



Documentation

PROJECT:

**RESEARCH ON HISTORICAL GUITARS - STUDYING AND DOCUMENTING
ARTISTIC DETAILS AND CONSTRUCTION**

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Acknowledgements

When I started this project I did not realize that my most ambitious dreams would in fact be realized so soon. Initially, measuring a guitar by Antonio de Torres seemed like a distant dream, almost like the vain folly of a young guitar maker. But thanks to James Westbrook, this project focused indeed on an instrument of such historical importance. His dedication to the arts, applied science and research, and his generous sharing of knowledge and resources have enabled me to learn more than I expected about Torres' instruments and the world of historical guitars.

And then there is the unsurpassed hospitality of James Westbrook and his wife Janith, who turned out to be the warmest, most generous hosts that I have encountered in my life.

I also thank my proofreaders and advisors Cate Friesen and Leanne Fenez for their exceptional advice and also their patience with my late phone calls, last-minute emails and lengthy phone conversations.

I thank Allan Beardsell for introducing me to the Manitoba Arts Council and the incredible opportunities involved, and for getting me in contact with James Westbrook. Due to Allan's help I could realise a project that exceeded the scope of my thesis a few years ago and that had been on hold ever since.

Last but not least I must thank the Manitoba Arts Council and their extremely helpful staff, whose grant has made this project possible. My expectations for potential research and artistic development at this point of my career have been greatly surpassed, and I hope to give back accordingly by sharing my findings and incorporating them in my future instruments and research.

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1 Introduction

Thanks to the generosity of James Westbrook, it was possible to study a guitar by one of the most famous guitar makers of the nineteenth century, Antonio de Torres.

The instrument will hereafter be described as the FE 18, which stands for the eighteenth instrument from the First Epoch of Torres' work as catalogued by José Romanillos. It is an example of the beauty of the instruments by Torres, and has been of enormous value for the researcher.

The main products of this project are technical drawings and the complementary documentation. The purpose of this brief documentation is to inform the reader of the methods applied throughout the project, and also to identify the areas where precise measurements were difficult or impossible to obtain. I trust that this documentation and the technical drawings will serve as a starting point for future discussions and research regarding this particular instrument.

Although the results presented here may be scientific and lacking creativity at times, their purpose is the documentation of the beauty and artistic details of Torres' work. With the unique craft characteristics of lutherie, technical drawings and a documentation yield much artistic information that capture the makers signature and the characteristics of the craftsmanship of his time.

Some artistic evaluations as well as measurements could not be obtained as they fell outside of the scope of this project. These should be added in the future, be it in the form of another project by the author or research done by other people. Meanwhile, I added some of the excellent observations by James Westbrook to complete the picture.

Let me point out that there is no intention to make general conclusions about Antonio de Torres' work and that any comparisons with other technical drawings of his instruments (and the resulting findings) can be expanded upon in future research.

I would also like to humbly ask the reader for forgiveness regarding any missing information or errors on my behalf. The guitar was in my hands for five consecutive days, and I hope that I extracted a reasonable amount of vital information in that timeframe.

2 Methods

2.1 Measuring and processing the data

During the five days that were spent examining and measuring the instrument, the relative humidity in the showroom (where the instrument was stored) was recorded every morning prior to beginning the measurements. Two thermometers of the same type were used in a sling psychrometer setup. For calculating the relative humidity, a psychrometric chart was used (as seen in Figure A 26).

Please note that for the temperature measurements, all digits after the decimal were estimated, since the scale on the thermometers did not provide a very precise readout.

	March 27th	March 28th	March 29th	March 30th	March 31st
Wet Bulb:	14.7 °C	15.5 °C	16.7 °C	15.4 °C	14.0 °C
Dry bulb:	20.9 °C	22.5 °C	22.0 °C	20.8 °C	21.0 °C
Resulting rH%:	47 %	54 %	59 %	59 %	46 %

Figure 1. Relative humidity measurements

The tools used for the measuring of the instrument were a stiff steel ruler, a sliding calliper, a thickness dial gauge and a Hacklinger thickness gauge.

All abrasive and potentially harmful parts of the tools were covered with masking tape to insure the guitar would not suffer any damage from measuring. The thickness of the tape was factored into the measurements present.

For example: the tape used on the thickness caliper for protecting the instrument amounts to a thickness of 0.25 mm. All measurements presented in this documentation and the drawing have this difference taken into consideration and reflect the calculated real measurements of the instrument.

