The lute in its historical reality

by Mimmo Peruffo

'Now divine aire, now is his soule ravisht, is it not strange that sheepes guts should hale soules out of mens bodies?'

William Shakespeare, *Much Ado about Nothing*

Foreword by the Author

The present work is the synthesis of a research (we might call it historical-archaeological) that began in the 1980s.

A synthesis we still have to consider as provisional, since liable to be expanded or modified after possible new discoveries or further reasonings on the subject of stringing the Lute in its several historical seasons.

For each historical period of the Lute I listed the diverse, concomitant historical evidence I have knowledge of (both treatises, and of a technological, epistolary, iconographical nature) dealing with strings, to which are added mathematical verification and experimental tests (every hypothesis must also work in practice in order to be accepted as plausible). The conclusive hypothesis, as harmonized synthesis of all sources, is expressed at the end of the exposition of the documentation.
Of course I tried to make sure it does not contradict any of the listed documents. When so, I left a doubt, or a different interpretational model, open.

On the other hand, wherever different points of view exist, I took care to expose them together with their reasons, pointing out their weak points (in the light of historical sources, mathematical calculations etc.).

To better tackle this task I drew on the synergic competence acquired from my former activities as chemical analyst, amateur lute maker and (again, out of passion) lute student.

To this sum of experiences is to be added my profession as string maker, which integrates the teachings received from my mentor, Arturo Granata (the last string maker in Italy who exercised his trade for many decades), in the active research in the fields of ancient string making and historical documentation and treatises on the Lute and other string instruments.

My activity as string maker plays here a fundamental role: the fact of never having seen and handled fresh gut strongly limits the very formulation of hypotheses that first of all must take into account whether gut can eventually produce what we expected it would do.

So a long and thorough study was necessary of the technologies in use in the 16th and 17th centuries (especially regarding the dyeing of leather, fabrics, silk, hairs etc. and then the techniques of metal wire), constantly supported by Franco Brunello, one of but a few experts in the world on the subject of applied chemistry to the tanning of leather and dyeing of fabrics and silk in the 16th-18th centuries.
It was thanks to his support that I had the good luck of having at my disposal original historical texts

or now very rare16th and 17th century reprints of a technological nature, which allowed me to carry out, in the period 1983-1990, at least 1,500 tests after ancient (and partly more recent) recipes from the dyeing and tanning trades, in the hope of being able to apply them to the loading of gut for bass strings.

Besides, I read several ancient recipe books and went through a few hundreds of volumes of lists of 16th and 17th century manuscripts from the principal Italian libraries, in the hope of finding some useful information about string making technology (and this is how the Statutes of Roman and Neapolitan string makers were found).

This kind of research was also extended to the State archives of cities that had been historical string production centres like Rome, Pistoia, Florence, Bologna, Naples, Lyon, Strasbourg etc.

It was, again, thanks to Brunello's personal knowledge and to his books that I eventually realized that the incorporation of insoluble pigments had been a very common practice in the past, prompting me to apply it to loading of gut and test its efficacy.

Very helpful was, specifically, the in-depth study of Renaissance techniques of silk treatment with minerals and so was my knowledge of chemistry applied to goods and of the mineral chemical compounds known in the past.

The research carried out in the museums of Vienna, Nuremberg, Paris, Florence, Bologna, Rome, Barcelona, Innsbruck, Berlin, Eisenach, or in private collections (with the scope of measuring the diameters of bridge holes on surviving Lutes) and at the same time the analysis of the iconographical sources of the time finally closed the circle.

At this point I would like to mention the surviving pieces of historical strings found in some European museums (Rome, Innsbruck, Brussels, Vienna, Nuremberg), on which I am keeping a constantly updated database that presently counts hundreds of specimens that can be defined as 'ancient'.

Finally, I would also like to mention the filmed interviews (with practical demonstrations of working techniques, tools, processes, etc.) with the last, very few, elderly Italian string makers, heirs of a historical technological tradition passed on from father to son, just in time to prevent its final disappearance.

Fortunately we were able to achieve that task before it was too late and we can now state that every phase of the whole historical production cycle is safely recorded and perfectly reproducible.

I hope that this work will help stimulate further debate and practical research rather than simply support the formulation of certainties (or, at the other end, superficial opinions) based, only too often, on scarce (or partial) knowledge of the documents, of the mechanical and acoustical properties of strings and of the technological resources of the past which, in archaeological work, nearly always only add to confusion and leave things as they were.

MP

A few words on the Lute

strumento perfectissimo et eccellentissimo

The Lute is no doubt the instrument on which the ancient lute and string makers invested all they could invest to obtain the maximum acoustical performance from the interface *string-instrument.*

The limited working tension, the sound emission obtained through just one initial impulse from the fingers (and not a continuous one as obtained with a bow) and the remarkable open string range (especially on instruments with ten or eleven courses on a single neck) made it a gymnasium of projectual and constructional abilities.

Just as any architect has to use a brick's mechanical properties as his starting point, the ancient lute makers designed their instruments - be they *Lutes, Violon d'arco or Viole da Brazzo* - starting from the mechanical and acoustical properties of the available gut strings, and not the other way round. Nobody would design a new internal combustion engine and afterwards start looking for the right type of fuel.

Concerning the string makers, we can safely assume that they always produced strings of the best possible quality compatible with the technology at their disposal.

As example in our opinion, the Lute 1st strings -in the early 16th century- had already reached, as far as the tensile strength is concerned, their *ultimate degree of perfection* (whereas their potential falseness remained an unsolved problem).

We must point out that improvements in the string quality never took place through a gradual, steady perfecting of production techniques but through *sudden technological leaps*, which always specifically dealt with the development of Bass strings of a better acoustical performance.

The success of such improvements always had important consequences on our instrument, first of all an increase in the number of bass strings (originally on one single neck).

Let us now try and explain by what criteria the Lute was the result of the optimization of *already available strings*, starting from a few basic elements:

1) Working tension: frequency and string length being equal, it only depends from the thickness of the string: the diameter was to be chosen so that the string would be neither too stiff, nor too slack to the touch.

2) Equal feel: once the diameter that granted the 'right' tension was found it should be applied to all strings on the instrument.

3) Inharmonicity of thicker strings: the thicker a string is (tension, string length, quality of the material and manufacturing technique being equal) the lower it sounds, but at the same time the overall acoustical qualities decrease in a progressive manner, until - beyond certain diameters - the increase in stiffness makes them completely unsatisfying.

Let's look at things in detail:

Points 1) and 2) are working conditions that are decided by the player alone.

Point 3) is a problem that has to do with a law of Physics, whose practical opposite is: any strategy apt to reduce the string's diameter can only go in the right direction.

The solutions leading to a reduction in diameter, frequency being equal, are:

1) - reduced working tension

2) - longer string length

3) - increased string elasticity

4) - increased specific weight

Point 1) depended on the player (neither too taut nor too slack strings); points 3) and 4) only depended on the string makers and were the cause of real organological and musical *eras*, as they introduced novelties onto the market.

The only point directly concerning the lute maker was thus point 2): string length and diameter are inversely proportional and in order to optimize the acoustical performance of strings it was necessary to adopt the longest possible string length. This was done to the benefit of the Basses, the thickest strings and therefore most liable to suffer from inharmonicity, in order to reach the smallest possible diameter and consequently the best possible acoustical performance.

On the other hand it was not possible to increase the string length at will, the breaking point of the treble being the limiting factor.

Let us see why:

When a string - of any material - is put under increasing stress between two fixed points (string length) a frequency will be eventually reached at which it will snap. This point coincides with the linear breaking load, which for gut experimentally averages 34kg/mm2 (an average value we can assume as reliable - on proven grounds whose demonstration lies beyond the scope of this article - and applicable also to gut trebles from the 16th and 17th centuries).

Such limit, called *breaking frequency*, is completely independent - counter-intuitive as it may sound - of diameter, and that can be easily verified both mathematically, through the general formula of strings, and experimentally.

This frequency is directly proportional to the string length; so if you, say, half the string length the frequency will be twice as high. In other words, the product of the string length (in meters) by frequency (in Hertz) is a constant, called *Breaking Index*.

Experimentally, the mean Breaking Index of a modern lute's treble breaking at 34kg/mm2 is 260 Hz/mt (that is, a string 1 meter long will break, will be expected to at 260 Hz, which equals a stress of 34kg/mm2).

In fact, the lute maker must reason the other way round: the frequency of the treble is the first parameter taken into account when designing an instrument.

According to the above described proportions, dividing the Breaking Index by the Frequency of the treble will give the *theoretical* string length at which that string will break.

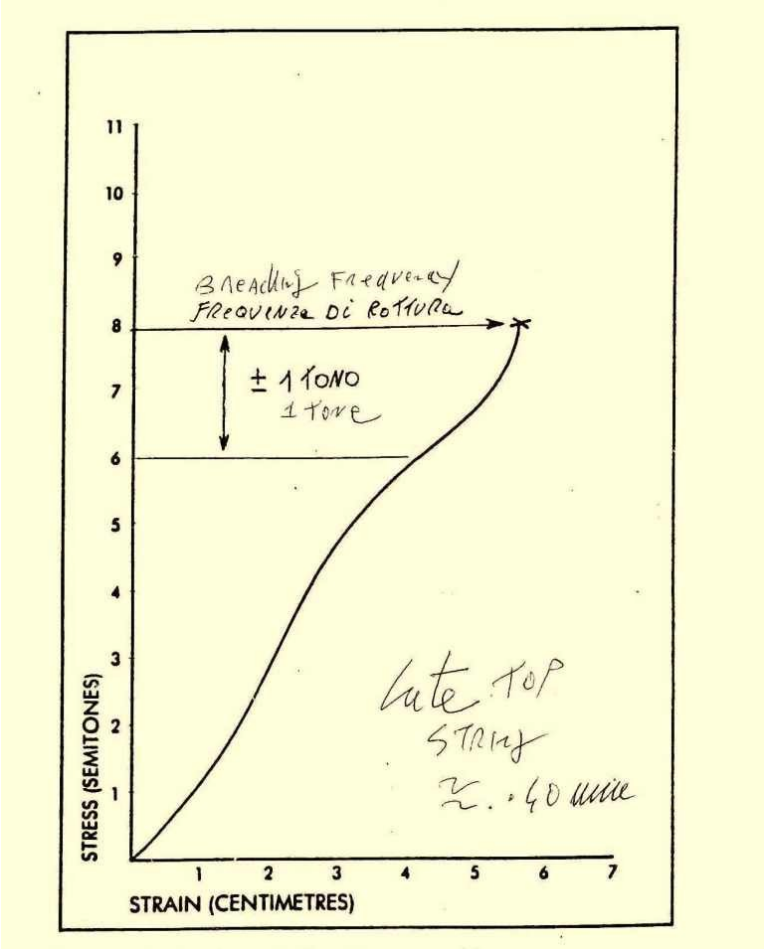
In the case of a lute in G (g=392 Hz at A 440) we obtain: 260/392=.66mt.

For the *practical* string length a certain prudential shortening of this critical length must then be taken into account. By how much? The shorter the string the more problematic the acoustical performance of the Basses.

From the examination of some (reliable) surviving Renaissance and Baroque lutes, and the proportions of the instruments described by Praetorius, we could ascertain that the *working* string length was 2-3 semitones below the *theoretical* string length described above.

