# The classical guitar soundboards and their bracing:

## The luthier´s dilemma - symmetry or asymmetry in the structural design of the soundboards.

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luthier

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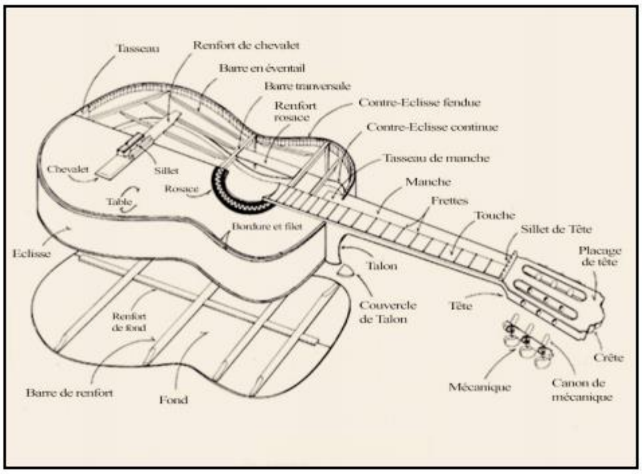
**Short description of the instrument:**

The resonance or harmonic chamber is made up of the sides, the back and the top, where the sound hole is located. Glued to the top, the transverse harmonic bars and the longitudinalbraces form the top bracing. The 5 to 9 braces, often arranged in a fan-like manner, are commonly referred to as “fan bracing”.




Around 1800, the guitars were small and their tops were flat, measuring no more than 30 cm in width, usually having only three or four internal braces, right above and below the sound hole.
During that same period, the 6th string, low E 82 Hz was adopted (single or double course)[1].
Thus, three important elements came together and were to be developed and fine-tuned in the fifty following years:

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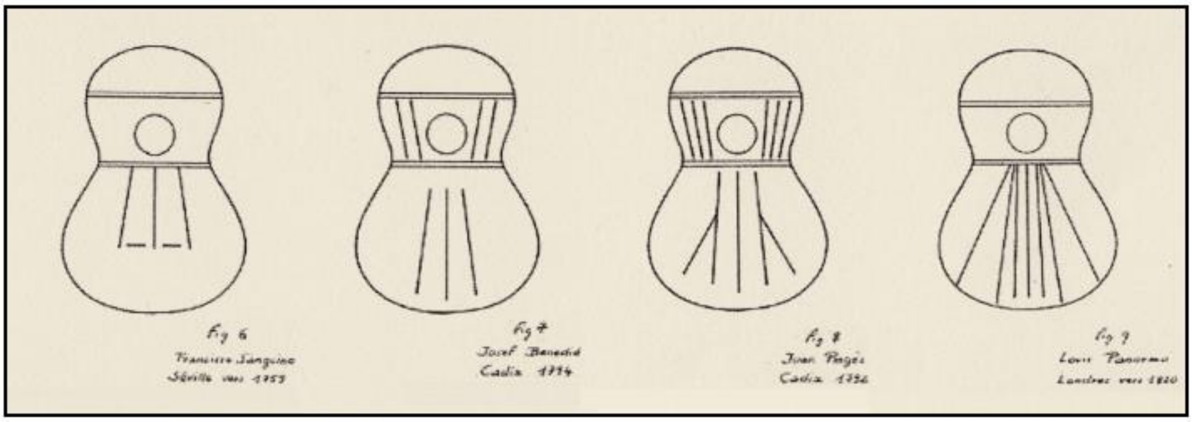
[1] *At that time we knew perfectly well how to make quality bass strings; the wrapping of heavy metal wire (copper, silver) in a spiral around a bare string, or “core” made of gut or silk, appeared in Europe in the second half of the 17th century. The gain in weight increased the linear mass without increasing its stiffness, allowing for a brighter timbre, and a longer, more powerful sound, which a simple, bare string cannot create.*

*At the end of the 18th century, the technical quality could be quite remarkable, as evidenced by the box containing 43 silk strings delivered at the Paris Academy of Sciences in October of 1798 by the citizen Baud of Versailles. The latter had developed a machine (for the low harp strings) that wrapped a pure, silver plated copper wire around a silk core with rapidity, precision and ease. The box was sealed, awaiting a patent of invention, and noticed only a long time afterwards, during an inventory made in 1977 by the Academy of Sciences and then entrusted to researchers of the University of Stanford (U.S.A.) who carefully studied its contents, in perfect condition nearly two centuries after its deposit. As Mr. Baud had claimed, these strings presented a high level of technical quality.*

**1 –** The braces, thin wooden strips glued lengthwise under the soundboard, first appeared in southern Spain, in Seville, circa 1759. The fan bracing was first used, according to our present knowledge, by the luthier Francisco Sanguino (Fig. 6) and later by Josef Benedid and Juan Pagès in Cadiz towards the end of the 18th century (Figures 7 and 8), followed by Manuel and Juan Muñoa in Madrid in the early 19th century and Juan Moreno around 1830, as well as Louis Panormo in England (Fig. 9), before being adopted, and complemented by the famous Antonio de Torres around 1850 in Seville and Almeria, who is the most renowned luthier of the 19th century (Fig. 10). All of these different bracing systems are symmetrical.