The measurements are generally recorded in millimeters with one digit after the decimal. In some cases there are two digits after the decimal, where readouts were precise enough: For example, the Hacklinger thickness gauge provides readouts accurate to 0.1 mm, but it was possible to estimate finer increments. These estimations generally do not go beyond 0.05 mm increments.

The measuring error with the thickness calliper can add up to 0.25 mm and in some rare cases even up to 0.5 mm (mostly because the protective tape on the caliper is a little soft and gives under pressure).

The measuring error with the steel ruler should be under 0.5 mm (the smallest increment on the steel ruler is 0.5 mm). Sometimes measurements taken with the steel ruler indicate numbers such as 6.7 mm. In that case, the digit after the comma is estimated.

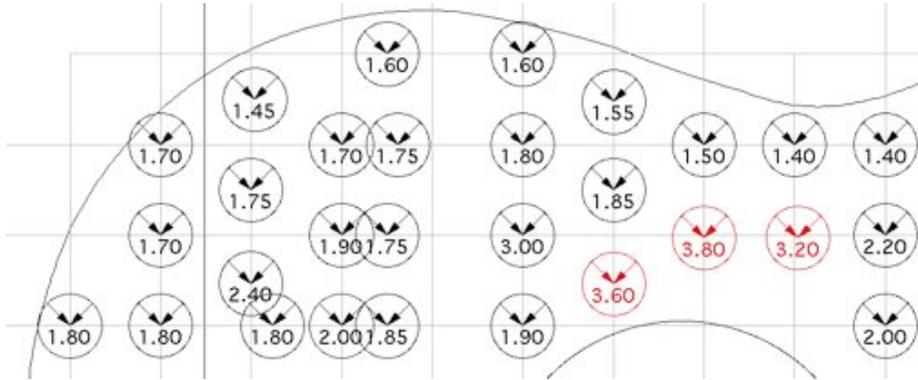
For documenting curves, digital photographs were traced on the computer and then transferred to the technical drawing.

2.2 Drawing the plan

The initial goal was to have the plan drawn according to the standards set by the DIN ("Deutsches Institut für Normung" which translates into "German Institute for Standardization") and ISO (International Organization for Standardization). Although standardisation is a useful tool to establish uniform technical criteria and processes for making technical drawings of musical instruments, some parts of the drawing have been modified to suit the needs of the instrument maker and researcher. The most apparent modifications would be the line thicknesses and the representation of the thickness measurements of the top, back and sides:

- According to ISO 128, the line thickness for a heavyweight unbroken line (e.g. for drawing outlines) is defined at 0.35, 0.5 or 0.7 mm. Accordingly, dimension lines would have to be at 0.18, 0.25 or 0.35 mm. The modified line thicknesses in the drawing are as follows: 0.25 mm for heavyweight unbroken lines (outlines, visible lines), 0.13 mm for broken lines (hidden lines, center lines, etc.) and 0.03 mm for auxiliary lines.
- Technically, the thickness measurements of the top, back and sides should be indicated in sectional views. Although conforming to the standards of technical drawings, it would make it difficult to make sense of the results. Especially when reproducing the instrument or trying to understand acoustic behaviour of its parts. For a more convenient representation, they are now placed in a top view, with arrows indicating the measured spot, and a side view, with a circle marking the approximate area of the measurement (see Figure 2.). In the future, such measurements should be displayed in a topographical map, with black lines separating the degrees of elevation. Such a map should be the most effective view for researchers and instrument makers.

Display of top thickness in the technical drawing:



Display of side thickness in the technical drawing:

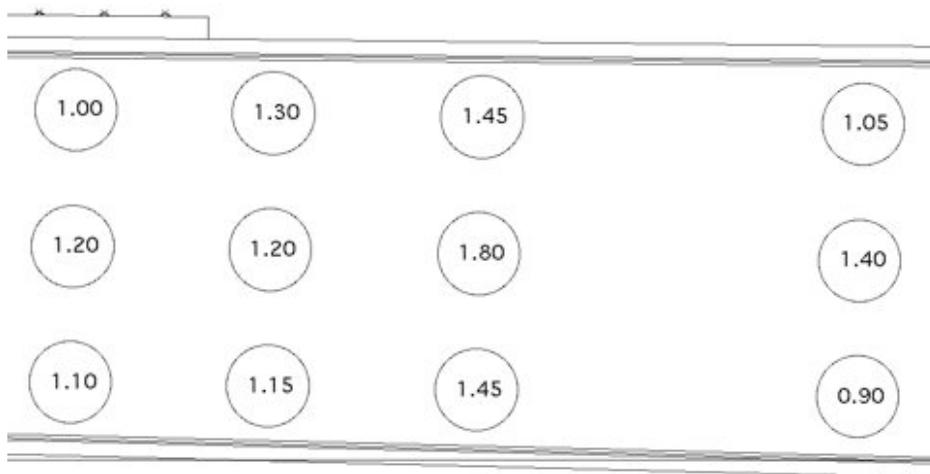


Figure 2. Modified views for easier use

3 The instrument

3.1 Headstock

The headstock is made of “[...] cedar [...] faced with rosewood”¹ The measuring of the headstock was initially done on the instrument, using a sliding calliper and steel rulers. Digital photographs were used for the tracing of the curves. The tracing led to some deviations mostly in the crown area (see Figure 3). The measured points were located (on the front side) on the apex of each of the three arcs, the four corners where the arcs end and the outside corner on the horizontal flat area. These reference points (acquired by measuring) did not line up with the same point in the photograph. The resulting outline from the curves in the digital pictures took precedent over the previously measured points.



Figure 3. Crown

The entire headstock visually appears to be out of alignment with the centerline of the neck and body. The degree of misalignment is difficult to measure with the presently used tools, and all measurements with the metal rulers indicated that in fact the headstock was not misaligned at all.

Please note that it is also difficult to extract clean and precise curves from an object of this age and condition. The plan shows only the front view of the headstock, and all edges are drawn as straight and well defined. On the real instrument, many of the edges display minor damage as seen in Figure 4, and they are far from straight and well defined.

¹ Westbrook, 2009, p.47



Figure 4. Back of the headstock

The centerjoint of the headstock veneer does not line up with the centerline. As seen in the drawing, it is shifted approximately 1.0 mm from the centerline to the bass side. James Westbrook describes: “The head facing is of a slightly off-centre two-piece book matched dark rosewood or possibly ebony. This in its self is unusual, in that most other Torres head faces are one-piece.”²

Since the tuners and strings were not removed at any point during this project, the depth of the tuner holes is not documented. Their diameter is approximately 9 mm.

The thickness of the headstock varies: Measuring along the centerline of the headstock, it is 16.55 mm to 17.55 mm thick (in the area of the crown), it is 17.25 mm thick (in the area of the

² Westbrook, 2009, p.51

middle tuner holes) and it is 18.0 mm thick (in the area of the ramps towards the nut). As a result, the headstock veneer and the back of the headstock are slightly hollow/concave shaped.

The headstock thickness also varies quite a bit between bass, middle and treble side. If one is looking from the direction of the bridge at the cross section of the headstock, the thickness is 17.55 mm on the bass side, 19.95 mm in the middle and 16.95 mm on the treble side. (This cross section was measured right by the nut).

The edge of the headstock collar is undefined and rounded. The curves in the technical drawing are idealized curves (constructed after taken measurements) that only represent the original marginally.

In the technical drawing, the headstock in the top view is distorted. For taking measurements on the plan, refer to the „detailed headstock top view“.

The “[...] tuning machines [are] by Wettengel with round ivory buttons and a release barrel mechanism“and “[...] [d]espite the austere appearance of the [...] machines, they work with a mechanical precision and are an engineering excellence“³.

3.2 Neck, heel and fingerboard

The fingerboard is a “[...] later ebony fretboard with eighteen modern T-shaped frets.“⁴

The neck shape was recorded for the first and the seventh fret, using a paper-cut template. This template was then photographed and redrawn in the technical drawing.

The thickness of the neck was measured for all the other frets, at the thickest point (presumably the center) of the neck. Since the measurements include the thickness of the fingerboard, it is assumed that the fingerboard is straight on both the outside and the joint side. This results in a fluctuating neck thickness in the technical drawing, which is supported by the optical impression of the instrument.

3 Westbrook, 2009, p.51

4 Westbrook, 2009, p.47

Since the nut was never removed during the measuring process, there are some noticeable differences in the width of the nut and the neck in the top view (the nut is wider than the neck at the zero fret). This makes it appear as if the nut is too wide for the neck. This is due to its width above the fingerboard and the nut is in fact flush with the neck.

The angle of the side slots in the heel varies. Whereas the treble side is perpendicular to the fingerboard, the bass side slightly deviates with 90.3° .