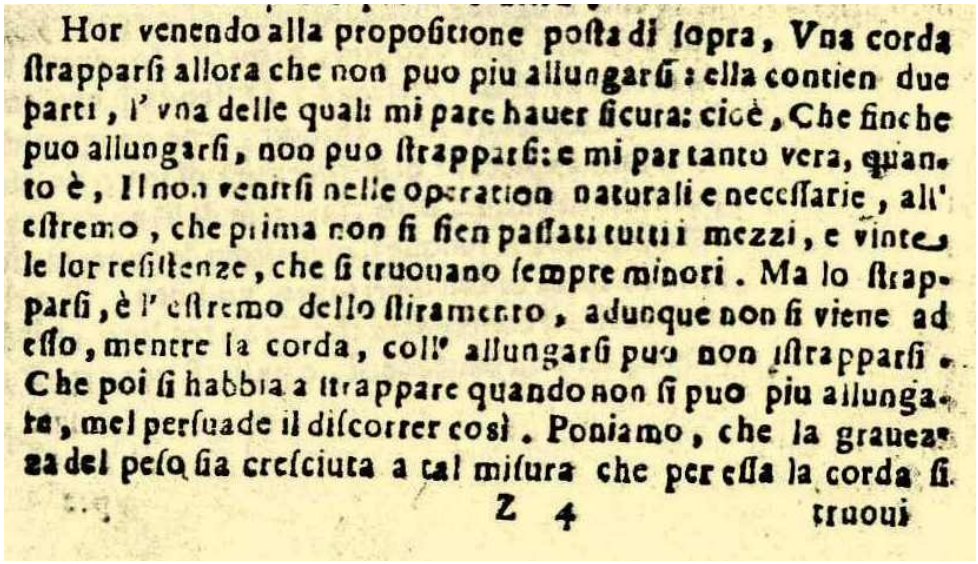
Why?

Using a research carried out by the lute maker David van Edwards ('*Gut strings and Angled Bridges*' in The Lute Vol XXV 1985) as a starting point, we put under increasing stress a Lute treble and obtained, too, the following curve:



As can be seen, the string keeps its linearity up to about two semitones below breaking point. From there on it loses almost completely its tensility under increasing stress and quickly reaches its breaking point.

This aspect was of course well known to the Ancients: this is what Bartoli wrote: ...*una corda strapparsi quando non può piú allungarsi*... -a string broke when it cannot stretch furthermore- (DANIELLO BARTOLI: *Del suono, de' tremori armonici e dell'udito*, a spese di Nicolò Tinassi, Roma 1679, p. 263):



Hor venendo alla propoſitione poſta di ſopra, Vna corda ſtrapparſi allora che non puo piu allungarſi: ella contien due parti, l' vna delle quali mi pare hauer ſicura: cioè, Che finche puo allungarſi, non puo ſtrapparſi: e mi par tanto vera, quanto è, Il non venirſi nelle operation naturali e neceſſarie, all' eſtremo, che prima non ſi ſien paſſati tutti i mezzi, e vinte le lor reſiſtenze, che ſi truouano ſempre minori. Ma lo ſtrapparſi, è l' eſtremo dello ſtiramento, adunque non ſi viene ad eſſo, mentre la corda, coll' allungarſi puo non ſtrapparſi. Che poi ſi habbia a ſtrappare quando non ſi puo piu allungare, mel perſuade il diſcorrer coſi. Poniamo, che la grauezza del peſo ſia creſciuta a tal miſura che per eſſa la corda ſi

Z 4 truoui

DANIELLO BARTOLI: '*Del suono, de' tremori armonici e dell'udito' 1679.*

So the critical point where the tensility of a treble begins to fail was taken as decisive element when calculating the longest possible working string length on a Lute, to the point of exploiting up to 90-95% of its tensile reserve under working condition.

In other words they constantly worked close to breaking point.

This curve also explains the well known Renaissance Lute *rule* which demanded that the first (and expensive!) string be tuned as high as it will go before breaking; but not to worry: the string would warn the lutenist when its extreme limit was nearly reached (a slight turning of the peg would cause a much higher frequency increase than before, thus signalling that the *exitus* was nearly reached).

We call this *upper limit*. There is another, a *lower limit*, which is, by its own nature, less clearly defined than the upper one, since it is essentially a subjective parameter and has more to do with the acoustical qualities of the lowest bass string. The open string range between the top string (which can not go any higher) and the lowest bass (which defines the boundary of what was acceptable to the ear of the time) summarizes, in extreme synthesis, the state of the manufacturing abilities of the string makers who were contemporaries of our instrument.

Just like a liquid, when poured into any vessel, immediately occupies the maximum surface available, the characteristic of the Lute, *strumento perfectissimo et eccellentissimo*, was that of exploiting to the largest possible degree the mechanical and acoustical properties of the available strings.

Even in its constructional optimization, though, it was bound, at both ends, to its limits: but whereas the upper one could never be exceeded (the tensility of gut chantarelles was *that* and remained *that*), the lower one was the real, practical field of experimentation for the coming centuries.

The strings and their names

Strings produced in the 16th, 17th and 18th centuries, unlike today, were identified by names that immediately pointed to the place of provenance, as a clear sign of quality.

This particular aspect, in a historical period where copyright did not exist, explains the utter severity with which the corporations of string makers prosecuted commercial frauds, including string makers within the same corporation if they were caught cheating.

Giving the client absolute guarantee that Munich strings were actually produced in Munich remained an absolute priority throughout centuries of Lute history.

Another point to underline is the manufacturing specialization typical of different geographical areas: in some regions, for instance, string makers would devote themselves to bass strings, in other regions to treble strings, reaching astonishing commercial successes. Florence (bass strings) and Rome (trebles) are emblematic examples.

This does not mean that Florence produced no treble strings at all, we simply wish to point out that if certain areas gradually specialized in a specific product, it was because they must have found a way to excel in it - be it through the high quality standards, or through new products and more rational and improved methods of production.

Sources from the 16th, 17th and 18th centuries specifically describing the production of strings for plucked and bowed instruments are scanty, mostly concerning the Lute, which was the most difficult instrument to string.

Regarding the Age of Enlightenment we have an interesting paradox: at a time when the Encyclopaedists started for the first time to describe in detail the string making art (together with some important aspects of stringing for bowed instruments, mandolin and especially five course guitar) we know virtually nothing about the Lute in S. L. Weiss' time: our instrument had already fallen in a dark corner of history which no Light of Reason could illuminate anymore.

Let us now examine the historical sources

15th century

We have no commercial denomination whatsoever for Lute strings.

16th century

The earliest mention of different types of strings come from the manuscript of the Venetian nobleman **Vincenzo Capirola** (c. 1517): for the first time we have a description of strings of superior quality from Munich (Bavaria); a type of string called *'Ganzer'* is also mentioned, whose origin is not quite clear, although it might hint at a roped structure (see below). Unfortunately Capirola does not specify where on the instrument the strings he mentions were employed.

Another known source is **Adrien Le Roy** (*A Briefe and plaine instruction*..., London 1574). Le Roy writes that the best strings are those manufactured in Munich (or near it), or in the town of L'Aquila, in Italy: '*…the best come to us of Almaigne, on this side the toune of Munic, and from Aquila in Italie*.'..

After this interesting start he goes on to describing how to tell a good string from a false one. He, too, gives no further information about where on the instrument the strings he mentions were employed.

This scanty information is all we have from the 16th century.

17th century

The first author who finally throws a bit of light on the question of Lute strings is **John Dowland**, 1610 (*Varietie &c*...) He divides strings as follows:

- Trebles: '*from Rome and other parts of Italy*'; '*from Monnekin and Mildorpe*' (most probably Munich and Meldorf, both in Germany); besides, he mentions other thin strings, *which &c.*

- Small and Great Meanes: Gansars

- Base: *Nuremburge &c.* (the best Basses, according to Dowland, are made in Bologna, in 'Lombardy')

In Dowland's work we can see a certain tendency to confusion when describing the *Meanes* as string typology: it is not quite clear, for instance, whether the *smaller strings* made in Livorno are *Trebles* or *Meanes*. Just as it is not clear whether the coloured strings he mentions belong to the *Trebles* or to the *Meanes* (or both). Echoing Capirola, he also mentions *Gansars*.

Next comes **Michelangelo Galilei** who on 6 August 1617, from Munich, wrote to his brother, asking him to get him *four thick strings from Florence, for his own and his pupils' needs*. Unfortunately we do not know the commercial name of those strings.

In the **Mary Burwell Lute tutor** (c. 1670) we read: '*The good stringes are made at Rome or about Rome and none that are good are made in any other place except the great strings and octaves that are made in Lyons att Fraunce and noe where else'*.

Here, too, no particular novelties: it confirms what already stated by Mersenne (1636), that the best strings came from Rome. What is new, though, is that Bass strings and octaves were made in Lyon.

Thomas Mace (1676) is definitely our most exhaustive and valuable source. Like Dowland, he describes three typologies of strings:

-Trebles: top three courses and octave 6th: *Minikins;*

-Meanes: 4th and 5th and all remaining octaves: *Venice catlins*;

-Basses: *Pistoys and Lyons*.

Mace, like Dowland, also mentions coloured strings, but is also not clear whether they were used as Trebles or Meanes (or both).

Romans, Venice Catlins and Lyons appear again in **James Talbot**'s manuscript (c. 1695), as strings for violin and bass violin.

This sums up all the information we have about string typologies in the 17th century.

18th century

We have no specific terminology about Lute strings.

In conclusion, the names given to Lute strings in the 17th century always refer to their place of origin, with two exceptions: Catlins (or Catlines) and Gansars. The former were produced, at least in Dowland's time, in Italy. We do not know what the Italians called them, though. In the 18th century terms like *Catlins/Catlines, Lyons, Pistoys* &c disappear completely, to give place to a more generic denomination like: *strings made in...*

All-gut bass strings made by string makers gave way to wound basses, which were wound up by the lute maker or even by the player himself.

An era had thus come to an end.

MP

The three ages of the Lute and the three Sorts of strings

(From here on, where we talk of string Sorts, we understand them in Dowland and Mace's sense, as in 'Varietie of Lute Lessons' and in 'Musik's Monument')

The history of the lute (meant as family of instruments), seen in relation to the string making technologies which were developed in then course of the 17th and 18th centuries, can be divided **in three basic periods**, which, generally speaking, are essentially connected to the types of available bass strings:

-Lutes from about the mid-15th century to about 1570-80 (6 course lute and vihuela).

-Lutes from about 1580 to the end of the 17th century (7, 8, 9, 10 course lutes, long and short extended archlutes, theorbos, 11 course and 13 course d-minor lutes with no, or short, extension and baroque guitars).

-18th century lutes (11 and 13 course d-minor lutes without extension, 13 course d-minor lutes with swan-neck extension, archlutes, theorbos, mandoras and baroque guitars).

We know that as from the early 17th century (i.e. the time when the lute had an open string range of *2 octaves and a fourth*) the ancients felt the necessity to identify *three Sorts of strings* (see Dowland, 1610): **Trebles**, **Meanes** and **Basses**.

After a long period of study and practical experimentation we came to the conclusion that, far from being a simple commercial description, the scope of such distinction was to achieve some kind of switch thorough the registers from trebles to lower bass. The acoustical and mechanical problems in the lower registers increase with the increasing string diameters and can only be solved by switching, at the right point, from one type (i.e.Sort) of string to the next. In other words, since it was not possible to unlimitedly increase the diameters, it was necessary to employ different types of strings, each able to overcome the limits reached in the previous register.