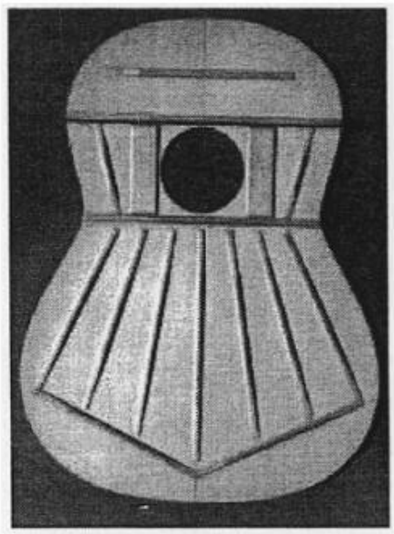
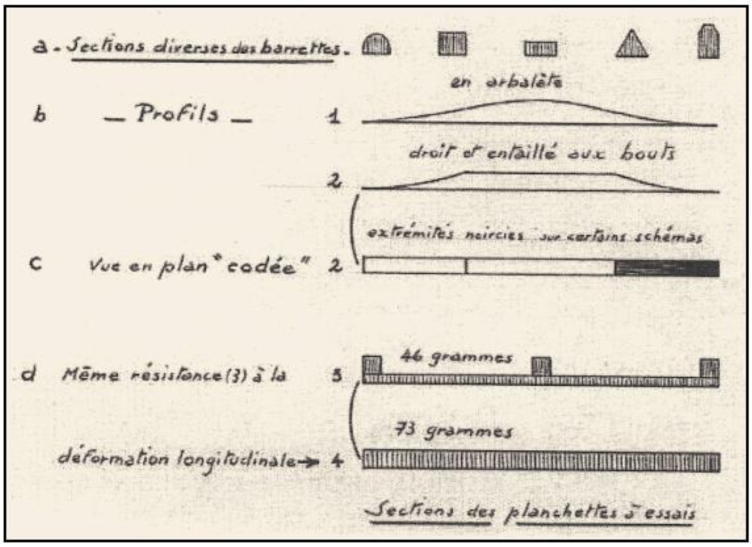



Fig. 10

The properties of the bracing are surprising. By carrying out some tests, we find that this method allows for as much rigidity lengthwise and more transverse lightness but with much less thickness, therefore less weight. It is enough to glue three braces, three transverse braces of 5 x 5 mm on a 40 x 9 cm board of 2.6 mm thickness to observe that it is necessary to take a perfectly identical board (quarter sawn) of 5.2 mm in thickness to have the same flexion, the same longitudinal resistance to deformation but going from a weight of 46 to 73 grams.

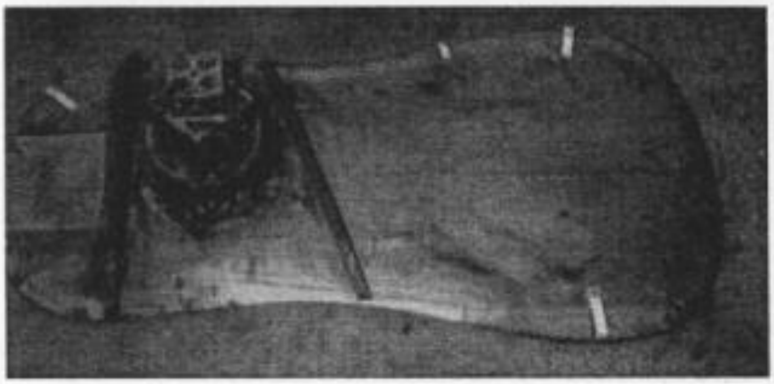
This lightness adds spontaneity, vivacity to the notes produced, and a better definition of sound. The full sound, just after the finger stroke, appears more rapidly, the arrival of the harmonics, constituting the characteristic of the latter, is formed more quickly according to my experience.




The cross-section of the braces and their profiles are important choices that allow for adjustments, for notable variations in the sound. We can shape the braces into several different profiles: half-round, square, flattened, triangular, rectangular and high, then a straight profile, scalloped at both ends, or a "crossbow" profile, high in the middle and sloping towards the ends, allowing a greater amplitude of vibration. The coupling of the soundboard to the body usually acts as a filter that attenuates certain frequencies, certain harmonics, or favors several others, on the other hand, which give character, a particular voice to the instrument, as seductive as possible.

Father Marin Mersenne has pointed out in 1636 in his "Harmonie Universelle" (Universal Harmony) about the lute: "It should be noted that the quality of the lute depends specifically on the bracing which should be neither too strong nor too weak, for when it is too firm the sound is not pleasant...
But it is difficult to attain perfection in the bracing without long experience and much observation regarding the difference between soundboards, where some might need heavier bracing while others will need lighter bracing, according to their material, their thicknesses... "
The makers of lutes and guitars were the same; therefore we may apply the remarks, the concerns of these luthiers, to both instruments.

**2 –** Another bracing system was also used around 1800, and was most probably born in Italy in the $17^{th}$ century[2] (the middle oblique bar which can be observed on guitars by Carlo Guadagnini and G. Fabricatore circa 1795). It consisted of a simple supplementary wooden bar glued at an angle under the sound hole.



[2] *A single slanted central bar had already been used on the ebony and ivory guitar marked with the initials G.C. (Paris, Museum of Music, E30), completely restored and examined by Pierre Abondance, who dates its second soundboard, after a transformation of a "battente" guitar into a normal, five double-string guitar, from the first half of the $17^{th}$century and its bracing before the $19^{th}$ century according to the evidence. Its origin is probably $17^{th}$ century Italy, due to its strong resemblance to a Jacob Stadler guitar dating from 1624 (cf. Harvey Turnbull, The Guitar from the Renaissance to the Present Day, London, 1974, pl. 23).*

*Cf. also the detailed study by Florence Gétreau and Pierre Abondance in "Guitares, chefs d'œuvre des collections de France" (Guitars, Masterpieces from the collections of France), pp. 244-259.*
*Cf. also in the same book, the guitar of Giovanni Tesler, Ancona 1618, p. 51, 73, 77, 278, 279. Presenting, before restoration, a soundboard with the same slanted central bar. (Nice, Instrument Museum).*

