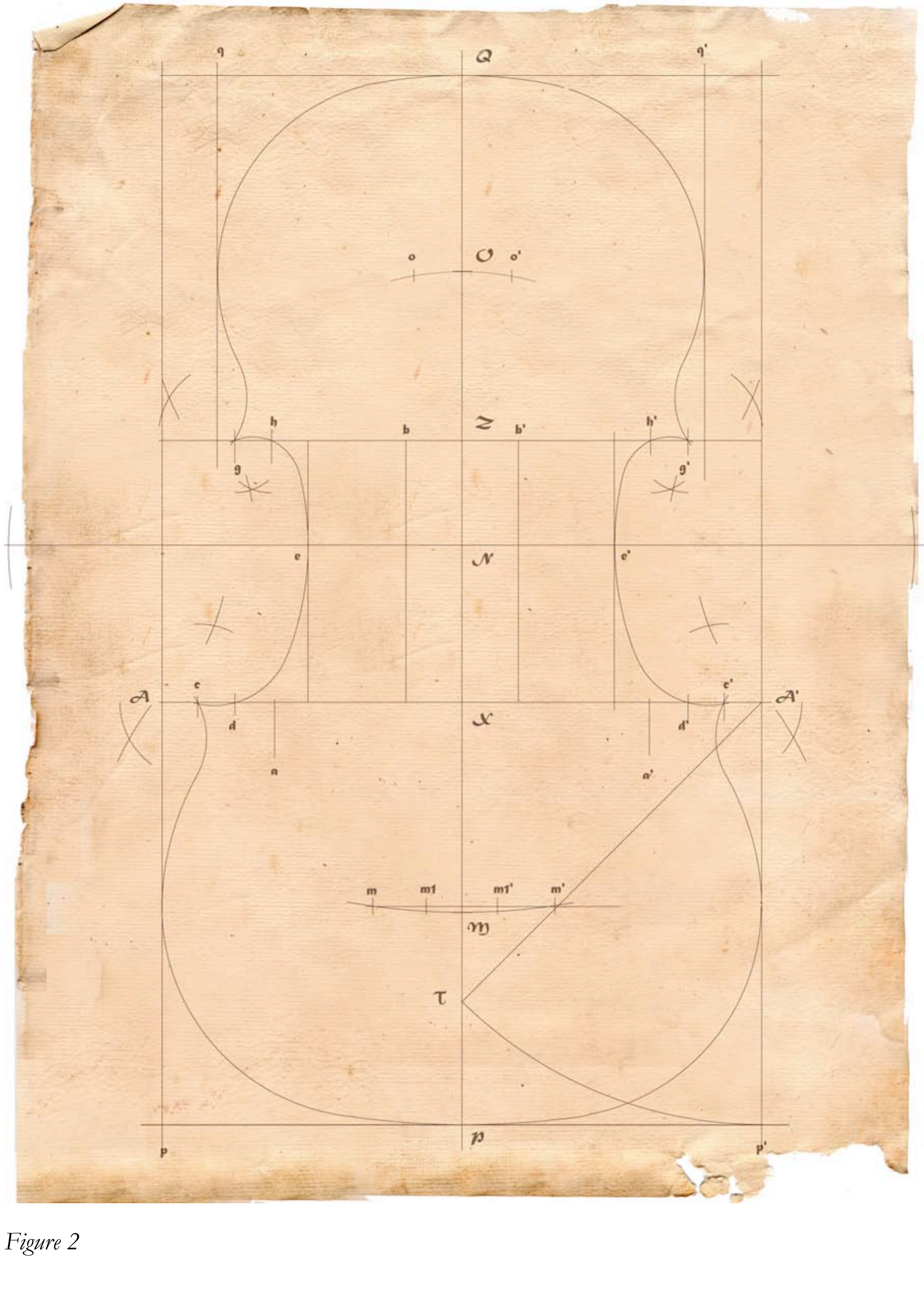
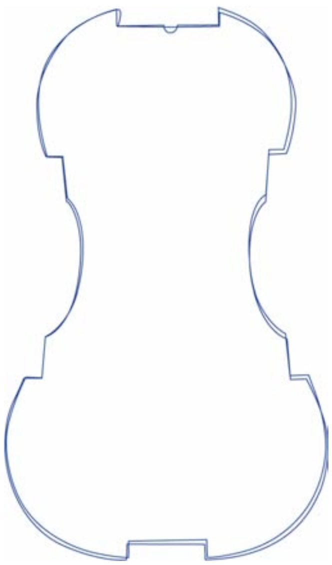


Figure 2

Figure 3

The outline of the Stradivari "Titian" compared to the "P" Ms 44 pattern and the "P" archetype. The most notable difference appears in the upper corners inside the "c-bouts".