Just like today when we have to work out a complete range of strings for the lute, we assume that ancient string makers followed, from the late 16th century on, **three different manufacturing processes** in order to produce:

-**Treble strings** (Dowland's and Mace's Trebles; i.e. *Romans, Minikins* etc), i.e. the first three courses of both Renaissance and Baroque lutes.

-**Mid register** (4th and 5th courses, Dowland's Meanes, which he divides in Small and Great Meanes; i.e. *Gansars*).

-**Low register** (from the 6th course down, the Basses; *Lyons, Pistoys, Catlins*).

That different manufacturing processes were not interchangeable is evident both in Dowland (1610) and in Mace (1676): the former says that *Gansars* (which in his opinion made excellent *Meanes*) could not be used as *Trebles* since they would immediately break under stress. On the other hand, had the *Meanes* been manufactured the same way the *Trebles* were, we believe they would have presented serious acoustical performance problems, since they would have been much too stiff: *Trebles* as described by Dowland were rather stiff and prickly to the flesh of the thumb pressing against the string's tip.

Also Thomas Mace, 66 years after Dowland, underlines the fact that the thin *Minikins* (treble strings) are so strong that if you pull them with your hands they *'will many times endanger the cutting into your flesh, rather than it will break, although it be a small Treble-Minikin string'*. On the contrary, *'your Venice-Catlins* (i.e suitables for the 4th and 5th courses) will *scarcely be broken, by a mans (reasonable) strength',* in spite of being thicker.

Research in the old sources and practical experience in the field of historical string making technologies prompted some hypotheses on what should be today (and probably were in the past) the mechanical and acoustical qualities of each Sort - the qualities we successfully obtained with our tests through three different manufacturing approaches. On top of that we also employ reckoning criteria strongly biased towards feeling, rather than kilograms, in selecting the lute set-up.

At the end of the day, working out gut stringing for the lute looks more like a narrow path than a roomy highway, and therefore we believe that the solutions we adopted must probably be the same as in the past.

Trebles

(*Romans*, *Minikins*)

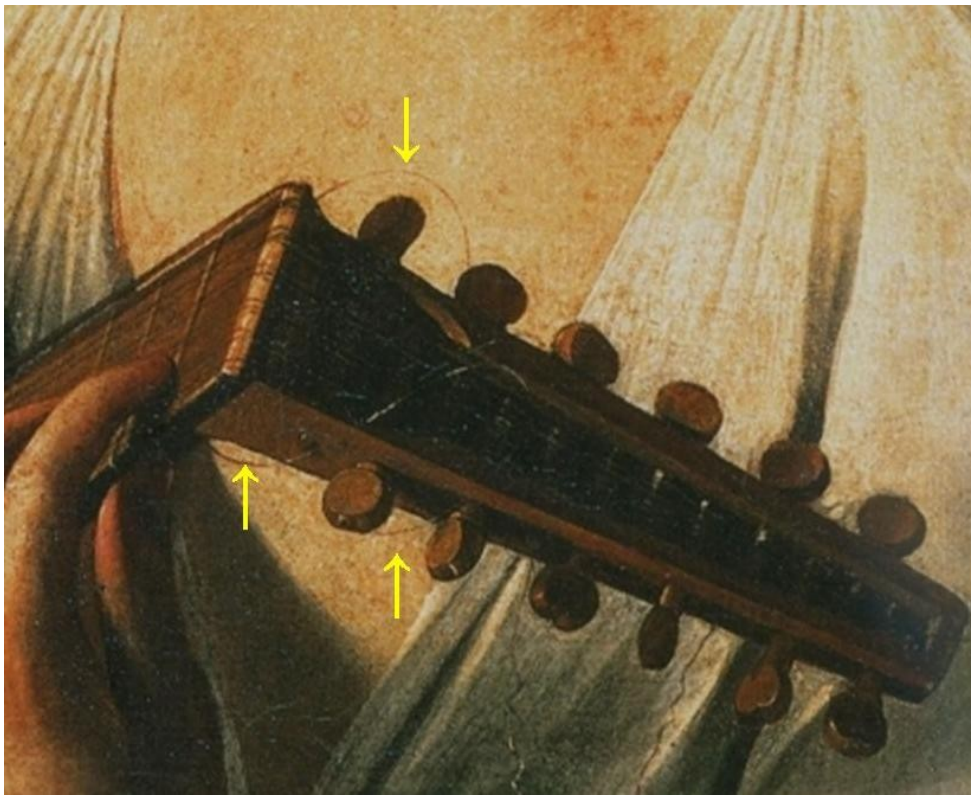
What we aim for here are the highest possible tensile resistance and mechanical resistance under the action of the player's fingers.

In order to achieve this we must sacrifice the elasticity. We find trace of this in some old sources: Dowland (1610), to quote him once again, stated that a good treble must feel stiff and prickly to the thumb; Baron (1727) claims that a good Roman treble can last up to 4 weeks. Could, say, a couple of weeks playing life have been the rule?

Late 16th, and 17th century sources add to treble strings for lute, guitar and violin only the adjective *rinforzato* -reinforced- (see Patrizio Barbieri's '*Roman and Neapolitan Gut Strings*, 1550-1950' in the GSJ May 2006, pp. 176-7).

We believe that this term was only reserved to strings that underwent particular treatments (as reported in some historical sources, like Skippon's description of a stringmaking workshop in Padua, c. 1660, for instance) apt *to stiffen* the gut.

This kind of strings also needs a low degree of twist, as well as other expediencies, **to reach a high breaking point and resistance to abrasion.**



Michelangelo Merisi da Caravaggio (1596 ca): detail of thin gut strings

For the **second and third courses** it is appropriate to moderately increase the amount of twist and leave out the 'reinforcing' chemical treatment: we need to start increasing the elasticity a bit, sacrificing a bit of tensile resistance, which is not quite as critical as for the trebles, here.

Meanes

(*Ganzer*, *Gansars*, thin *Venice catlins*)

By increasing its thickness, string length remaining equal, a string will gradually lose its acoustical qualities, until it becomes completely dull. This is due to the inner damping effect, called Inharmonicity. On the Renaissance lute the problem begins to appear as from the fourth course, becoming increasingly serious as we move down the registers. Pairing octave strings on the lower courses was the expedient the ancients employed to retrieve the lost harmonics (see Virdung, 1511).

In order to remedy this loss of acoustic capacity it is necessary to achieve the highest possible degree of elasticity, which is here the most important parameter. This is

obtained, no doubt, at the cost of tensile resistance but it is no real problem, since we are far away from the Breaking Frequency .

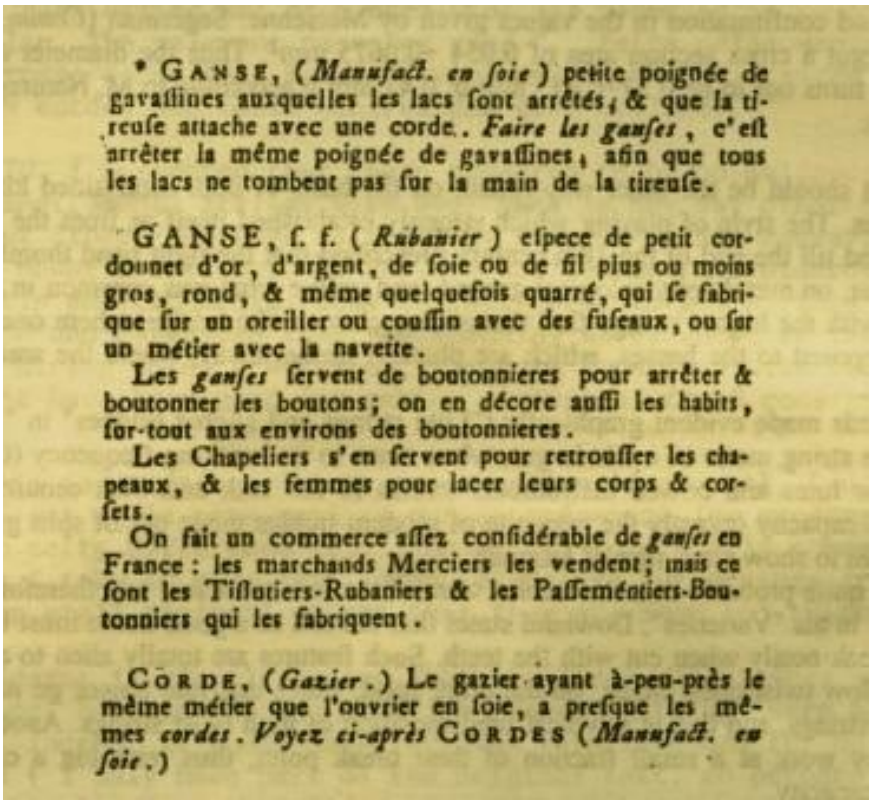
The way we accomplish this is:

1. By specifically treating the fresh gut in order to reduce its stiffness as much as possible, before twisting.

2. By employing a more complex twisting procedure (i.e. smooth roped) than that used for ordinary high twist strings in order to further increase suppleness and elasticity.

There is an historical trace about this process: the etymology of *Ganzer* (Capirola c. 1517) or *Gansars* (Dowland 1610) may go back to the French *Ganse*, *Ganses*, *Ganzier*, which was a rope-like cord used in the tailoring trade.

Here is what we could find on this subject:



* GANSE, (*Manufact. en ſoie*) petite poignée de gavaſſines auxquelles les lacs ſont arrêtés, & que la tireuſe attache avec une corde. *Faire les ganſes*, c'eſt arrêter la même poignée de gavaſſines, afin que tous les lacs ne tombent pas ſur la main de la tireuſe.

GANSE, ſ. f. (*Rubanier*) eſpece de petit cordonnet d'or, d'argent, de ſoie ou de fil plus ou moins gros, rond, & même quelquefois quarré, qui ſe fabrique ſur un oreiller ou couſſin avec des fuſeaux, ou ſur un métier avec la navette.

Les *ganſes* ſervent de boutonnieres pour arrêter & boutonner les boutons; on en décore auſſi les habits, ſur-tout aux environs des boutonnieres.

Les Chapeliers s'en ſervent pour retrouſſer les chapeaux, & les femmes pour lacer leurs corps & corſets.

On fait un commerce aſſez conſidérable de *ganſes* en France : les marchands Merciers les vendent; mais ce ſont les Tiſſutiers-Rubaniers & les Paſſemétiers-Boutonniers qui les fabriquent.