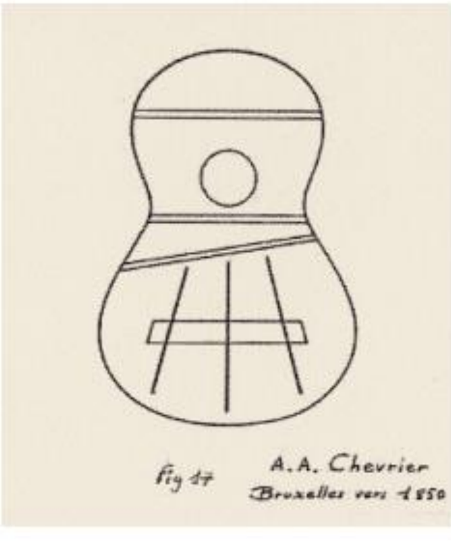
*For convenience, I will speak of the "Italian influence" in this study regarding this slanted bar, even though it´s not the whole story. However, we can assume that this procedure persisted until the 19th century, through various paths. It´s known, for example, that Antonio Stradivari seems to have used it on three of his guitars (of the six known to date) between 1679 and 1681.*
*Cf. recent studies by Gianpaolo Gregori at the end of the attached bibliography (Books).*

It has long been observed that psalteries, harps and harpsichords, had their high strings stretched over the shorter parts of their soundboards for various practical reasons and simple common sense. Someone had the idea of subdividing the guitar soundboard with a second slanted median bar glued under it so as to shorten the vibrating area on the side of the high strings.

This <u>asymmetrical</u> concept was adopted by the renowned luthier René Lacote and other French luthiers during the 19th century. This idea, this concept, has been repeated many times since the beginning of the 20th century as we will see.

It is worth noting here the surprising mixture of influences on the bracing of a guitar signed by the luthier from Mirecourt "A. A. Chevrier - Brussels" who could have built a following and been very successful in developing the ensemble.[3]




His bracing consists of three fan bars in a "crossbow" shape passing over a bridge patch with a flat section and two transverse central bars, one of which is at an angle, and a single typical bar under the fingerboard. One immediately notices that this is the essential feature, a design obviously simplified

[3] *Information kindly transmitted by my Parisian colleague Dominique Field. Several luthiers of the stature of Chevrier were practicing during the 19th century. André Augustin Chevrier was born in 1798, apprenticed in Mirecourt and married there in 1829, but from 1823 he lived in Brussels. In the document of marriage, he is noted as being an instrument merchant according to the research of Evelyne Bonetat, of Mirecourt, whom I thank.*

from the bracing used by the very famous contemporary luthier (1897-1977) Ignacio Fleta who certainly had never seen the guitars by André Augustin Chevrier, otherwise very rare. Numerous French tests of all sorts were made during the $19^{th}$ century with an abundant production coming from Mirecourt.

**3 –** A third modification concerns the size and width of the instrument which grew slowly at the beginning of the $19^{th}$ century through some occasional trials, coming, for example, from Gaetano Guadagnini, already mentioned, in Turin around 1820, from Nicola Carnevali, in Imola in 1825, or from Juan Muñoa in Madrid as well as Louis Panormo in London in 1829, for an admittedly quite unusual instrument, called an "enharmonic guitar" (Fig.18).

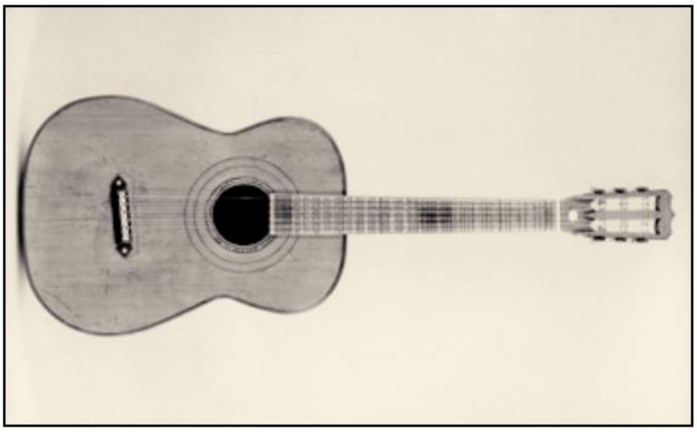


Fig. 18

To make the 6th string, low E 82 Hz, sound with sufficient depth, it was necessary to give a little more volume to the body.

This enlargement was proposed regularly around 1850 (or soon thereafter) in Spain, by Antonio de Torres[4] (Fig.19), in addition to the more elaborate "fan" bracing of his soundboards; a bridge to tie the strings at a precise spot; a wider, more convenient neck, etc. Almost all of these elements were visible separately in the works of the luthiers of his time[5], but he presented a complete synthesis, and some of his larger instruments with rosewood back and sides, with more full-bodied sounds, warmer, established themselves as models which led to the modern and international classical guitar, still very much present today. It was built in a symmetrical manner and this practice remained the norm in Spain until about 1900.


Fig. 19

We see reappear in that country an old idea of which I have spoken earlier, which led to asymmetry in the Spanish style, “fan” braced soundboard, an essential part of the sound of the instrument. In 1903, it was the Madrilenian luthier Santos Hernandez who set the middle bar at an angle to enlarge the

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4 *Romanillos J.L. "Antonio de Torres, Guitar Maker", 1987, p.173 to 208.*

5 *Romanillos J.L. "Antonio de Torres", p.42 to 45 and 89-90. Torres' Spanish predecessors, in the first half of the $19^{th}$ century, showed imagination and realism in inventing, adopting, combining, various elements such as the doming of the soundboard, a bridge containing a saddle consisting of a strip of ivory or bone, delimiting exactly the vibrating string length and also allowing them to be lowered or raised according to one´s need.*

*The French luthiers also made a great deal of effort and research, La Prévotte in 1838 presented an evolved bridge as well and a totally longitudinal soundboard bracing which could have developed with the size of the instrument (Museum of Music, Paris, E.675 and E.1042).*

vibrating part of the soundboard on the side of the bass strings and shorten it on the side of the treble strings (Fig.20).

