A Note on a Geometric Method for the Guitar's Contour

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Abstract— the following work presents a geometric method based on nine circles and straight lines to obtain the contour line of a classical guitar. The method is based on the five-center method used in architecture to obtain an arc of ellipse. The contour line of the guitar shape can be obtained with a rule and a compass.

I. INTRODUCTION

The modern "classical" guitar has a long history of ancestors dating back to the 13th and 14th centuries in Spain where two instruments were used: the *guitarra latina* and *guitarra moresca*. During the next centuries the adjectives *latina* and *moresca* went out of use and only variants of the term *guitarra* persisted. It took its present form when the Spanish luthier Antonio de Torres Jurado, from 1850 until his death in 1892, increased the size of the body, altered its proportions, and introduced the revolutionary "fan" top bracing pattern [1]. His design greatly improved the power, tone and clarity of the instrument, and with time it became the accepted construction standard. To this day it has remained essentially the same.

The use of geometry by craftsmen of former ages is known from the evidence of very few practical treatises or handbooks. One such handbook was written by Henri Arnaut de Zwolle [2], in the 15th century devoted to the lute, where the only plan of this musical instrument has survived along with a description of its measurement. These documents are the only remains that bear witness to the methods of drawing with rule and compass that apparently fell into oblivion from the 17th century on. In recent times the French luthier F. Denis [3], has been working on the unveiling of some of the geometric methods that might have been used in the design of the violin and viola contours. With the advent of the computer some methods to obtain the arching of a violin have appeared such as that given by Ekwall [4], [5].

Though the literature concerning the acoustics of the guitar is now extensive (see for example [6], [7]), to the author´s knowledge there is not an accessible geometric method to obtain the guitar´s contour shape. Childers [8], gave an analytical expression that represents the shape of the guitar, that can be computerized. No documents seem to have survived relating to the procedures used by previous luthiers, or from A. de Torres, in the design of the shape of the classical guitar. Apparently most guitar makers use templates or just copy the contour of existing guitars [1].

The curve which here approximates the top and bottom curves of the guitar is very similar to the so called “basket handle arch", or three center method for an arc of ellipse, used in architecture and a standard traditional method using rule and compass in old drafting texts [9]. The arcs shown here are constructed using a variation of this method, which is not strictly speaking a pure “rule and compass” method. Dimensions are imposed to fit the guitar shape, and are not purely the result of ratios or compass divisions, etc. This variation will be established later on. The method presented here uses as given parameters the body length and upper and lower bout widths.

Even though the method is applicable to a Torres design (as given for example by Sloane [10], some variations in the arc radii and bout dimensions can be made. A computer program could be written to draw the guitar´s contour using the method given but is not included in this report.

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II. Description of the geometrical procedure

The normal dimensions of the modern classical guitar vary from half a centimeter up to 1 centimeter around the following average values (from 14 guitars shown in [1]) from various constructors: body length 48.1 cm, lower bout 36.2 cm, upper bout 27.5 cm. The previous values can be approximated by the following proportions: given the body length L, lower bout is ≈ (3/4) L, upper bout ≈ (4/7) L, waist ≈ (1/2) L. These values however have no real significance and are used only as approximations to real dimensions. If real dimensions are desired they can be used instead of these relations. The tracing of the method is shown in **Figure 1**, for a given body length L.