CORDE, (*Gazier.*) Le gazier ayant à-peu-près le même métier que l'ouvrier en ſoie, a preſque les mêmes *cordes*. *Voyez ci-après* CORDES (*Manufact. en ſoie.*)

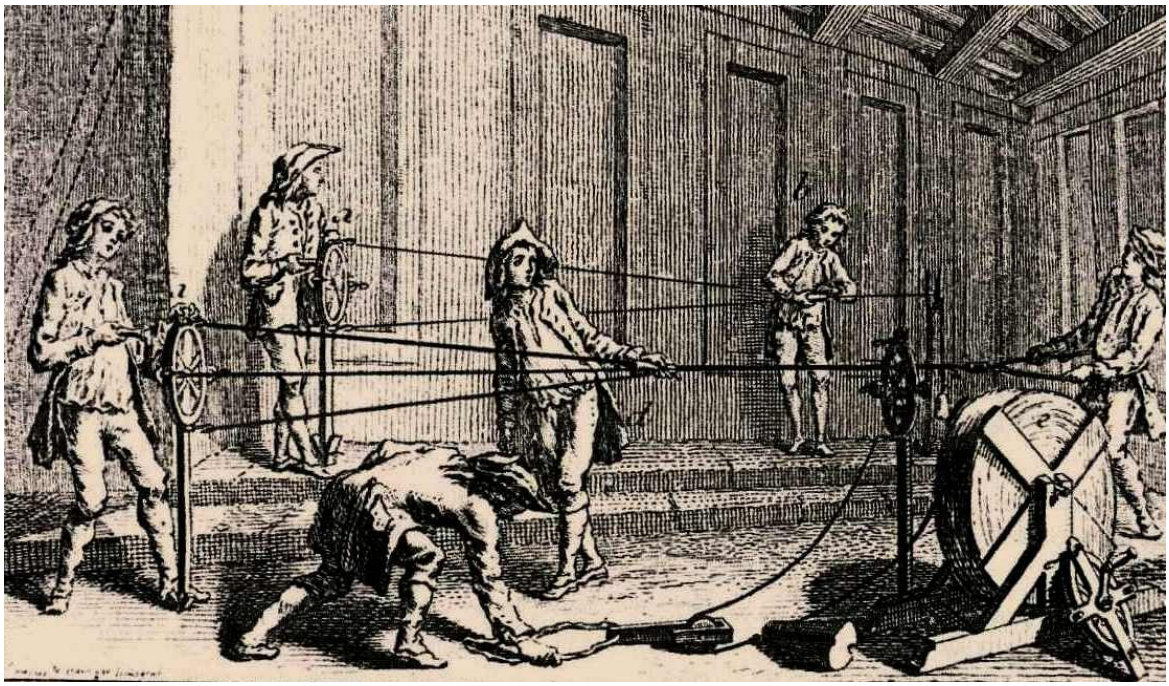
Basses

Lute/Vihuela bass strings before c. 1570: high twist or roped?

Here are our update considerations, based on some recently acquired sources (see Patrizio Barbieri: *Roman and Neapolitan gut strings*, 1550-1590, GSJ, May 2006, pp 176-7.):

1) roped strings were already in use on musical instruments as from mid of the 15th century (Ugolino of Orvieto: '*Declaratio musicae disciplinae*' Liber quintus, Capitulum IX: '*De cordarum seu nervorm instrumentalium subtilitate et grossitie*'. 1430-40 ca.)

2) the presence of *orditori* (i.e. wheels with three or four rotating hooks used to make ropes) in some 16th century roman stringmakers workshop inventories.



The Orditori

(from Patrizio Barbieri: '*Roman and Neapolitan gut strings*, 1550-1590', GSJ, May 2006, pp 176-7.)

3) musical roped strings were probably already in use well before the 15th century: see here an example from the late Roman imperial period:

.

4) there is a question of acoustical importance strictly connected to lute (and other gut strung -plucked instruments of the time) stringing with double courses rather than single strings.

As known, a course consists of a string of a given diameter paired with a unison or, in the bass register, with a much thinner one, tuned one octave higher, both to be fretted and plucked simultaneously.

Had the lute bass strings from the first half of the 16th century been of the ordinary high twist type we should expect the intonation to be rather critical (it would vary a lot by a minimum turn of a peg) and, by fretting, a noticeably higher frequency increase on the thick string than on the thin octave; a thick string, being stiffer, would also manifest

a remarkable frequency instability, depending on amount of pressure and side pull exerted by the fretting finger.

This would have caused the two strings in the course to be constantly out of tune.

Furthermore it must be noted that it is exactly the thicker string that is first met by the fretting fingers, adding a certain *extra* amount of pressure as compared with the thinner octave: this increases the above mentioned problem even further, especially on the thicker frets.

This is called *pitch distortion* and is a function of the string diameter and stiffness, plus the diameter of the fret.

Early 16th century lute players **never complained** about such a problem, although, we must remember, they always were pretty fastidious about what they considered to be their *problems* like, for instance, string falseness (and explained how to recognise it with a simple test). Capirola, c. 1517, even revealed his *Secreto da ligare le corde sul lauto - Secret for tying strings on the lute* - which he deemed necessary because the strings of his time were, it seems, somewhat 'conical' and would therefore increase or decrease in pitch by fretting.

This leads to the conclusion that the problem of pitch distortion was never felt: the thick fundamental bass strings must therefore have been stretchy enough to compensate for the frequency increase that a thick (and stiff) string would inevitably have suffered by fretting.
And this is only possible with a rope-like string

Conclusions

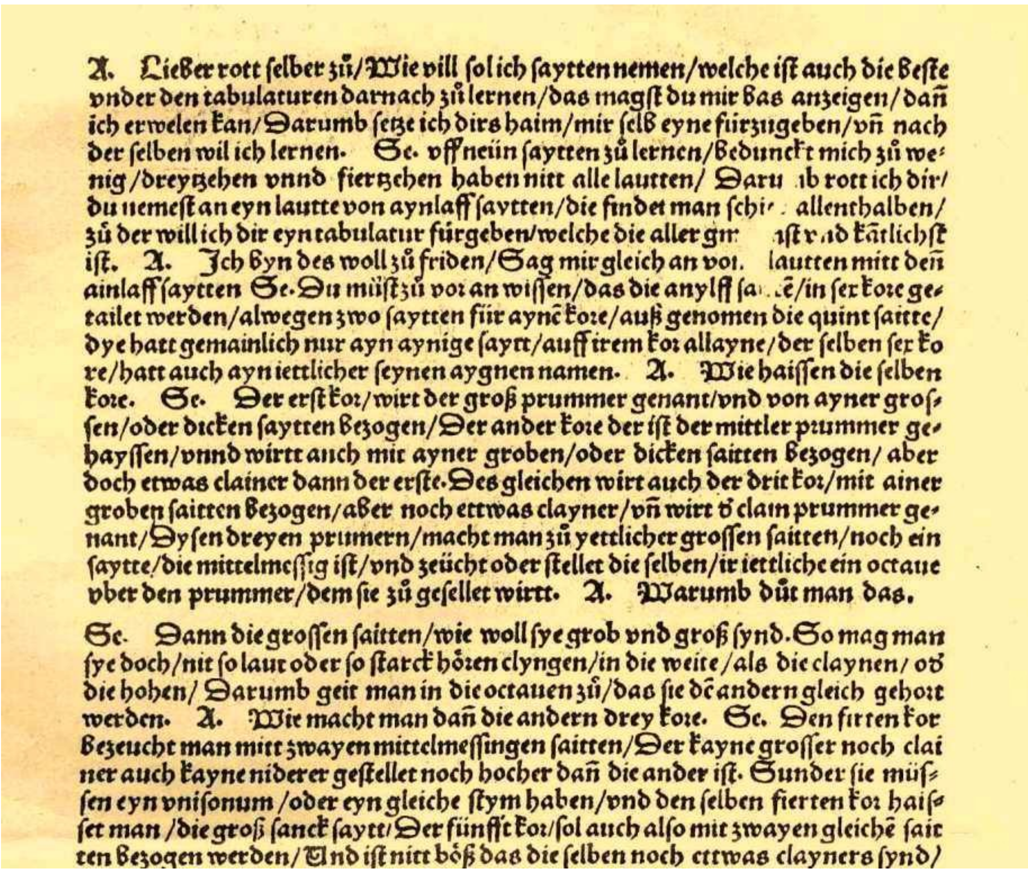
We believe that strings with. *a smooth rope-like structure* (done on fresh gut) were in use for the basses of the 6 course lute until about 1570. In other words, we do not believe that the idea that in the first half of the 16th century the lute basses would be strung with *ordinary high twist strings*, as commonly accepted until recently, is tenable anymore.

So we advance the hypothesis that around the middle of the 15th century it became possible to add a sixth bass course thanks to the introduction of this type of string, which is much more elastic than an high twist gut string.

The *two-octave* open string range typical of the 6 course lute **was clearly the acoustical limit for the ears of the time**: complaints about the feeble sound of lute basses sound quite actual:

Johannes de Tinctoris (*De Inventione et Usu Musicae*, c 1487) already wrote: '*An arrangement of five, sometimes six, principal strings was first adopted, I believe, by the Germans: viz. two inner ones tuned in a third, and the other ones in fourths [...]. Furthermore,* ***in order to obtain a louder sound****, another string tuned an octave higher can be added to each of the principals, except for the first one.* ' (our traduction from latin)

Sebastian Virdung ('*Musica Getutsch*', Basel, 1511): '*...to all three basses (Prummer) are added strings of medium thickness...one octave higher. Why that?* ***Because the thick strings cannot be heard so loud in the distance as the thinner ones****. Therefore octaves are added, so that they be heard like the others*':



A. Lieber rott selber zů/Wie vill sol ich sayttennemen/welche ist auch die beste vnder den tabulaturen darnach zů lernen/das magst du mir bas anzeigen/dañ ich erwelen kan/Darumb setze ich dirs haim/mir selb eyne fürzugeben/vñ nach der selben wil ich lernen. Se. vff neün sayttẽ zů lernen/Beduncket mich zů we- nig/dreytzehen vnnd fiertzehen haben nitt alle lautten/ Daru [illegible] rott ich dir/ du nemest an eyn lautte von aynlaff sayttẽ/die findet man schi[illegible] allenthalben/ zů der will ich dir eyn tabulatur fürgeben/welche die aller gm[illegible] ist v[illegible]d kätlichst ist. A. Jch byn des woll zů friden/Sag mir gleich an vo[illegible] lautten mitt deñ ainlaff sayttẽ Se. Du müst zů vor an wissen/das die anylff sa[illegible]ẽ/in sex kore ge- tailet werden/alwegen zwo sayttẽ für aynẽ kore/auß genomen die quint saitte/ dye hatt gemainlich nur ayn aynige saytt/auff irem kor allayne/der selben sex ko re/hatt auch ayn iettlicher seynen aygnen namen. A. Wie haissen die selben kore. Se. Der erst kor/wirt der groß prummer genant/vnd von ayner gros- sen/oder dicken sayttẽ bezogen/Der ander kore der ist der mittler prummer ge- hayssen/vnnd wirtt auch mit ayner groben/oder dicken saitten bezogen/ aber doch etwas clainer dann der erste.Des gleichen wirt auch der drit kor/mit ainer groben saitten bezogen/aber noch ettwas claynner/vñ wirt d̛ clain prummer ge- nant/Dysen dreyen prumern/macht man zů yettlicher grossen saitten/noch ein saytte/die mittelmessig ist/vnd zeücht oder stellet die selben/ir iettliche ein octaue vber den prummer/dem sie zů gesellet wirtt. A. Warumb důt man das.