The length of the heel cap was measured at 15.2 mm. However, the side view of the heel cap was traced in a digital photograph (see picture). Since this process may distort some measurements, refer to the technical drawing only for the curve shape of the heel. The heel cap size in the drawing is not accurate.

The neck is made of “cedar and [a] two part cedar heel”⁵.



Figure 5. Photograph used for tracing the heel curve, view from the bass side

⁵ Westbrook, 2009, p.47

3.3 Bridge

According to the visual inspection, the wings of the bridge appear to be thicker towards their ends, and the wing profiles differ from each other. This means that the wings would be thinnest close to the tie block. Also, the deviation of the profiles of the treble and the bass wing seems unusually drastic in the technical drawing (The bridge wings in the technical drawing were traced from a digital photograph). At this point it is difficult to determine the reliability of that information. Further detailed measurement in the future would be recommended to verify this observation.

The string hole diameters and positions are approximate. What is seen in the technical drawing is based on a visual assessment of the instrument and measurements using digital photographs.

The saddle slot appears to be cut at a 90 degree angle to the top plane, and it appears to be rectangular. The depth of the saddle slot has only been visually assessed, and represents an approximation.

James Westbrook states that the bridge is made of „Rosewood [...] with bone tie-block and two diamond shaped mother-of-pearl inlays“⁶.

3.4 Top

The procedure for getting the top outline is as follows:

- The instrument is laid on paper. Then the outline is traced using a half pencil (note that a very dark and clear outline is needed for this).
- The traced outline is photographed and retraced on the computer.
- The retracing is best done on the inside of the pencil outline, using segments of circles with varying radii.

The top thickness ranges from 1.25 to 4.7 mm, whereas the maximum thickness may include braces and/or patches. Over 200 measurements were taken with a Hacklinger thickness gauge, using a reference grid printed on paper to find the right location for each measurement. The grid

⁶ Westbrook, 2009, p.47

consists of squares 20x20 mm, and the paper also protects the top from any potential damage from the measuring procedure. Since the grid paper added to the measured thickness of the top, the thickness of the paper was subtracted and the final values were recorded in the technical drawing.

Also, the measurements in the technical drawing are given in black and red. Whereas black represents a flawless measurement, red indicates:

- a measurement taken either on the edge or on top of a brace or patch,
- an unusually high fluctuation in value regarding the surrounding values.

The joint of the top halves is located approximately 2.7 mm left (towards the bass side) of the wheatear inlay joint and binding joint at the tailblock. The exact location of the centerline (as is shown in the drawing) relative to these joints is unknown at this point.

James Westbrook observes a “[s]oundboard of two-piece unmatched fine quality spruce (close grain towards the centre). Five gable-end shaped radial braces flattened off towards the bridge, with two diagonal ones.”⁷ He also writes: “Although the soundboard is not book matched, some degree of thought has been taken in order to give the appearance of a slightly off-centre book match. The gable-ended braces were slightly modified by having the peaks truncated. This may have been carried out in order to increase the flexibility of the soundboard.”⁸

7 Westbrook, 2009, p.47

8 Westbrook, 2009, p.51

3.5 Label

The label reads: “POR D. ANTONIO DE TORRES, / SEVILLA. / Calle de la Cerrageria número 32. / Año de 186[4.]”⁹

The position, angle and size of the label and all visible parts of the backstrip have been traced from a digital photograph (see Figure A 8). Distortions may have occurred.

James Westbrook observes that the “[...] border of the label does not contain the customary ‘three inverted spirals’ to the upper right-hand side”¹⁰. This interesting aspect is explained in more detail in his thesis.



Figure 6. Label (photo courtesy James Westbrook)

⁹ Westbrook, 2009, p.47

¹⁰ Westbrook, 2009, p.47

3.6 Binding and lining

Looking at the top, the joint of the bindings at the tailblock is approximately 0.8 mm left (towards the bass side) from the middle of the end graft. The purfling contains “the wheatear motif contained in the rosette”¹¹.

There are no measurements present for the lining, which is best described as a “continuous kerfed cedar lining”¹².

3.7 Rosette and inlays

Since the inlays (namely the rosette, purflings and the back center) have been documented superficially, any indications to their thickness is approximate.

In the top view of the rosette, one sees side grain in all inlayed woods except for the green and white checkerboard pattern. Due to constructional methods, the checkerboard pattern is end grain.