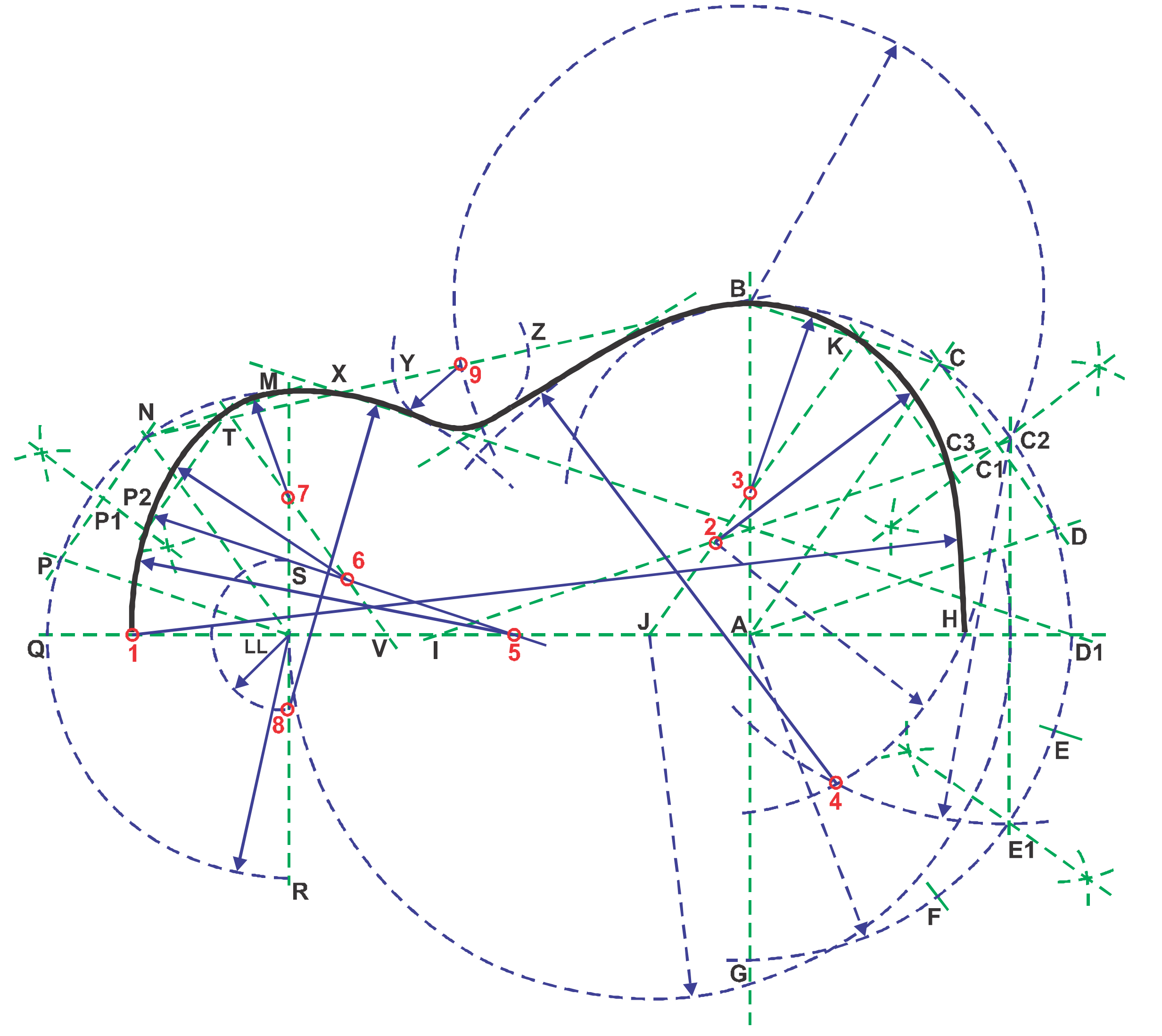

Figure 1 - Tracing to obtain the guitar's contour line by a nine-center method. Different colors are used to make clear the tracing of circles and lines.

1. A semicircle centered at the initial point A and radius equal to half the lower bout width, is divided in 5 equal parts giving thus points: B, C, D, E, F and G. This can be made with a standard geometrical procedure (for example inscribing a decagon) or with a protractor.

2. A straight line is traced perpendicular to the line BG through point A which locates point D1 on the semicircle. On this line points H and 1, at (2/3) of the radius of the previous semicircle to the right of point A and the body length (L) to the left of from point H, respectively, are marked.

3. Lines BC and CD are drawn. Line CD is divided in two by a perpendicular line, this locates points C1 on CD, and C2 on the semicircle. A parallel line to AD through C1 is drawn to locate point I on 1H.

4. Taking as center point 1 draw an arc of radius 1H locating thus C3 on IC1. A parallel to line CD through C3 is drawn locating point K. A parallel to AC is drawn through K meeting 1H at J. The intersections of KJ with BA and KJ with IC3 give centers 3 and 2 respectively.

5. Taking as center point 3, arc BK is drawn and extended to the left.

6. Arc EF is divided in two, locating point E1. Line C2E1 is traced. An arc centered at C2 and radius C2E1 is drawn towards and near AG. An arc centered at 2 and radius 2H is drawn to almost intersect line AG. The crossing point of these two arcs locates point 4.

7. With 4 as center draw an arc tangent to the prolongation of BK. At this point one can see that the lower half of the guitar's body outline has been drawn. Continuing:

8. A semicircle centered at J is traced tangent to C2E1 locating point LL on line 1H. A line tangent to this semicircle at LL is drawn (which is perpendicular to 1H). A semicircle, centered at LL and radius equal to half the upper bout width, is traced to the left of the figure. This semicircle is divided again in 5 equal parts locating points M, N, and P. Point Q is located at the intersection of the semicircle and the left-extended LL1 line. Point R is located at the intersection of the semicircle and the previous tangent line.

9. Lines MN and NP are drawn. Line NP is divided in two by a perpendicular line, locating thus point P1. A parallel to the line PLL is traced through P1 meeting lines 1H at 5 and LLM at S respectively. Note that this line does not appear on the figure due to occlusion by other objects.

10. With 5 as center scribe an arc equal to <u>5 1</u>, (an underline is used here for clarity when two points labeled with numbers are joined) locating thus point P2 on line <u>P1 5</u>.

11. A parallel to NP through P2 is traced which intersects line NM at point T. A parallel to NLL through point T is drawn which intersects line 1H at V. The intersections of line TV with MLL, and of TV with 5P2, locate centers 7 and 6, respectively.

12. With centers 6 and 7 draw arcs equal to 6P2 and 7T respectively, which meet at point M.

13. A semicircle of radius SLL centered at LL is traced which intersects line RLL at 8. An arc of circle centered at 8 and radius 8M is traced. A line tangent to this circle through point D1 is drawn. BN intersects this line at X. Centered at B and radius BC2 an arc of circle is drawn which meets BX at 9.

14. Centered at 9 a semicircle tangent to D1X is traced which locates points Y and Z on BX.

15. Finally a line tangent to both arc 4B and semicircle YZ is drawn; this completes the contour outline of the guitar.

The aforementioned variation of a 5 centered "basket handle" arc refers to the way point C3 is obtained; in one method this is obtained by tracing a parallel to line DD1 through point H. The arc of circle C3H would be centered at point I. Instead it is centered at point 1.

The geometrical method presented here is applied as an approximation to the Torres design. The method solves at least a very mundane problem: how does anyone draw, without relying on a template or plan, a guitar's contour at a given scale? Even if limited in scope it could be of some interest for those who deal with these matters.

IV. ACKNOWLEDGMENTS

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