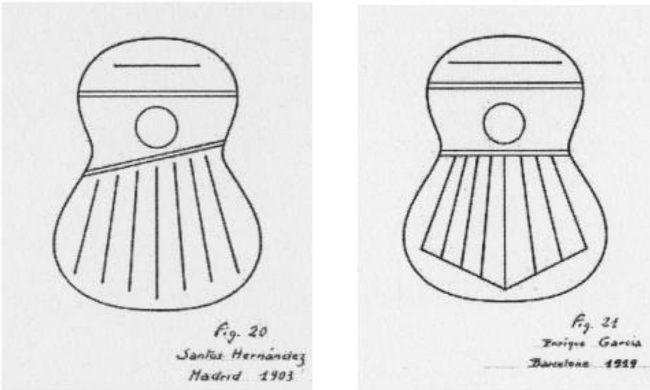

Fig. 20 et 21

Soon afterwards, it was his colleague from Barcelona, Enrique Garcia, who used another way of taking advantage of asymmetry (Fig. 21) by placing 3 braces on the side of the bass strings and 4 on the side of the treble strings, soon followed by Enrique Sanfeliu and Francisco Simplicio.


E.García


E.Sanfeliu

Note, however, that this idea is a little simplistic albeit still present among luthiers. According to today´s physicists, this systematic and selective separation is not so straightforward; the vibration travels where it wants to go, in the configuration that suits it best. I willingly use the expressions bass strings side and treble strings side as a quick and easy reference point while certainly recognizing the knowledge and the insight of the preceding luthiers of the 20th century for my comments.

**We return to the heart of the matter; two arguments are possible:**

**1 –** Making the soundboard a little thinner, with lighter bracing on the bass strings side, all in favor of more ample movements locally, stronger bass notes, and stiffening the treble strings side a little more which must favor the high notes (this is the case of the luthiers Garcia, Sanfeliu, Simplicio).

**2 –** Or taking into account that the three bass strings, wound by a heavy metal wire, produce more movement on the bass side[6] and that the three treble strings have more rapid movements, but being lighter, produce less movement on the soundboard, hence:

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[6] *The expression of the energy contained in a vibrating string takes into account the factors: linear mass, amplitude of motion and tension.*

Make the bass side more reinforced to expand the vibrating area (as for the harp) and organize the treble strings side with less bracing, lighter, since the high strings have notoriously less power to drive the soundboard.[7]

We can see that since 1950-60, the most productive or reputed luthiers have shown imagination in both approaches. Namely Fleta, Bouchet, Ramirez III, Hernandez y Aguado, Khono, Yamaha, Kasha and Friederich, among others.

Ignacio Fleta (Fig. 22), after having long used the Torres style bracing and building guitars with strong basses until the 1950s, changed his approach and started making his soundboards much thicker in the central area around the bridge.
He also resumed the system of the double middle bar, one of which at an angle, (which found great success in France during the 19th century), and he increased from seven to nine the number of braces in the fan arrangement.
The strong nodal area created at the waist, at the narrowest part of the soundboard, and the importance of the bracing, made it an instrument with clearer, longer sounds, (a bit more difficult to play) and very homogeneous. The vogue for guitars with very strong bass was declining. The vibrating zone on the treble side was and remains shortened to the present.

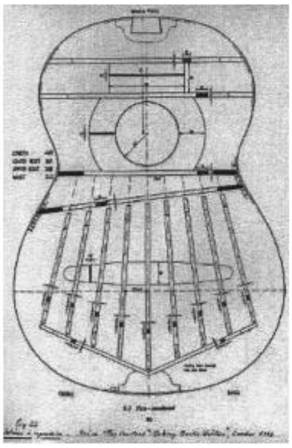

Fig. 22

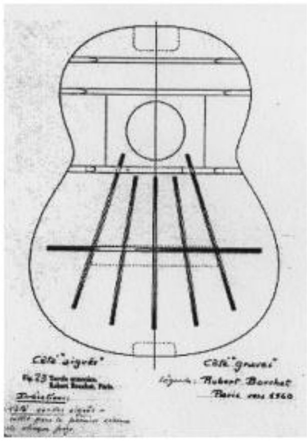


Fig. 23

Robert Bouchet (Fig. 23) in Paris, around 1958, also changed his bracing style, until then very influenced by Torres, and kept only five bars in his fan arrangement, but added a bar placed under the bridge, certainly inspired by what he had seen on his own Lacote guitar, placed close to the bridge, in the 19th century. He therefore audaciously conceived an asymmetrical bracing; the braces on the bass side were clearly thinner and strongly scalloped toward the edges, contrary to the braces on the treble side, which

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[7] *In 1654, luthier Christophe Koch chose to make some transverse bars thinner on the bass side of the soundboard of an archlute in the Museum of Music in Paris and added three small short bars on the treble side coming from the lower edge and moving towards the center of the wide part of the soundboard, towards the bridge, hence a very clear asymmetrical arrangement of his bracing and a precise acoustic project.*

were made taller and less scalloped toward the edges. In addition, the bar placed under the bridge was strongly profiled and low on the low strings side, reaching about 12 mm around the middle of the treble side. In this manner he got longer sounds, a little less explosive but clearer, more homogeneous and with more character; the treble side of the soundboard was thus more heavily braced.