James Westbrook describes the rosette as follows: “A rosette of black, yellow and brown concentric circles of various inlaid woods, with added greens forming ladder, wheatear and a central square mosaic design.”¹³

In addition to the “[...] three rosette segments on either side of the fingerboard made with an ‘incomplete’ black line”¹⁴ there is also one inverted chessboard pattern to be found on the bass side of the rosette. (see Figure A 13) James Westbrook mentions that the “[...] rosette is of Torres’ finest designs, and is somewhat similar in design to FE17 (Tárrega’s guitar)”¹⁵.

11 Westbrook, 2009, p.47

12 Westbrook, 2009, p.47

13 Westbrook, 2009, p.47

14 Westbrook, 2009, p.49

15 Westbrook, 2009, p.51

The position and size of the diamond shaped inlays in the bridge were traced from an x-ray photograph (see Figure 7).

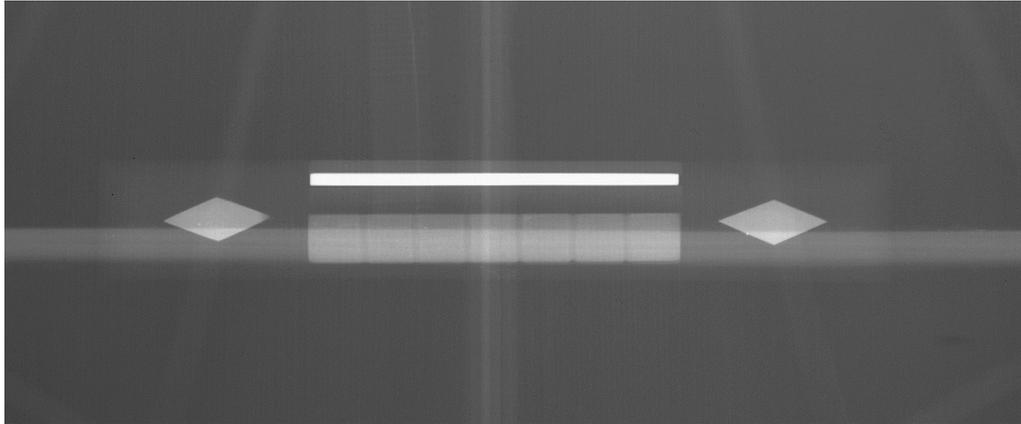


Figure 7. Photograph used for tracing the bridge inlay (photo courtesy of James Westbrook and Nuffield Hospital)

3.8 Back and sides

The outline of the back was documented using the same method as detailed for the top. The centerline in the drawing does not correspond with the joint of the back plates, but it is centered on the end graft and the heel cap. The joint of the back or the position of the back inlay will be slightly off center in the technical drawing.

The back thickness ranges from 2.0 to 5.0 mm, whereas the maximum thickness may include the back center joint reinforcement and/or patches. Almost 200 measurements were taken with a Hacklinger thickness gauge, using a reference grid printed on paper to find the right location for each measurement. The grid consists of squares 20x20 mm, and the paper also protects the back from any potential damage from the measuring procedure. Since the grid paper added to the measured thickness of the back, the thickness of the paper was subtracted and the final values were recorded in the technical drawing.

Also, the measurements in the technical drawing are given in black and red. Whereas black represents a flawless measurement, red indicates:

- a measurement taken either on the edge or on top of a brace or patch,
- an unusually high fluctuation in value regarding the surrounding values.

The deviations between the back and top outline in the top view are quite large. Although both outlines were recorded using paper templates and then traced on a digital photo, the amount of deviation may indicate an error in the process. Upon visual assessment of the instrument, the back and top seem not to differ as much from one another as they do in the drawing. This should be reexamined in the future.

Looking at the back, the center inlay is 0.7 mm left (towards the treble side) of the center of the end graft and 0.5 mm left (towards the treble side) of the center of the heel cap. The back is made of “[...] two-piece[s] [...] of book-matched maple separated and bound with multicoloured woods”¹⁶.and the “flamed maple back of FE18 is almost definitely a consecutive cut from the same tree as FE17 [...]”. Although the sides match the back in colour, the grain is very different.“

¹⁷

The sides are made of flamed maple, and some thickness measurements have been made.

3.9 Doming and other geometrical issues

The top and back are drawn as straight lines in the side view. None of the present doming of the instrument is included in the drawing, but it appears that in fact the joints between the top and the sides and also the back and the sides align in a plane. This leads to the assumption that Antonio de Torres worked the rim of this guitar completely planar, and then added any doming on the inside of the perimeter of the rim.