THE PLOWDEN BY GUARNERI DEL GESÚ (1735)

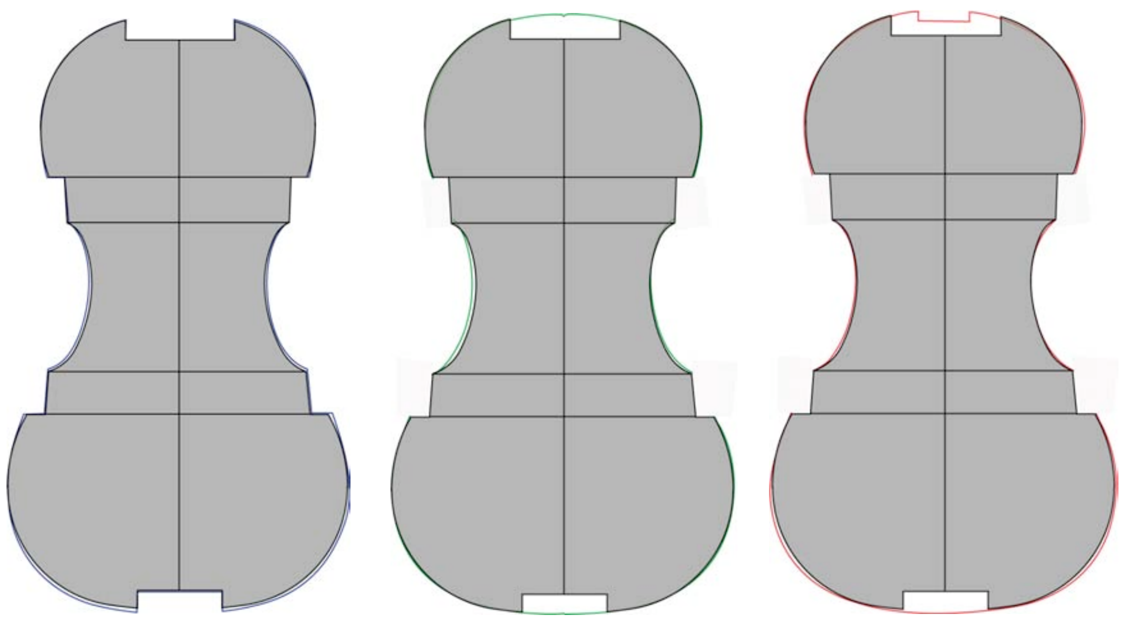


Disregarding the discrepancies, these two contours proceed without any doubt from the same wooden form because they are the superimposition of the top and back outlines of the Del Gesu Allard (Musée de la Villette).

Despite having been constructed on a mold, the instruments of Guarneri del Gesú are known for their asymmetries. In fact, the often rough work excludes the possibility that any shape had been clearly defined at the corners. These slightly impredictable outlines, which are part of the charm of del Gesú violins, also complicates their study. Nevertheless, we will show that this quick work is supported by a well-established architecture that remains fundamental to the overall impression.