José Ramírez III (Fig. 24), around the same time, also developed an asymmetrical bracing system by crossing two bars in the middle part of the soundboard, thereby creating a strong nodal zone (inert, passive) at this location and an even more pronounced shortening of the "useful" vibrating part of the treble side. Like Fleta, he used a bridge patch, a thin plate of wood, borrowed from the German luthier Hermann Hauser following a procedure already in use or being developed in the 19th century. Note that the bracing on treble side of the soundboard is sparsely barred.
José Ramírez III had a huge commercial success after providing several guitars to Andrés Segovia.

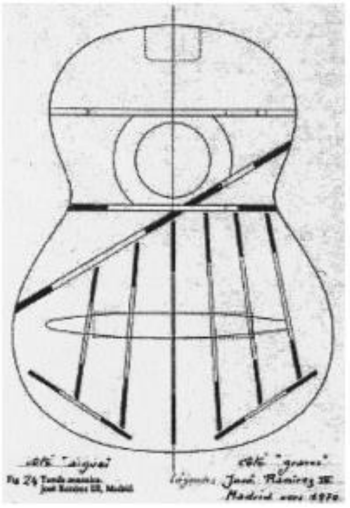
Fig. 24

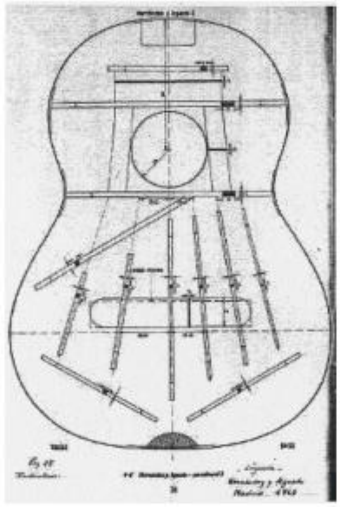
Fig. 25

Hernández y Aguado (Fig. 25) and associated luthiers in Madrid, wondered, in the 1960s, if one could not do without the X crossing of the two middle bars and placed a half bar at an angle only on the side of the treble strings. The general plan resembles that of Ramirez, the treble side is sparsely barred longitudinally. This half bar has often been used since, by Manuel Velázquez and Thomas Humphrey in New York for example. The effect produced is less obvious and different, the nodal zone being less firm and much less clear.

Masaru Kohno (Figure 26) and the Japanese manufacturers made a strong entrance in the late 1960s. Kohno proposed an original and sophisticated bracing which gave his guitars a clear, biting, long, homogeneous and spontaneous sound.
Like Robert Bouchet, he distinctly reinforced his bracing on the treble side; the ensemble being very rigid with a long bridge patch going from edge to edge at the widest point of the soundboard.

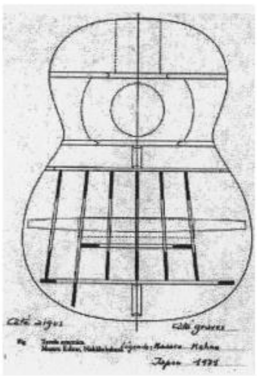
Fig. 26

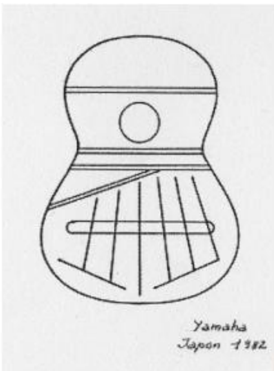

Fig. 27

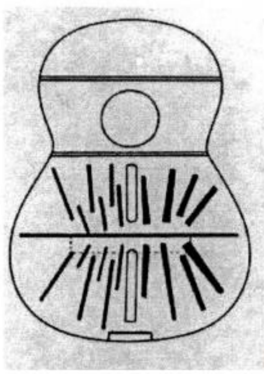
Fig. 28

The Yamaha Company (and its counsel of luthiers) (Fig. 27) also betted on a clear asymmetry and used two parallel middle bars and a half slanted bar with only two braces on the treble side of the fan arrangement similar to Ramirez. Almost all of these bracings represent a major effort for their execution.

Kasha-Schneider (Fig. 28) The height of asymmetry was reached in 1970, when Dr. Michael Kasha, Director of the Institute of Molecular Biophysics of Florida (Tallahassee) began to ponder, with luthier Richard Schneider, of Detroit, how one could rethink the guitar soundboard bracing system in a rational, new and advantageous way.[8] In order to preserve the rotundity of the soundboard, he maintained the bar under the bridge, which had been used successfully by Robert Bouchet, and distributed small pieces of wood radiating from it, to divide, to fragment the vibrating surface. We can observe small short braces on the treble side and fewer and larger pieces on the bass side. Many systems were proposed, this one numbers 22 radiating pieces; the small, short and closely placed parts should favor the high frequencies, while the larger pieces should favor the low. It should be noted that the bridge of these guitars was not symmetrical nor consisted of a single piece, it was divided into two parts: A heavier one for the three bass strings, and a smaller one for the three treble strings; this added much to the reliability of the system within the unit.