Since the sides enter the heel almost perfectly perpendicular to the top plane, the back of the instrument must be slightly shifted towards the tail block (in contemporary instruments, the heel slot often tilts away from the bridge towards the heel cap side). As a result, the back must either

¹⁶ Westbrook, 2009, p.47

¹⁷ Westbrook, 2009, p.51

be shorter than the top in its original outline, or the angles at the tailblock between top, sides and back must be trapezoidal. This was not verified in detail during the measurement process, therefore the details in the plan may be lacking accuracy.

3.10 Preservation and provenance

James Westbrook writes in his thesis that “[c]ompared to most other surviving Torres guitars this one is in remarkable condition. The sides are very thin, and move when pressed lightly. The soundboard retains its original doming, and perhaps due to the small surface area it too is in good condition.”¹⁸ He acquired the instrument in 2007 from Erik Stenstadfold, who had the instrument refretted by Gary Southwell¹⁹. No other documented restorations are known to the author.

3.11 Omitted measurements and planned revisions

The following measurements have not been done at this point, and should be part of further study and documentation:

- position of the string slots in the nut
- the precise weight of the instrument
- if there presents itself an opportunity to measure the instrument with the strings taken off, there should be measurements taken of the width of the nut and the proper alignment of the headstock, and also angle, depth and shape of the saddle slot
- the precise location and size of the diamond shaped bridge inlays

Many measurements could not be taken during the scope of this project. All interior measurements of the bracing, patches and the shape and size of the tail block and slipper heel are not included in this drawing. For rough guidelines, two x-ray photographs have been scaled to size (using the width of the lower bout as reference) and included in the technical drawing. The bracing has been analyzed to some degree, as is seen in Figure A 27.

Regarding artistic observations, there is still potential for much more research and analysis. For the future, I would suggest some of the following topics as worthwhile researching:

¹⁸ Westbrook, 2009, p.52

¹⁹ Westbrook, 2009, p.52

- The analysis of the body and headstock outline. Often musical instruments are designed based on circle geometry and the golden ratio, and an analysis can help understand how the maker designed their instruments.
- The design of the inlays. A comparison of several of Torres' instruments and also the instruments of the makers of his time might yield much insight.
- The techniques and tools used by Torres. Many questions still remain, like: Why did he choose certain species of wood over others, which tools did he have available, and did he use them out of necessity or choice? How can his techniques be evaluated in comparison with other techniques of his time?
- Last but by far not least, the sound. Ultimately the genius of Antonio de Torres is to be found in the sound of his instruments, and the visual artistic characteristics of the instrument are secondary. Unfortunately, analysing the sound is technically possible but difficult and costly. Some may find it hard to make reliable interpretations regarding the sound of a guitar, and maybe analysing and comparing several instruments in the same fashion is most appropriate. If possible at all, one could learn how the maker influenced the acoustic processes in the instruments.

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Appendix



Figure A 8. Front view (photo courtesy Malcolm Maxwell)



Figure A 9. Back view (photo courtesy Malcolm Maxwell)



Figure A 10. Side view (photo courtesy Malcolm Maxwell)



Figure A 11. Front view, detail (photo courtesy Malcolm Maxwell)



Figure A 12. Back view, detail (photo courtesy Malcolm Maxwell)



Figure A 13. Rosette detail (photo courtesy Malcolm Maxwell)



Figure A 14. Tuning machines (photo courtesy Malcolm Maxwell)



Figure A 15. Heel and back detail (photo courtesy Malcolm Maxwell)



Figure A 16. Bridge detail (photo courtesy Malcolm Maxwell)



Figure A 17. Lower bout (photo courtesy Malcolm Maxwell)



Figure A 18. Interior view of the center fan brace and one treble fan brace (photo courtesy James Westbrook)



Figure A 19. Interior view of the center fan brace and one bass fan brace
(photo courtesy James Westbrook)



Figure A 20. Interior view of the center fan brace and cloth patch, focus on
the patch area (photo courtesy James Westbrook)



Figure A 21. Interior view of the center fan brace, cloth patch and tail block, focus on the tailblock (photo courtesy James Westbrook)



Figure A 22. Interior view of damage on the top and center fan brace (photo courtesy James Westbrook)



Figure A 23. Interior view of the side, kerfed lining, rib blocks, rib reinforcing bars, and transverse braces (photo courtesy James Westbrook)