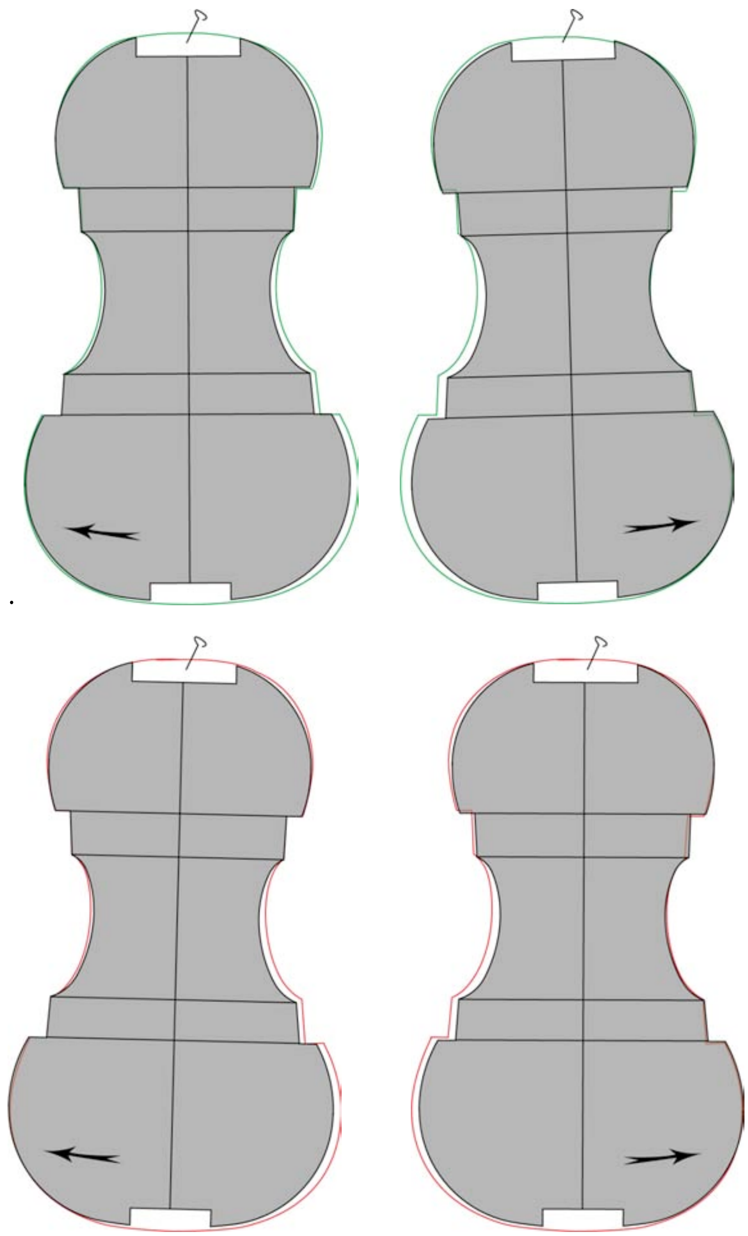
To overcome the difficulty of analysis due to asymmetry of the corners, it is preferable to ignore the space allotted to the wooden blocs. This being done, the extent of the random or intentional variation of a contour becomes more apparent. Ultimately, it is clear that the instruments of del Gesú reviewed here fall into two categories irrespective of their period of production.

The outlines of the first category follow a clear geometrical construction but in the second category this construction appears to be incomplete. In addition, the study of–the first category leads to a model that is not a del Gesú "innovation" but rather the well-known "grand pattern" of the Amati family.



Left: the blue contour is the Soil from 1736. Centre: the green contour is an instrument of 1743. Right: the red contour is an instrument of 1733. These three examples are superimposed onto a theoretical model of the 'Grand Amati' pattern (internal forms in grey). It appears that these three instruments have undoubtedly been made from this pattern.

The next step of this study reveals another aspect of del Gesú's technique. The instruments of the second category correspond, but only partially, to the 'Grand Amati' model. The pattern of these instruments appears to have been empirically generated from a previous one.



An instrument of 1733 (green contour) appears to have been made after the same pattern as the Plowden of 1735 (red contour second below). This new form seems to have been generated by swivelling the previous model (grey) with respect to a point on the upper block

Remark:

One might suppose that this second category of forms could have been derived from the natural flexibility of a rib garland when detached from the wooden form. But experience suggests that the contour variations obtained in this way lead to significantly different results from what is happening here. While not entirely ruling out this possibility, the making of a wooden form by sideways movement around a pivot point seems, so far, the most likely hypothesis.