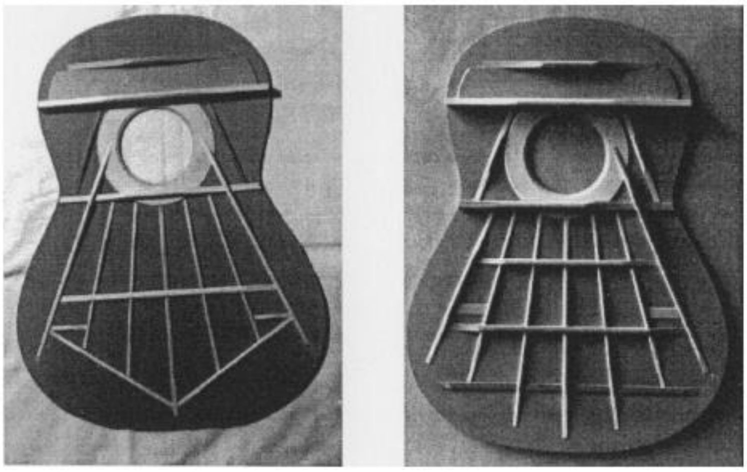
Fig. 29 et 30

Daniel Friederich. As far as my bracing system is concerned, after a Torres period, while retaining a bar under the bridge (which has varied in location) inherited from Robert Bouchet, I devised a symmetrical, almost triangular system, to maintain the doming of the top which has given me good results (Fig. 29). More than ten years later, in 1975, I removed the bar forming the triangle on the treble side and made the bracing asymmetrical, which seemed to me as satisfactory, if not more so (Fig. 30). Then, from guitar nº 540 onwards, I developed another symmetrical system with a double middle bar and I use both variations, according to the playing style of the future owner and according to the wood of the soundboard.

Thus, two major questions arise:

Question 1: In view of the complexity of these bracing systems, one wonders whether this is useful and essential.
Answer: every luthiers would like to attain a personal sound; seductive and with character, by use of simple and not so labor-intensive means. But this is clearly not the case, few have succeeded in the long term.

Question 2: Do asymmetrical bracing systems provide undeniable benefits?
Answer: one is tempted to believe it by observing the number of luthiers using these processes. It is certain that an asymmetrical bracing system or bar will have an effect on the general vibratory mode of the soundboard; and experience has shown me that we can also create interesting modern instruments building symmetrically, as is the case of excellent colleagues in Europe and elsewhere.

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[8] *Tom and Mary EVANS, Tom et Mary EVANS, Le grand livre de la guitare (Guitars: From the Renaissance to Rock) 1979, Paris, p. 66 and 206. See also: Journal of Guitar Acoustics, Vol. VI, Sept. 1982 p. 104 to 121, in memory of Dr. Michael Kasha and Nicolas Kasha.*

Comments: According to specialists in physics, in the low notes of the guitar; from the low E 82 Hz (the open 6th string) and for the fundamental frequencies, the volume of air in the resonance chamber considerably reinforces the sounds produced. The soundboard vibrates in block with the bridge in a "piston-like" vibration mode which extends widely around it, and the acoustic energy is radiated through the sound hole. Then, it gradually weakens, and towards 250 Hz another vibratory but dipolar mode appears (Fig. 31) producing a vibratory zone at each end of the bridge, the two of which may be in phase opposition.[9]

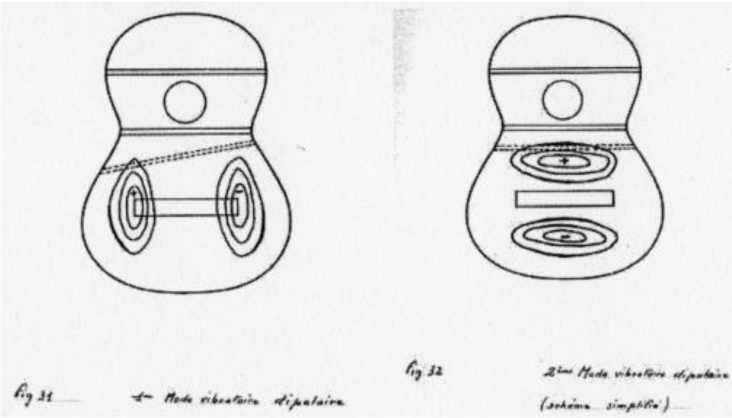

Fig. 31 et 32

Thus, it is not necessary that the two vibrating poles be equal in surface and amplitude, since their movements risk being counteractive, diminishing the emitted sound (one of the sides starting at the same time but in opposite direction)[10]. In this case, the placement of an angled bar between the sound hole and the bridge, a supplementary brace, or one of a different thickness on one side, must be useful at certain frequencies to prevent this disturbing phenomenon.

The same problem may arise in the equally dipolar vibration, by the torsion of the soundboard in the area below and above the bridge which oscillates rapidly (Fig.32). Again, it is necessary to avoid that the two parts, necessarily in phase opposition, be equal. A second middle transverse bar placed horizontally between the sound hole and the bridge may suffice to modify considerably the response of the first treble string (330 to 988 Hz). All these vibratory modes, and others, are superimposed, combined, to form a complete sound with its harmonics. It is up to the luthier to make the most satisfying choice, as did our colleagues of the 19th century and before, by gluing a lower transverse bar or a supplementary transverse bar; it is an important part of his art.

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[9] *The holograms obtained by interferometry give us partial information because the studied soundboards are excited by vibrators placed in direct contact with them, which give rise to artificial movements of great amplitude to be able to obtain images, visible configurations; these are forced vibrations at simple frequencies.*

[10] *This phase shift may be due to the more flexible structure of the soundboard on one side, the bridge being a bit asymmetrical and quite flexible, or the position of the string further away from the vertical axis of the guitar. Note also that the difference in tension of the three low strings, added, compared to that of the treble strings, is not very great for the classical guitar; the observable mean is 25 kg for the lows and 21 kg for the trebles, it is therefore the lineal mass (weight per string length) which is the cause of the most important soundboard movements created by the three low strings.*
*In spite of this problem, we can see that around 300-500 Hz the soundboard, at its widest point, is divided into two important vibrating zones, and that towards 1000 Hz it is subdivided into six small concentric figures, alternating within each figure, inert nodal zones and the zones with movement. Between these two frequencies (the first treble string), most of the sounds radiate directly from the soundboard without going through the sound hole according to competent researchers; see:*
*- Jansson E.V. "A study of acoustical and Hologram Interferometric Measurements of the top plate of a Guitar ", Acustica 25, 8/1971, 95-100.*
*- Jovicic and Jovicic "Le rôle des barres de raidissement sur la table de résonance de la guitare; leur effet sur les nodales de la table" (The Role of Radial Ribs on the Resonance Board of the Guitar . II. Their Effect on the Nodal Lines of the Board (Holographic Study), Acustica 38, 9/1977, 180-185.*

Conclusion: In any case, if one has developed a bracing system, an ensemble which gives good results, whether symmetrical or not, one should carefully preserve the formula, while attempting variations to improve and adapt it to the different guitarists.