Figure A 24. Interior view of the side, kerfing and back brace (photo courtesy James Westbrook)

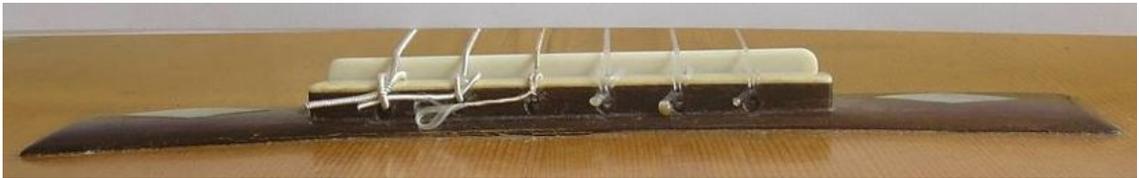


Figure A 25. Doming of the bridge (photo courtesy James Westbrook)

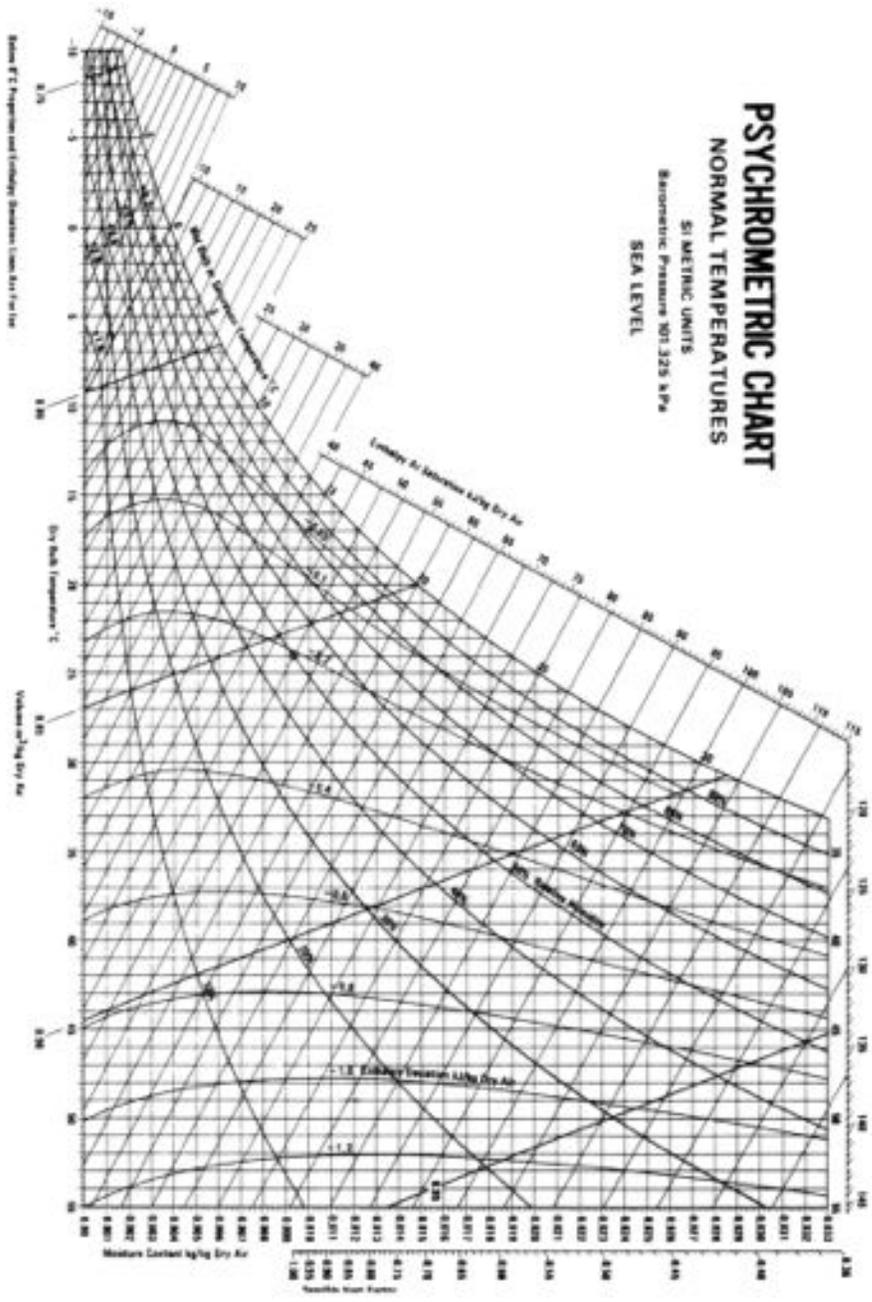


Figure A 26. Psychrometric Chart