DESIGN OF THE FORM BY THE AMATI BROTHERS

The typical framework of del Gesú's violins is very close to that of Stradivari's violins. It is also undoubtedly related to that of the Amati brothers. In the example below, the construction by the diagonal has been replaced by this approximation: XP being divided into 7 parts, the half-width Pp' corresponds to 5 of these parts. The rest of the construction is identical to that of the archetype P with AA'= 198.5mm.[11]

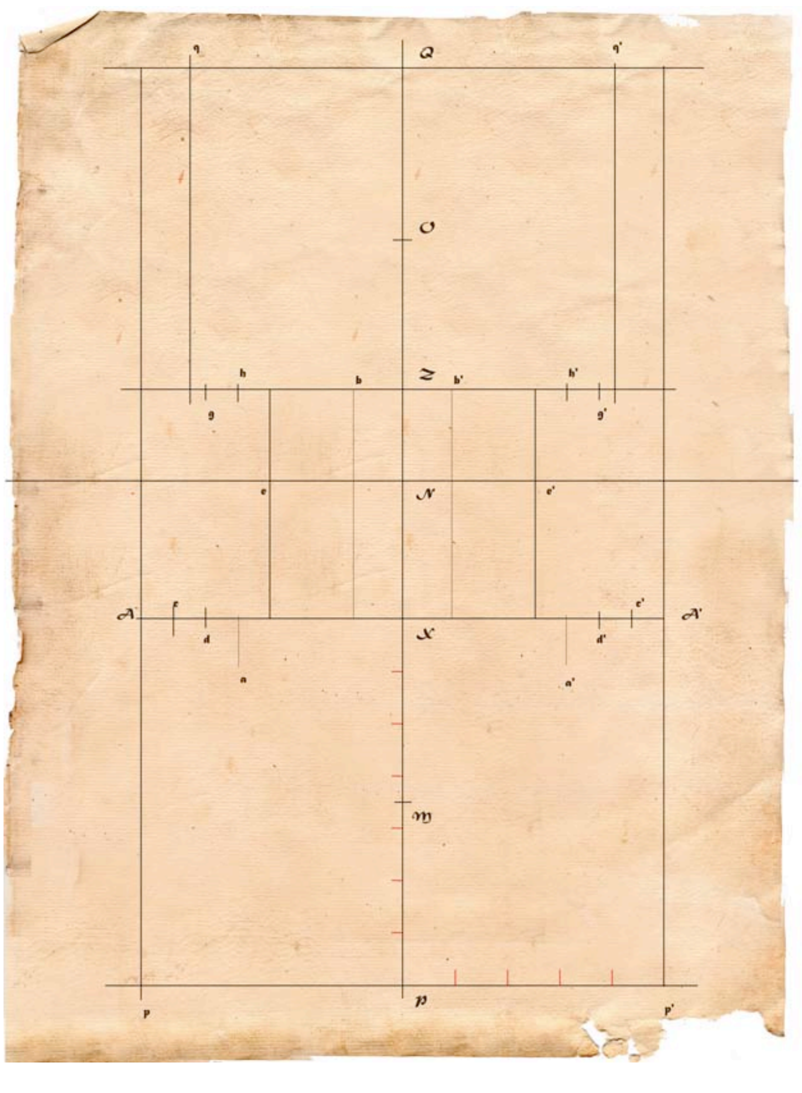


Figure 4

The difference between the archetype P and the del Gesú model appears in the choice of the radii. Indeed, with the exception of the wooden blocks, this contour remains faithful to that of the Amati brothers. The measurements of the radii are the following:

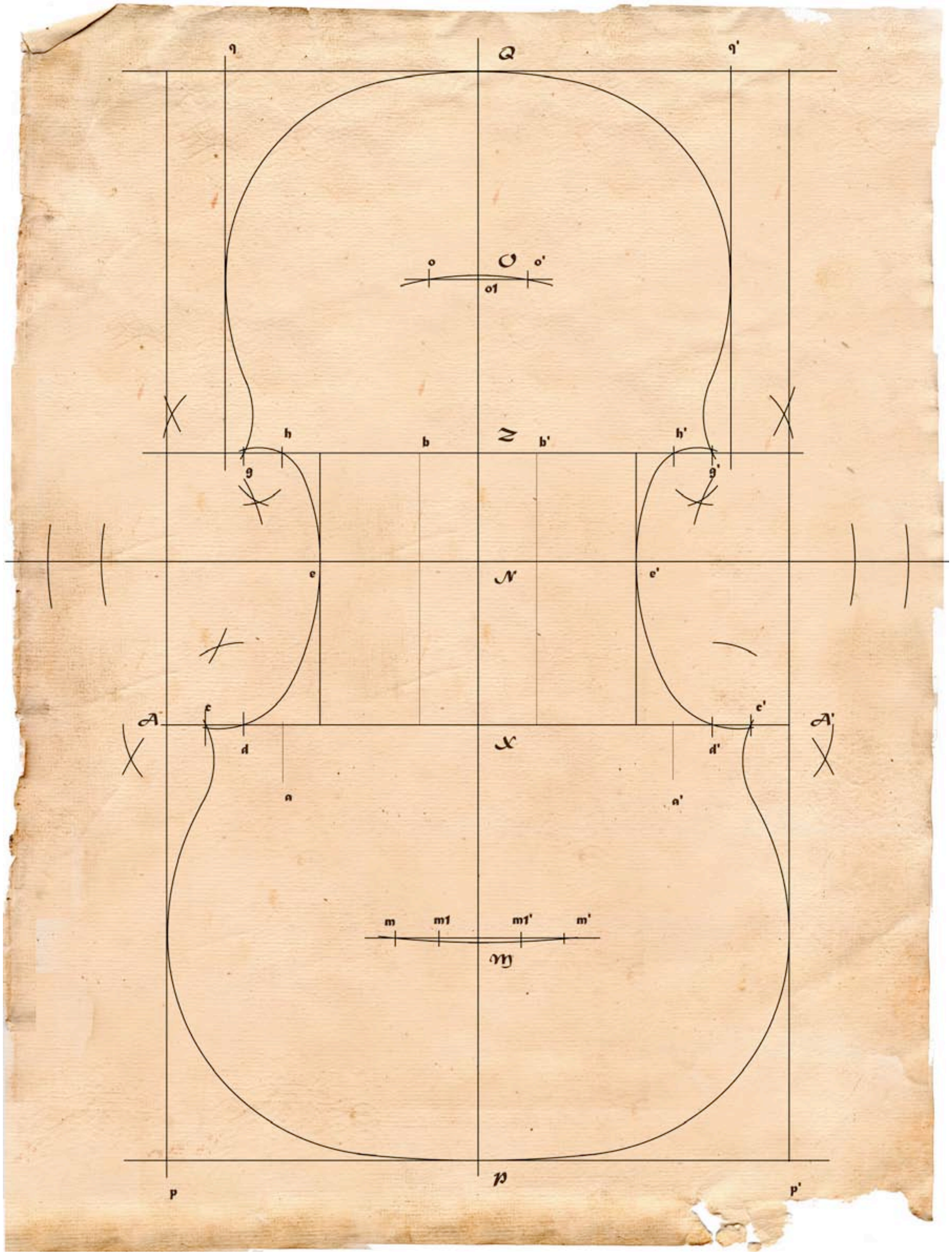


Figure 5

- *For the lower part:*

R1 = ZP (arc from the bottom block, of center Z).

R2 = PX / 2 (tangential arcs to arcs R1 and to vertical lines passing through p and p' and of centers m and m').

R3 = XZ (tangential arcs to arcs R2 and to vertical lines passing through p and p ', of centers m1 and m1').

R4 = XN / 2 (corner arcs tangential to arcs R3 and passing through the points c and c').

- *For the middle part:*

R1 = XZ (descending arcs, tangential to the vertical line passing through e and e' with their centers on the horizontal line passing through N).

R2 = XN+NZ / 2 (ascending arcs, tangential to the vertical lines passing through e and e', with their centers on the horizontal line passing through N).

R3 = XN / 2 (tangential arcs to arcs R1 passing through points d and d')

R4 = NZ / 2 (tangential arcs to arcs R2 passing through points h and h').

The tips of the top corners can be turned as one likes, because del Gesú's violins show a great variability in shape at these locations, even on the same violin.

- *For the upper part:*

R1 = NQ (lower arc from the top block, of center N).

R2 = OQ (tangent arcs to arcs R1 and to vertical lines passing through q and q', of centers o and o').