Both ways, both methods are possible, in my opinion; asymmetry does not seem indispensable to me.

**Doming of the top - pronounced or subtle?**

Low doming: less then 2mm at the widest point
Normal doming: from 2 to 4 mm
High doming: over 4mm

Until about 1800, the guitar soundboards were flat. Is the doming as important as a structural and determining element as it is for the violin? I do not think so[11], but it is an interesting security measure to avoid shrinkage cracks in dry and very dry climates.

In order to maintain, to consolidate and stabilize this arch, this curve, we have two solutions:

a) We can glue a thin 0.7 to 1.5mm wide strip of wood under the soundboard, where the bridge is located, with the same width and longer than the bridge. Used first by Hermann Hauser I in the first half of this century (around 1930), this prevents the wood of the soundboard from shrinking or expanding. This counter-bridge is very light.
b) We can also glue a small wooden bar under the bridge, around thirty centimeters in length.

In both cases, the dome will be much more stable and will only sag very little in case of severe dry weather, by moderately lowering the bridge and strings, which will not destabilize the instrument too much.

The application of the bar under the bridge also gives special characteristics to the sound. The soundboard, through the bridge, where the strings are attached (40 to 47 kg of tension), undergoes a significant torsion and a slight pressure. The addition of a long plate under the bridge or of an extended bar (especially when placed on the back) distributes these pressures over a greater area of the soundboard, thus placing less stress on the central part.

There will possibly be less explosive bass, but a longer sound in general; the energy available at the release of the string will be dissipated differently, the attack will be changed, the nature of the sound will change. The right balance is to be found for one or another guitarist.

Another non-negligible effect will be the increase in sympathetic resonances emitted by the strings. A bridge reinforced by a plate or a bar forms a more rigid, one-piece assembly which ensures a greater transversal connection. Many more notes played on a sharp string will find a stronger harmonic echo spontaneously emitted by the bass strings. Most guitarists appreciate the strong sympathetic resonances; the luthier will have to make his choice after experimentation.

[11] Around 1981, the laboratory of musical acoustics of Jussieu Paris VI received a trainee, Dominique Douau, working for a Master of Advanced Studies in acoustics entitled "Study of the acoustic behavior of the guitar soundboard. Influence of the soundboard bracing system on the sound of the instrument" (1983). The soundboard on the experimental guitar was flat, with no doming, and it functioned properly.

**The signature of classical guitars**

Another consequence of the bracing system adopted by the builder has to do with the “signature” of the instrument during the attack, which is an important component of the whole sound, it´s the instrument´s “face”; if the attack is cut off artificially, the instrument cannot be recognized.
The signature is a resonant sound, a deep, underlying frequency that we find under each note produced by the finger that plucks the string and rests on the neighboring string. In this small shock, we identify mainly the lowest dominant elastic frequency of the soundboard, coupled by the volume of air from the body and sides. This frequency is easily discernible by a simple thump of the thumb against the bridge; it generally goes from the F 87 Hz to the A 110 Hz, currently. It is usually interesting for a guitarist who uses a lot of fingernail on his attack (without resting), to have an instrument with a profound attack, round, with a deep signature that will serve his sound. By contrast, a musician who plays “*apoyando*”, using the flesh of the fingertips and little nail, will be better served by an instrument with a clear attack, with “bite”, more “harpsichord-like”, with a higher pitched signature. (The small guitars of the mid 19th century may have a signature reaching D 147 Hz, the fourth open string of the guitar.)

Nowadays, to orient this signature towards the A 110 Hz, a thicker soundboard would be needed, heavier bracing, a smaller body, and more importantly, having the middle of the soundboard, near the sound hole, heavily braced by two transverse bars that would shorten the main “useful” vibrating part by establishing a line, a nodal zone, a very firm and clear barrier, a precise delimitation. In addition, a larger opening of the sound hole seems to increase this frequency.

**The template, the shape of the soundboard**

On the other hand, luthiers have long sought to enlarge the vibrating, "useful" surface of their soundboards or the template of their shapes. We can briefly note that:


*La Prévotte*


*Simplicio*


*Contreras*

Etienne de La Prévotte in Paris, 1838 (Paris, Museum of Music, E.675), designed a bracing system without transverse bars consisting of four longitudinal bars going from the lower bout to the extremity of the upper bout.[12]

Antonio de Torres after 1850, lightened the transverse center bar strongly with two significant scallops on some of his guitars with the purpose, it seems to me, of not stopping the vibrations completely at the edges.

Eustaquio Torralba in 1863, in Logroño[13], imagined a bracing radiating from the bottom of the sound hole (and asymmetrical...) without a middle bar, presumably with the same intention as the two aforementioned luthiers.

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[12] *Instrumentistes et luthiers parisiens XVIIe - XIXe siècles,* Paris, 1988, p. 180 nº 185. *(Parisian* players and luthiers 17th – 19th centuries).

[13] Romanillos J.L. Antonio de Torres, p. 46.