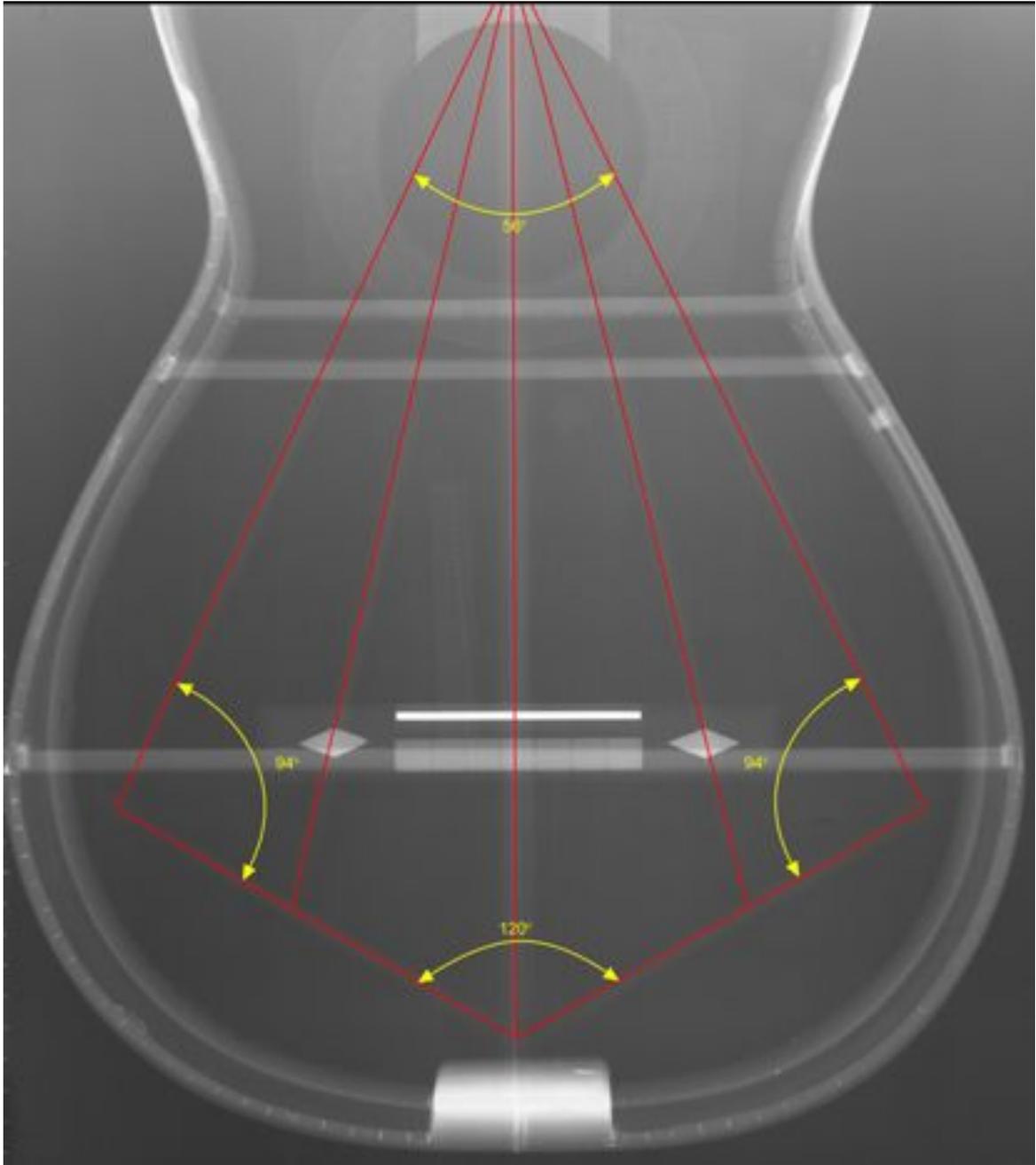


Figure A 27. X-ray photograph with schematics for the top bracing. *Note that the angle indicated as 56 degrees should read 52 degrees.* (photo courtesy James Westbrook and Nuffield Hospital)

Edition 3.6

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