R3 = qQ (tangential arcs to arcs R2 and to vertical lines passing through q and q' of center o1 below O).

R4 = NZ / 2 (corner arcs tangential to arcs R3 and passing through the points g and g').

CONCLUSION

Stradivari's 'Titian', made after the "P" Ms 44 pattern, and del Gesú's 'Plowden' appear to be two variations of a unique proportional scheme inherited from the Amati family.

As mentioned previously, the work of Stradivari and Guarneri del Gesù took place at a particular moment in violin history. During that period, the luthiers designed few, if any, new forms from geometric principles. Some Amati models were redrawn by following the inherited recipe or simply by duplication. Each violin maker's style had many opportunities to express itself, but in most productions of that period, the main curves of the form varied little, with the exception of the corners. When a violin maker wanted to innovate, a reference mould became a drawing template and, by copying/translation (or swivelling in the case of del Gesú), a new form was created. The freedom taken with regard to the initial model also has an impact on the coherence of the placement of the "f" holes in relation to the proportions of the exterior contour. The clear geometric relationship present in the f hole layout of the Amati brothers (and also in Brescia before 1630) is replaced here by a more empirical approach, already limited by the well-established practice of the previous century. The loss of the last original molds and templates made according to the processes of the Renaissance seems to mark the end of this period, one that must be called *post-geometric*.

Since then, we have been in another era, where the model is no longer derived by the design of a wooden form but from an existing instrument. In this type of work, based on copying, the lack of a conceptual approach to the outline will be sublimated into romantic and mythic discourse, which capitalizes on the charisma of dominant figures and their "secrets". *Geometric, post-geometric* and *romantic* periods are the three important stages in the history of bowed and plucked string instruments design from the thirteenth century to the present day.

At a time when the furthest reaches of violin history are being revealed, recent scientific studies are presenting the vibrations of these instruments as we have never seen them before. The fact that the frontiers of our understanding are suddenly extended in these two directions assures future generations of violin makers diverse and stimulating avenues of research.

ENDNOTES

[1] RAULT (Christian), « Los instrumentos musicales en el siglo XVI. » in : *Encuentro TomásLuis de Victoria y la musica espa˜nola del siglo XVI,* Avila : UNED, mai 1993, pp.231-242.

RAULT (Christian), « Les modifications structurelles radicales des instruments à cordes au XVI° siècle », in *Pastel n°21*, sept. 1994, pp.30-36.

[2] REYNAUD (François), « Les luthiers tolédans au XVI° siècle » in :*Tolède et l'expansion urbaine en Espagn*e AA. VV. Collection de la Casa de Velázquez nº 32, 1991.

REYNAUD (François), *La polyphonie tolédane et son milieu, des premiers témoignages aux environs de 1600,* CNRS ÉDITIONS, Paris, 1996, pp.411-412.

[3] On this topic, one should read VITRUVE, *De l'architecture,* livres III*, «* définition et nécessité de la symmetria », trad Gros Pierre*,* Les Belles lettres, Paris,1990, p 6 and as well DÜRER (Albrecht), *Géometrie*, presented and translated by Jeanne Peiffer, Seuil, Paris, 1995, p 139.

[4] These relationships are in fact what we call comparisons. The idea of a relationship – comparison between unconnected elements did not really make sense at that time. For this reason, relative measurements concern only joined dimensions. This principle is now out of date, but it is fundamental in the ancient conception of shape.

[5] This conception of the line as a trajectory of a point is deeply different from the more descriptive and less intuitive geometry which develops from the XVIIth century. For further information, read "Traité de lutherie" ibid. note 1 pp 101-113.

[6] DENIS (François), « Traité de lutherie- the violin and the art of measurement », ALADFI, Nice, 2006.

[7] This essential distinction does not have much sense for us now. About this topic, read ibid. note 6 pp 25 sqq.

[8] AA' is here the only so called "metrologic" measure ibid. note 6.

[9] An animated illustration about drawing techniques is available on-line: tab « learn to draw », « anime Guarneri » on www.traitedelutherie.com

[10] About this rupture of tangent, ibid. note 6 p 216.

[11] Many possible versions of this construction exist, giving very slightly different measures (± 1 mm) for the relative positions of the points, ibid. note 6 pp 139-149.