Se. Dann die grossen saitten/wie woll sye grob vnd groß synd.So mag man sye doch/nit so laut oder so starck hören clyngen/in die weite/als die claynen/ od̛ die hohen/ Darumb geit man in die octauen zů/das sie dẽ andern gleich gehort werden. A. Wie macht man dañ die andern drey kore. Se. Den firten kor bezeucht man mitt zwayen mittelmessingen saitten/Der kayne grosser noch clai ner auch kayne niderer gestellet noch hocher dañ die ander ist. Sunder sie müs- sen eyn vnisonum /oder eyn gleiche stym haben/vnd den selben fierten kor hais- set man /die groß sanck saytt/Der fünfft kor/sol auch also mit zwayen gleichẽ sait ten bezogen werden/Und ist nitt böß das die selben noch ettwas clayners synd/

Sebastian Virdung ('*Musica Getutsch*', Basel, 1511)

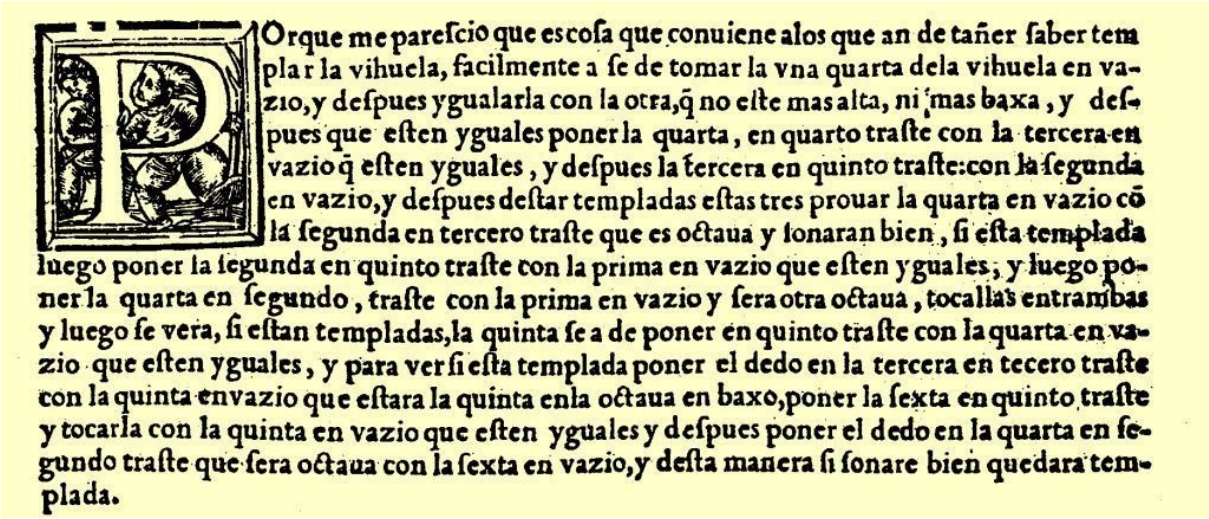
So we can assume that, at least from the string manufacturing point of view, *only two Sorts* of string were used on the 6 course lute.

The vihuela case: unisons or octaves?

1. Italian and German string making technology before 1570 ca. (the best of that time) was not so advanced as to grant the production of efficient enough bass strings (octaves were needed to provide the harmonics), as made clear by Virdung and Tinctoris.

2. Spain, in the 16th century, ruled over large parts of Italy and, indeed, the *Viola da mano* enjoyed a certain popularity: hard to believe that they could possess any '*secret*' technology for the production of bass strings without Italian and German string makers, the most renowned in Europe, knowing anything about it. We also know that Spain imported large quantities of strings - from Munich, to be precise - and, had they had bass strings of a superior quality themselves, it would be fair to expect an intensive exporting activity to the rest of Europe, as was later the case with Rome in the 16th and17th century, for example.

3. Pisador (1552), talking about the 4th course, made it clear it ought to be strung in unison:



Porque me pareſcio que es coſa que conuiene alos que an de tañer ſaber tem plar la vihuela, facilmente a ſe de tomar la vna quarta dela vihuela en va- zio, y deſpues ygualarla con la otra, q̃ no eſte mas alta, ni mas baxa, y deſ- pues que eſten yguales poner la quarta, en quarto traſte con la tercera en vazio q̃ eſten yguales, y deſpues la tercera en quinto traſte: con la ſegunda en vazio, y deſpues deſtar templadas eſtas tres prouar la quarta en vazio cō la ſegunda en tercero traſte que es octaua y ſonaran bien, ſi eſta templada luego poner la ſegunda en quinto traſte con la prima en vazio que eſten yguales, y luego po- ner la quarta en ſegundo, traſte con la prima en vazio y ſera otra octaua, tocallas entrambas y luego ſe vera, ſi eſtan templadas, la quinta ſe a de poner en quinto traſte con la quarta en va- zio que eſten yguales, y para ver ſi eſta templada poner el dedo en la tercera en tecero traſte con la quinta en vazio que eſtara la quinta enla octaua en baxo, poner la ſexta en quinto traſte y tocarla con la quinta en vazio que eſten yguales y deſpues poner el dedo en la quarta en ſe- gundo traſte que ſera octaua con la ſexta en vazio, y deſta manera ſi ſonare bien quedara tem- plada.

Such a statement could imply that the use of octaves was standard but he did not like it, or it was not appropriate for his music. Hence the necessity to write down something that was outside the musicians' common practice.

4. Fuenllana (1554) prescribes playing only one of the two strings in the course in some passages (as does Dalza): this artifice *is only limited* to the 2nd, 3rd and 4th course, though, another hint that at least the 4th would be strung with unisons. We know nothing about the 5th and 6th.

5. Bermudo (1555) states that the guitar's 4th course has an octave, like the fourth of the lute, or Flemish vihuela. Here can be inferred that the 4th of the vihuela was a unison while the lute wasn't, since he needs to refer to the lute, an instrument less familiar to

him, while it would have been natural to refer to the vihuela. Again, we know nothing about the 5th and 6th.

6. Bermudo also says that if you wish to turn a vihuela into a guitar (4th with octave, all other courses in unison) you simply have to take off the 1st and 6th courses. This would suggest that the vihuela had a unison 4th (but sometimes also a paired octave, as implied by Pisador - see above 3.), i.e. guitar 3rd, and the 5th, i.e. guitar 4th, with octave. It follows that the 6th must also have had an octave.

7. On top of that Bermudo also discusses slanting the bridge (ch. LXXXV), in order to compensate for the amount of space taken by the large knot of the 6th string, which is always referred to *in the singular*, never in the plural. So the course must have had a paired octave. The larger amount of space taken by *the knot* (not by the knots!) and the resulting need to slant the bridge in order to keep the length of all strings equal, clearly indicate that the string must have been pretty thick.

If the basses were that thick, they could not, owing to their high Inharmonicity Index, have had such a good acoustical performance. The stringent consequence is that it needed an octave.

8. The only source clearly mentioning unison stringing on the vihuela dates back to 1611, a fairly long time after the instrument had fallen into disuse. This source (Sebastian de Covarrubia's *Tesoro de la lengua castellana*, 1611) does not specifically treat musical matters. It is a dictionary compiled at a time where the progress made in the string making technology already allowed to dispose of octave strings on the lute. So it is an anachronism to apply a piece of information from the early 17th century to an instrument that was in use in the mid 16th century. Applying the same principle we could assume, reading Dowland, that Francesco da Milano's lute was strung with all unisons!

9. Double treble and unison courses: the fact that the vihuela was generally (but not always) strung with a double treble led some scholars to take that as evidence in favour of all courses having been strung with unisons. We fail to grasp the logic of it. There is, on the other hand, evidence proving that the vihuela could have a single treble, whereas most Renaissance lutes where strung with double trebles.

Conclusions

In the light of all the information we have so far, we suggest that the Spanish Vihuela de mano was not strung with unison courses throughout.

Lute gut bass strings after c. 1570 (7; 8; 9; 10 and 11 course lutes)

(The *Strasbourg and Nurenberg-* basses; *Venice Catlines*, *Lyons*, *Pistoys*)

According to some documents we could examine, as from about 1570-75 *a seventh course* was added on lute, tuned a 4th or 5th below the sixth course: '*The Lutes of the newe invention with thirtene strynges, be not subiecte to this inconvenince, where of the laste is put be lowe: whiche accordyng to the maner now abaies, is thereby augmented a whole fowerth*', remarks Adrien Le Roy in his '*A briefe and plaine instruction...*' in 1574.

The problem

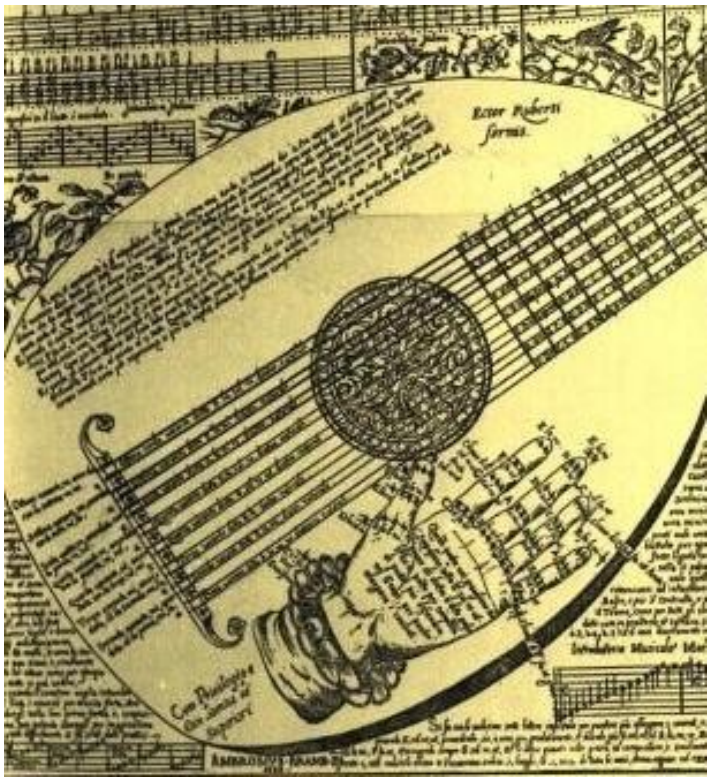
If, as by now proven, rope-like strings were *already in use* in the mid 15th century, and the 6 course lute needed paired octaves in the bass register to compensate for the poor sound, what made it possible to extend the basses down another 4th or 5th?

Maybe at the beginning the acoustical quality of the new basses **was not excellent** ('*...and God knows how well one can hear them... and ...although they are perceived by the ear as not very sweet, because of their poor sound...*' comments Vincenzo Galilei in 1568, in his *Fronimo)*:

Fr. Mi diſſe eſſerſi ritrouate,per hauere nel Liuto come nell'organo,il pedale. Eu. Ha,ha,ha.
Fr. Miſeri loro,che ſe ſapeſſero quello che nel organo ſia reputato il pedale da gl'huomini di qualche va
loro,ſi muterebbono di parere ſicuramẽte,& ſarebbono appunto da quelli come il pedale da que
ſti,abborriro & diſprezzato,ſenza fare tutto il giorno tanto ſchiamazzo quanto ei fanno. Vedete
di gratia qual ſia l'acquiſto loro,ei non ne cauano altro fuor dell'ordinario,che il potere quando
a loro piace,toccare l'ottaua del tenore auuoto,& coſi quella del bordone, & l'inclule tra que-
ſte: le quali ottaue ancora ,Dio ſa quanto & come ſe ſi odono .Se queſta loro nuoua aggiunta di
corde,di ceſſero hauerla trouata & introdotta per galanteria,& non per neceſſità, o ne cauaſſero
la comodità che con meno potrebbe cauarſi,come di non hauere a poſſ are le canz. ni che ſono
per G ſol re vt,ma ſonarle ne proprij luoghi & naturali,& ſe non queſte, almeno quelle che il baſ
ſo loro ha ſegnata la chiaue di F fa vt nella prima linea,ſarebbono di qualche ſcuſa degni, ma cõ
eſſe non hanno per ancora ſaputo fare, piu di quello hauete intelo, ben che con poca dolcezza
venghino quelle ancora dall'vdito comprele,mediante la debilità del ſuono loro.