Francisco Simplicio, circa 1930 in Barcelona[14], divided the sound hole of some guitars into two parts, arranged on each side of the fret board, and placed the middle bar much higher, which accentuated the lows and gave them an explosive character (the guitar had been increasing its sound range towards the bass since the end of the XVI$^{th}$ century; he was perhaps tempted to produce even deeper basses, very full-bodied, which had not yet been presented).

Other luthiers, by increasing the volume of the body, its width or thickness, have equally tried to create more vigorous or deeper sounds.

As early as 1907, José Ramirez I made some guitars 38 cm wide; Manuel, his brother, also made a large sized model.

Nowadays, this feature was taken up in Madrid by Manuel Contreras (38 cm) and by Thomas Humphrey of New York among others. This is almost a novelty for young guitarists today and a temptation for young luthiers... although to me it does not seem really necessary.

**Soundboards in spruce or American "western red cedar", lighter?**

The Spanish manufacturer José Ramirez III used the first, shortly before 1970, a western North American wood, the "red cedar" (*Thuja plicata*), observing that good quality spruce was becoming rare and very expensive in Europe.
This wood can have a beautiful bronzed appearance, patinated, very tight grain, but most importantly, it is lighter and more longitudinally flexible than spruce in most cases (it is also more fragile, more susceptible to blows and scratches).
A density of less than 400 kg per cubic meter is a rare quality for spruce and "Red cedar", in addition, they are very large trees, homogeneous in their growth, growing very old and, after having cut into massive logs, bought in the ports of the Atlantic, we can have almost identical boards coming from the same trees and developing more predictable sound quality, more uniform in its production. Otherwise, adjustments and modifications become random or almost impossible to control.
Unfortunately, the precise sawing of thin boards is not easy to execute nowadays, the special band saws having disappeared.
Whether in "red cedar" or spruce, by taking some comparative measurements for each board, such as longitudinal flexibility, combined flexibility after the soundboard has been joined, as well as the density, one can better access the thicknesses that will be needed and the precise bracing necessary to safely obtain a guitar with generous sustain, easy touch, with good contrast and a beautiful and spontaneous voice (I have been using mainly “red cedar” since 1974 with great satisfaction regarding the sound results).

**Choosing the soundboard: aesthetics or functionality**
Regarding the aesthetic aspect, the extreme tightness of the annuals growth rings (very tight dark grain represents the harder autumn wood), has more to do with the commercial area of dealers or lovers of botanical curiosities. So much the better if dark annual growth rings are regular and spaced 1 mm or less; I have no objection in this respect but do not systematically search for it.

In technical terms, the word "grain" is used for this specific point and the word "texture" for the ratio between the width of the dark brown autumn wood and the total width of the annual growth. A ratio of 1/4 or 1/5 is generally considered satisfactory.
Spruce with very tight grain can be a dreadful cause of sound problems due to its excessive rigidity. Dark rings that are too wide and a soft spring wood, which is too flexible, can produce a sound lacking definition and sharpness to the attack. Note that within the same species, trees are very different amongst themselves.

In the late 20th century, the trend, the demands of guitarists, shifted once again towards spruce top instruments which had been much less used during the previous twenty-five years. However, this tree

[14] La guitarra española, Expo Catalogue 1991, p. 172.

has no magical virtues but as it is more resistant to scratching and blows caused by intensive use, it gives luthiers and collectors the hope of having well preserved instruments for a few decades to come, or perhaps even more...

**General Concepts - New Trends**

Over the last two decades, some independent builders have rethought the design of the instrument, the soundboard and its bracing. An Australian, Greg Smallman, apart from all trends, has created extremely thin and fragile soundboards, reinforced on the inside by a regular grid of balsa strips intersecting in a lattice with a more or less steep angle. The assembly is very light and symmetrical, similar to a loudspeaker membrane system that receives and amplifies all frequencies provided by the strings, but we hear a lot of finger attack, which can annoy some discerning listeners and connoisseurs (one can maliciously call them "drum guitars".)
Charles Besnainou, in his studio lab in Paris VI Jussieu, engineer with the CNRS (National Center of Scientific Research), completes the development of a guitar using wood and a composite material for his extremely light soundboard, with an adjustable core in its interior, which gives a strong and homogeneous response to each note; it's an asymmetrical system of a small original bracing that produces a strong and homogeneous response across all notes.

Note: the soundboard and its bracing are not the only important elements in the structure of the guitar; all of the parts forming the resonant body are linked to give an interesting overall response in traditional classical lutherie. The total weight has increased from 800 to 1,000 grams around 1800, to 1,800 grams and more in the late 20$^{th}$ century.

This structure is not invariable, different guitarists look for different characteristics of sound; there are four schools in Paris, four styles and techniques for learning how to play (French, Spanish, Latin-American and Central European). There is, therefore, a wide field for creative expression with the dozen or so variable criteria that define the sound of the guitar, namely:

1. Power (from up close, from a distance); the "reach"
2. Sustain
3. Uniformity of sound level
4. Timbre (the quality and texture of the guitar's voice, its color)
5. Balance between bass and treble
6. Whether the instrument is easy or difficult to play
7. Evenness of the sound quality
8. Degree of responsiveness and sensitivity
9. Attack of the sound (audible or slight)
10. Contrast (more like a harpsichord or like a piano)
11. Sympathetic resonances (noticeable or not)
12. Clarity of the chords; polyphony or opacity

The creative style of the luthier, in line with his knowledge and his personality, relies upon the observation of the masters of the past; an enlightened empiricism, intuition, calculation, common sense, realism.
He also needs a lot of perseverance, audacity and successes...
Along the way, as time passes, other questions, other dilemmas will surely arise during one's career.

*by Daniel Friederich, guitar luthier in Paris*

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