Vincenzo Galilei "*Fronimo*", Florence 1568

but things **improved quite rapidly**, implying an important manufacturing development: Michele Carrara's 'manifesto', printed in Rome in 1585, already describes an 8 course lute with the 7th course tuned one 4th, and the eight course one 5th, below the 6th course.



The new basses were probably developed to their best in a region between Florence and Bologna (which is where the Venice Catlins mentioned by Dowland in 1610 were produced).

Fact is, the lutenist Michelangelo Galilei, in a letter to his brother Galileo, asks to send him '*...four thick strings from Florence to meet his own and his students' needs...*'. Michelangelo at the time was living in Munich, one of the most renown string producing centres. It would seem obvious that the local strings were no match for the Florentine basses.

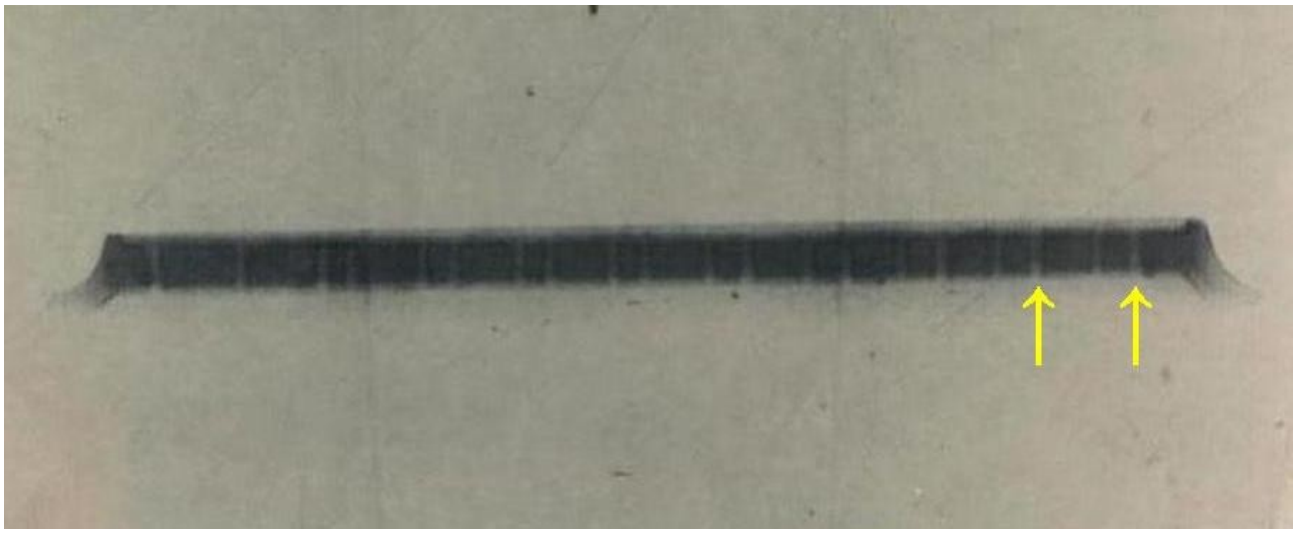
In Alfonso II d'Este's expense list for the period 1587-97 we read: '*210 dozens thin strings sent from Rome to serve Music...*' and: ' *denari 4 four buckets of thick strings specially made in Florence...*' (see Elio Durante & Anna Martellotti 'Un decennio di spese musicali alla corte di Ferrara', Schena Ed, 1982). In the ten years covered by the expense list , the associations 'Rome' to thin strings and 'Florence' or 'Bologna' to thick ones are repeated many times.

What can we say in matter of the new basses?

Here are some considerations

1) Lute bridge holes: we found consistently *small diameters of string holes* in bridges regarded as original: over a period of ten years we carried out a thorough survey on some **sixty** lutes (and on some bowed instruments) from several european collections.

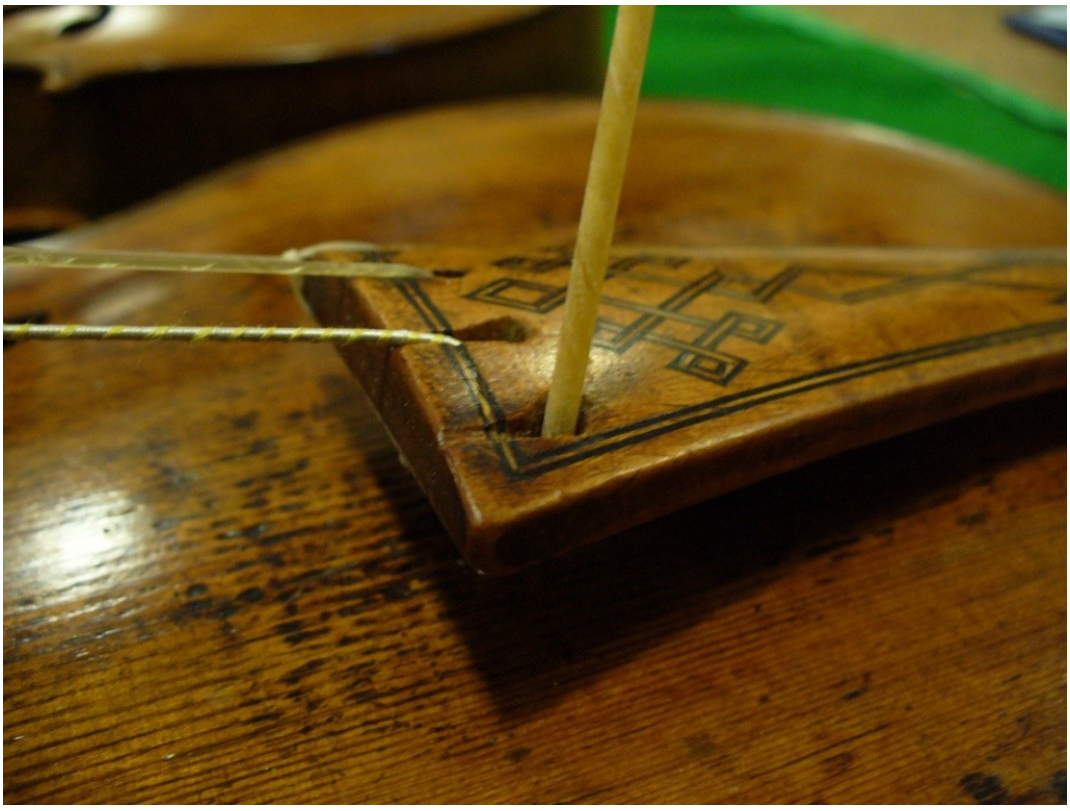
About half of them have bridges we thought we could trust to be *original.*



'*Joan. Seelos 1699*'. Bridge X-ray. Paris, Musèe Instrumental E.540 C.216.

The measuring of the bridge-holes was carried out with accuracy, using rods of increasing exact diameters thus we have verified the maximum passing diameter. It will be worth mentioning that by so doing we do not obtain the actual string-diameter but that of the hole, which was obviously drilled with a certain empirical oversize.

6th bass bridgehole on the Gerle Lute, Wien 1991



4th 2.3 mm hole crossing-diameter on the Charles IX Andrea Amati's viola. Ashmolean Museum, Oxford 2007

Natural gut bass strings fitting such small diameters would have to work under a mean tension of about 1.2-1.3 kg; this is the equivalent of a modern lute strung with a tension of 3.0 kg per string and then tuned down 8 or 9 semitones (see Ephraim Segerman: '*On Historical lute Strings Types and Tensions*', FOMRHI bull 77, October 1994 pp54-7; in this work the actual maximum string diameter was considered equal to the 85% of the maximum passing string hole-diameter).
A *critical re-examination* of these calculations, though, indicate that the resulting working tensions for historical lute basses may still be overestimated: those calculations were made on the assumption that the string's diameter **remain, under tension, unaltered and the specific weight of gut be 1.3 gr/cm³**: a condition applying *only to a low twist string*, which allows for minimal stretching while keeping its maximum possible compactness and, indeed, density.

But this is not quite the case with rope-like strings (assumed to be *the only possibility*): the average density of those strings varies between 1.1 gr/cm³ if left 'knotty' and 1.2 gr/cm³ if polished smooth.

Finally, those strings stretch noticeably when under tension, lowering the diameter to between 87 and 90% of its original value (depending on the degree of stiffness they were produced with), when compared with an equivalent high twist string.

And a loss in diameter inevitably implies a lower working tension.

So, the combination of these two parameters (lower density and longer strain) result in tensions which are, in fact, reduced to some 74 to 83% of the value previously calculated (depending on whether they are 'knotty' rope-like strings with a high stretching index or smooth-polished and not too 'stretchy').

In conclusion, where the result of theoretical calculation (unstretchable string and 1.3 gr/cm³ density) is a tension of 1.2 kg, the actual tension will only be between .9 and 1.0 kg, for rope-like strings. Thus, given a theoretical estimate of 1.5 kg, the actual tension will result in 1.1 - 1.2 kg.
On a modern lute, strung with an average 3.0 kg tension per string, the corresponding intonation would be some 10 - 11 semitones lower.
Just try it once on your all gut strung-lute.

If we consider the traditional gut strings, there are only two options for such small string-holes:

a) Only the basses worked at a much lower tension

This is historically not tenable: it clashes against all 16th and 17th century treatises we know of, where the concept of *equal feel* is always insisted upon (which is *broadly speaking* a light scaled tension).

Here is, for instance:

-**Thomas Mace** (*Musik's Monument*, London 1676): "*The very principal observation in the stringing of a lute. Another general observation must be this, which indeed is the chiefest; viz. that what siz'd lute soever, you are to string, you must so suit your strings, as (in the tuning you intend to set it at) the strings may all stand, at a proportionable, and even stiffness, otherwise there will arise two great inconveniences; the one to the performer, the other to the auditor. And here note, that when we say, a lute is not equally strung, it is, when some strings are stiff, and some slack*".

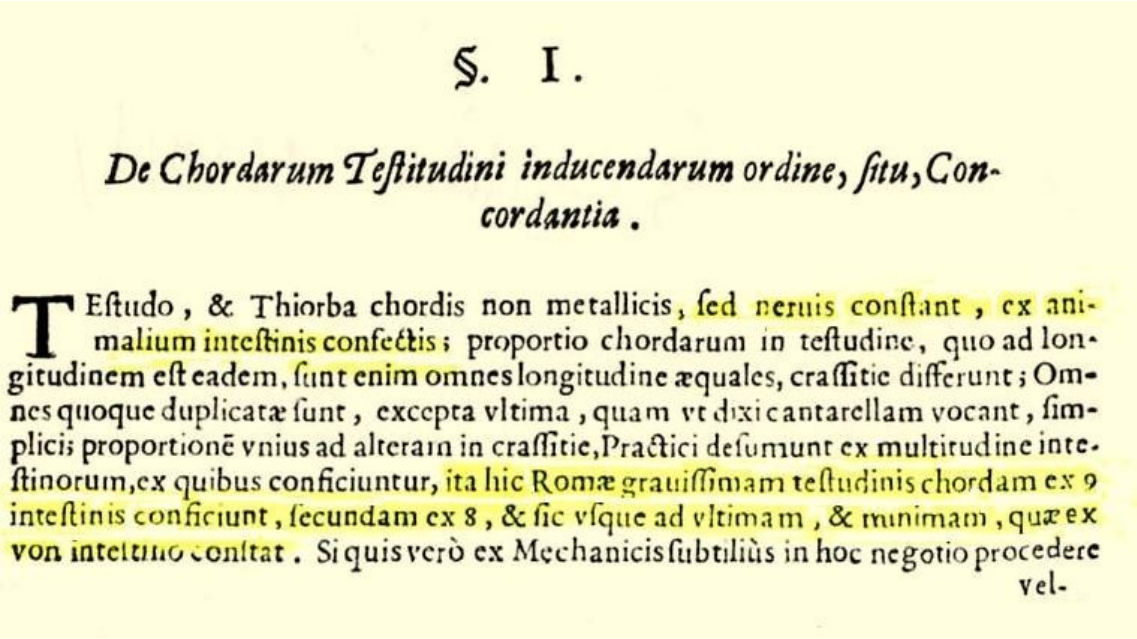
-**The Mary Burwell lute tutor** (ca. 1670): "*When you stroke all the stringes with your thumbe you must feel an even stiffnes which proceeds from the size of the stringes*".

-**John Dowland** ('*Varietie of Lute Lessons*', di Robert Dowland, 1610): "*But to our purpose: these double bases likewise must neither be stretched too hard, nor too weake, but that they may according to your feeling in striking with your thombe and finger equally counterpoyse the trebles*".

b) Lutes were generally very low strung throughout

It is likewise not tenable: with a mean tension of 1.2 kg or less, the first two or three courses would require such small diameters as to be technically impossible to produce (for example, the first three courses on D-minor baroque lute with a 70 cm string length at a-415 Hz pitch would be: 1st = .25 mm, 2nd = .30 mm, 3rd = .40 mm).

In other worlds they are much more thinner than allowed by a fundamental string making rule in the 16th century, i.e. one single whole lamb's gut must be employed to produce a treble string as described, for instance, by Athanasius Kircher in his '*Musurgia Universalis*' (Rome 1650):



§. I.

De Chordarum Teſtitudini inducendarum ordine, ſitu, Concordantia.

TEſtudo, & Thiorba chordis non metallicis, ſed neruis conſtant, ex animalium inteſtinis confectis; proportio chordarum in teſtudine, quo ad longitudinem eſt eadem, ſunt enim omnes longitudine æquales, craſſitie differunt; Omnes quoque duplicatæ ſunt, excepta vltima, quam vt dixi cantarellam vocant, ſimplicis proportionē vnius ad alteram in craſſitie, Practici deſumunt ex multitudine inteſtinorum, ex quibus conficiuntur, ita hic Romæ grauiſſimam teſtudinis chordam ex 9 inteſtinis conficiunt, ſecundam ex 8, & ſic vſque ad vltimam, & minimam, quæ ex vno inteſtino conſtat. Si quis verò ex Mechanicis ſubtiliùs in hoc negotio procedere vel-

Athanasius Kircher: '*Musurgia Universalis*' (Rome 1650)

Our tests shows out that, starting from one single whole lamb gut (as A.Kircher suggested), gauges had just an average of .45-.48 mm, not less.

It has to be borne in mind that with a tension of about 1.2 kg or less, gut basses not only hardly give any sound at all, but also feel more like *rubber bands* and are very hard to control by the thumb of the right hand.

However, the spontaneous question is: for what *plausible* reason should they string the basses only at such low tension? Why did they not simply drill slightly bigger holes?

2) The remarkable performance of all-gut basses in use towards the middle of the 17th century as opposed to the *poor quality* of bass strings in use in the first half of the 16th century (see Virdung, 1511, and Galilei, 1568): here is what we read in the Mary Burwell lute tutor (c.1670), about the all-gut basses on the lute with short extension: '*...the confusion that the length of sound produce it alsoe..' and '...every basse sound make a confond with every string...*' and, talking about the eleventh course '*...the lutemasters have taken away that great string because the sound of it is too long and smothis the sound of the others*'.

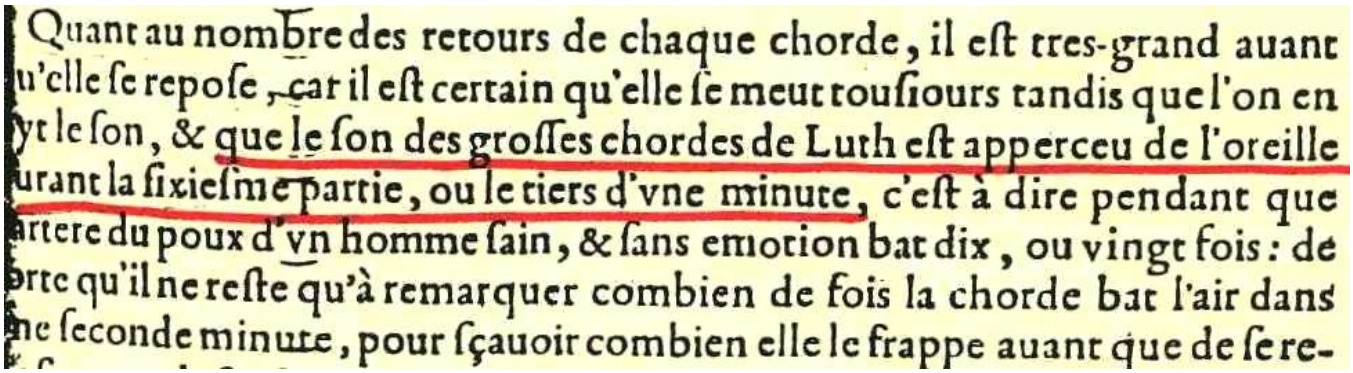
English Gaultier with a double-headed lute, as described in the Mary Burwell lute tutor

Thomas Mace (Chap. XLII, p. 208): "*This inconvenience* [i.e. the power and persistence of sound of the basses which causes confusion and dissonances with the higher registers] *is found upon French Lutes, when their heads are made too long; as some desire to have them...".*

Just a question: what kind of sound did the basses of the time produce, then? Here is the only testimony we know of (Edward Benlowes, 1603-76): *'...still torturing the deep mouth'd Catlines till hoarse thundering diapason should the whole room fill...'*.

Our tests pointed out that, on short extended necks, no modern roped or high twist gut string was able to reach such high performances.

3) Mersenne ('*Harmonie Universelle*', 1636): the 11th bass of a lute (without extension) can ring up to 20 seconds: '*...& et que le son des grosses chordes de Luth est apperceu de l'oreille durant la sixsieme partie, ou le tiers d'une minute...*' a performance that's hard to obtain even with a modern wound string, never mind by a thick rope-like string. Here, though, we can't hide the feeling that Mersenne might have somewhat exaggerated!



Quant au nombre des retours de chaque chorde, il eſt tres-grand auant
u'elle ſe repoſe, car il eſt certain qu'elle ſe meut touſiours tandis que l'on en
yt le ſon, & que le ſon des groſſes chordes de Luth eſt apperceu de l'oreille
urant la ſixieſme partie, ou le tiers d'vne minute, c'eſt à dire pendant que
rtere du poux d'vn homme ſain, & ſans emotion bat dix, ou vingt fois: de
orte qu'il ne reſte qu'à remarquer combien de fois la chorde bat l'air dans
ne ſeconde minute, pour ſçauoir combien elle le frappe auant que de ſe re-

Marin Mersenne "*Harmonie Universelle*", Paris 1636

4) Iconographical sources:

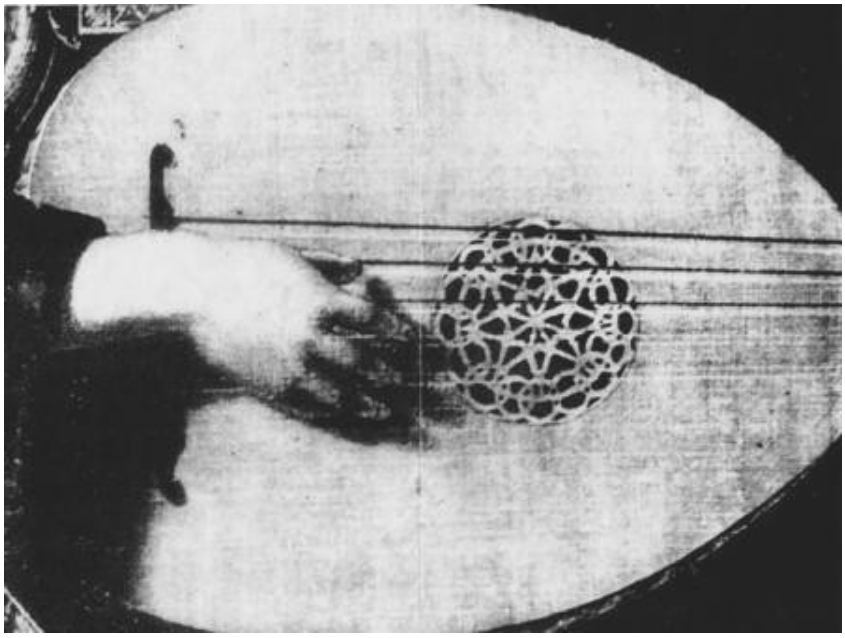
a) Most of the 17th C. paintings show bass Lute strings with apparently very thin gauges: they recall us the narrow bridgehole diameters

b) Where we find coloured basses, they are always coloured in a homogeneous way and *exactly where we have to imply, today, wound strings*, i.e. all the same red colour (or brown etc) from the 6th course down.

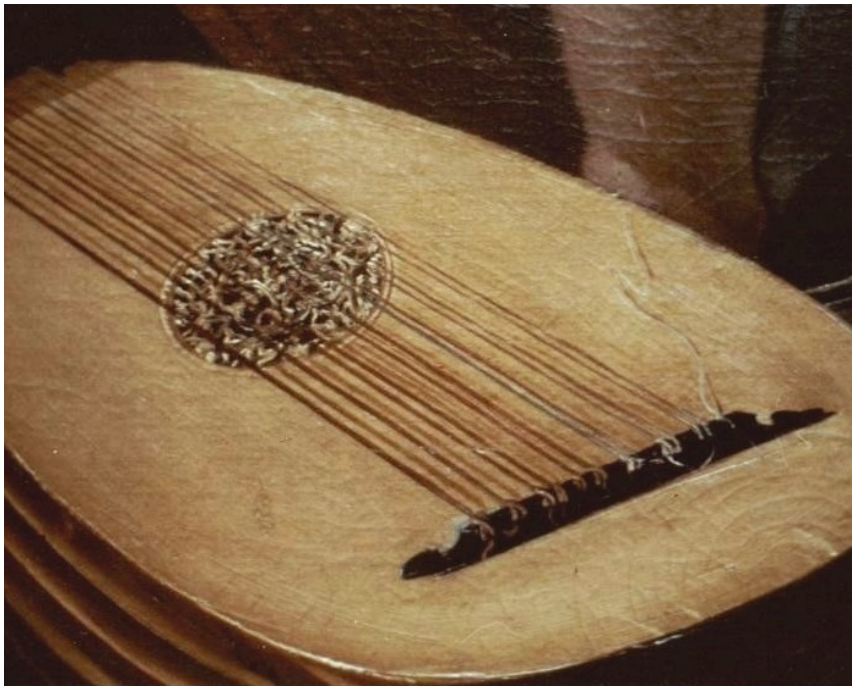
c) The chromatic transition *is not a gradual one*, i.e. strings do not get darker and darker according to the increasing thickness of the strings, but by *sudden changes*, from yellowish higher strings to completely different colours.

Some iconographical examples

Lutes



Seven course lute by anonymous (late 16th c?): detail



Rutilio Manetti, Siena 1624: detail on the brown Lute bass strings

Jean de la Reyne: lute player; 1640 ca

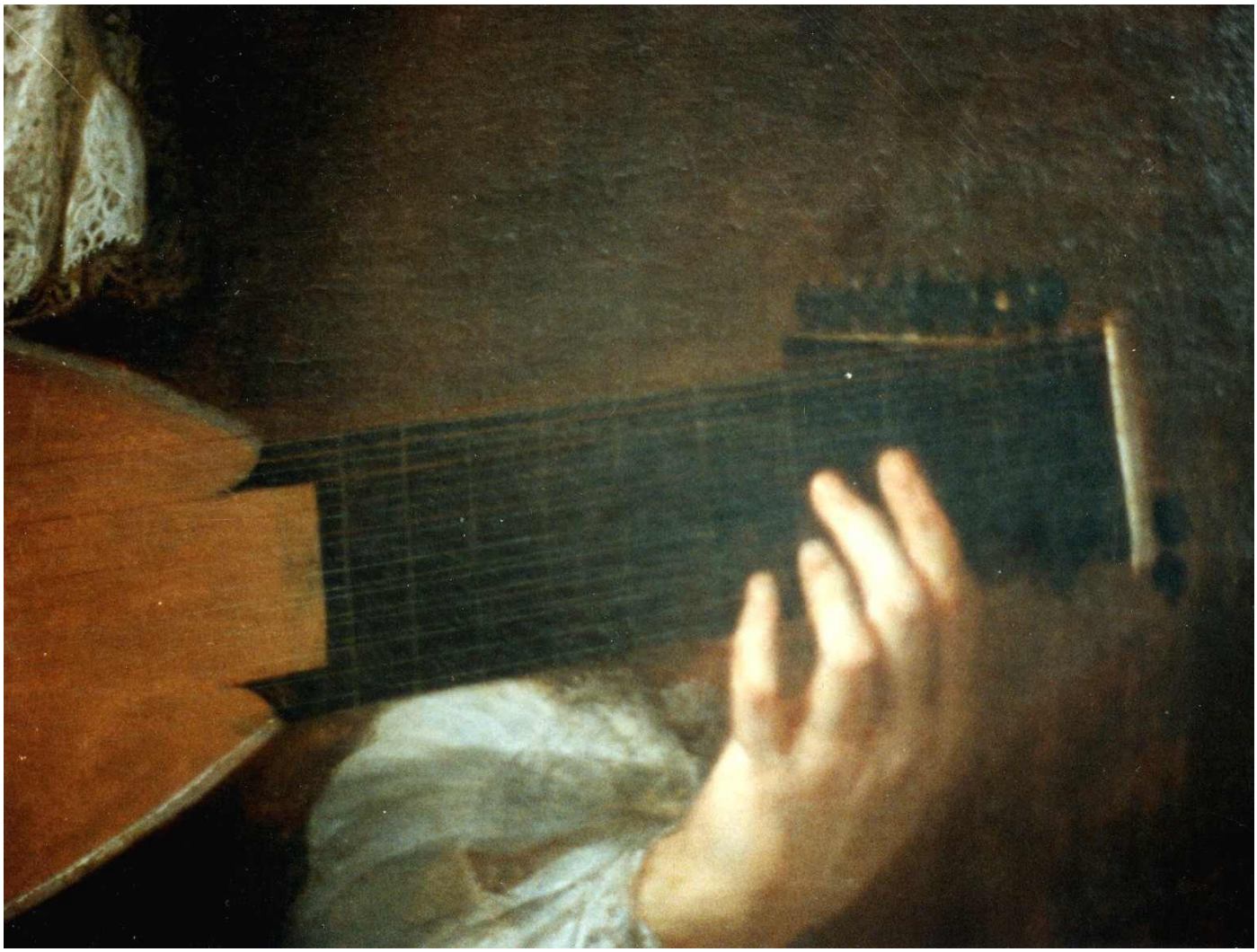
Detail on bass brown- strings

Anonymous French painter, 1st half of the 17th C (Amburg -Kunsthalle)

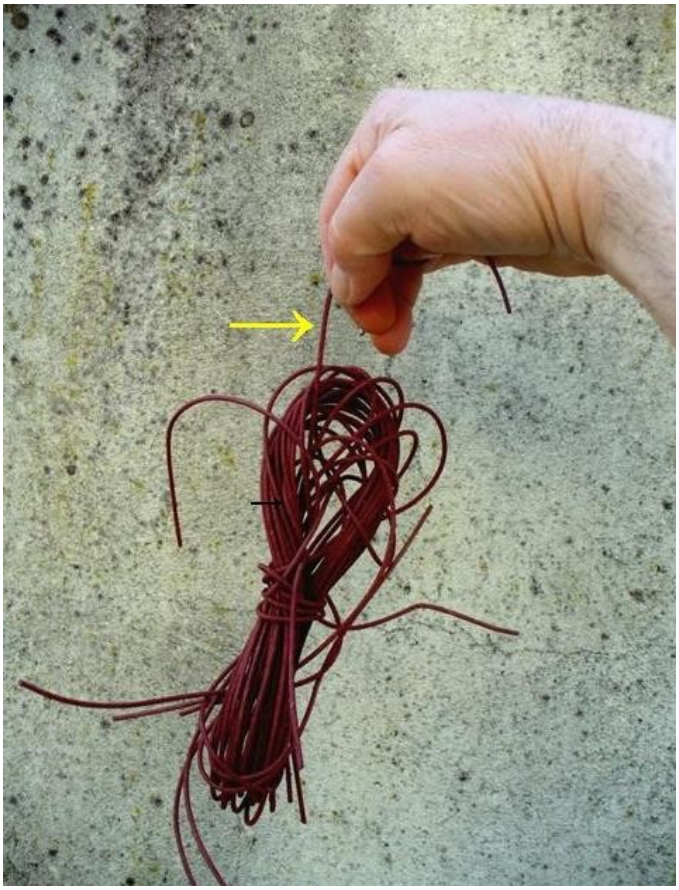
Anonymous French painter, 1st half of the 17th C: details of the lute bass red strings

Anonymous Dutch painter, 2nd half of the 17th C: detail of the red bass strings on a 12 course lute

Anonymous Dutch painter, 2nd half of the 17th C: detail of the red bass strings on a 12 course lute



F. Le Troy (1690 ca.) Detail of the Charles Mouton's portrait



Dutch painter (?), 2nd half of the 17th C: detail of the bundle-red bass string. Note the straight string profile due to the string-weight

Francois le Troy, 2nd half of the 17th C: detail on the brown basses

Bowed instruments

Rutilio Manetti, Siena 1624: detail of the Violin brown 3rd & 4th strings (*"...best strings are Roman 1st & 2nd of Venice catlins: 3rd & 4th best be finest & smoothest Lyons, all 4 differ in size..."* James Talbot's manuscript, 1695

Bilcius (?) 2nd half of the 17th: detail on gamba head

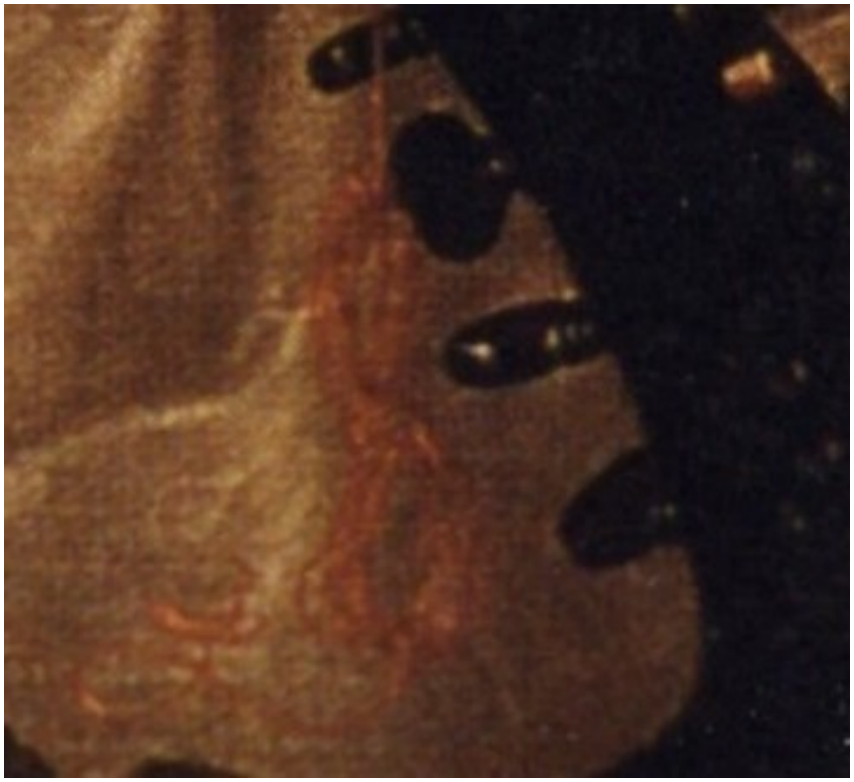
Girolamo Martinelli, 2nd half of the 17th C: Concerto in casa Lazzari

Girolamo Martinelli: detail of the brown bass violone strings

Girolamo Martinelli: detail on the brown Bass-violin string

d) Such dyed strings must have also been **quite supple**; see the details of the bass string knots at the bridge:

detail on the pliable brown basses



Detail of the pliable bundle-red bass string

5) Dowland (1610): the fact that he prescribes a unison 6th is a strong suggestion that the basses of his time possessed a high acoustic performance, unknown before and unthinkable in a rope-like string. In practical terms, his 6th course strings must have been thin enough to grant a lower Inharmonicity index and thus allow the use of unisons.

6) Mace (1676): the best lute bass strings in his time were '*...dyed in a deep dark red colour...*'.

The surface of bass gut strings

-Mersenne(1636) affirms that gut strings were well- polished by the use of a grass with an abrasive properties, but do not says anything that leads to believe that this procedure was deserved only to thin-strings.

-Thomas Mace (1676) state clearly that Pistoys were smooth: "*They are indeed the very best, for the basses, being smooth and well-twisted strings...'* This does not imply, automatically, that Lyons were not. In fact nothing at all is said about the surface of the Lyon bass strings.

-James Talbot (end of the 17th C) says that Violin-Lyons were smooth: '*Best strings are Roman 1st & 2nd of Venice catlins: 3rd & 4th best be finest & smoothest Lyons, all 4 differ in size...'*.

-The Mary Burwell Lute Tutor (1660 ca), describing the best strings for the Lute (*Romans* for Trebles, and *Lyons* for Basses and respective octaves) explain that an important feature from strings is exactly that the surface should be well smooth and free from *knotte* and *rugged*, Lyons -basses included.

-Mace, in addition, states that the (thin) Venice -Catlins for Meanes were smooth ('*The Lute made Easie*', Chap VI p.67), so when he also states that 'Pistoys' were but thicker Venice-Catlins we must infer that they, too were smooth: '*Secondly, when your String is well open, and you find it smooth, and free of knots...*'.

In conclusion it seem that the Venice Catlines, Lyons, Pistoys (i. e. the most common basses in the late 16th-first half of the 17th centuries), <u>all had a smooth surface</u> and never a knotty one like a rope.

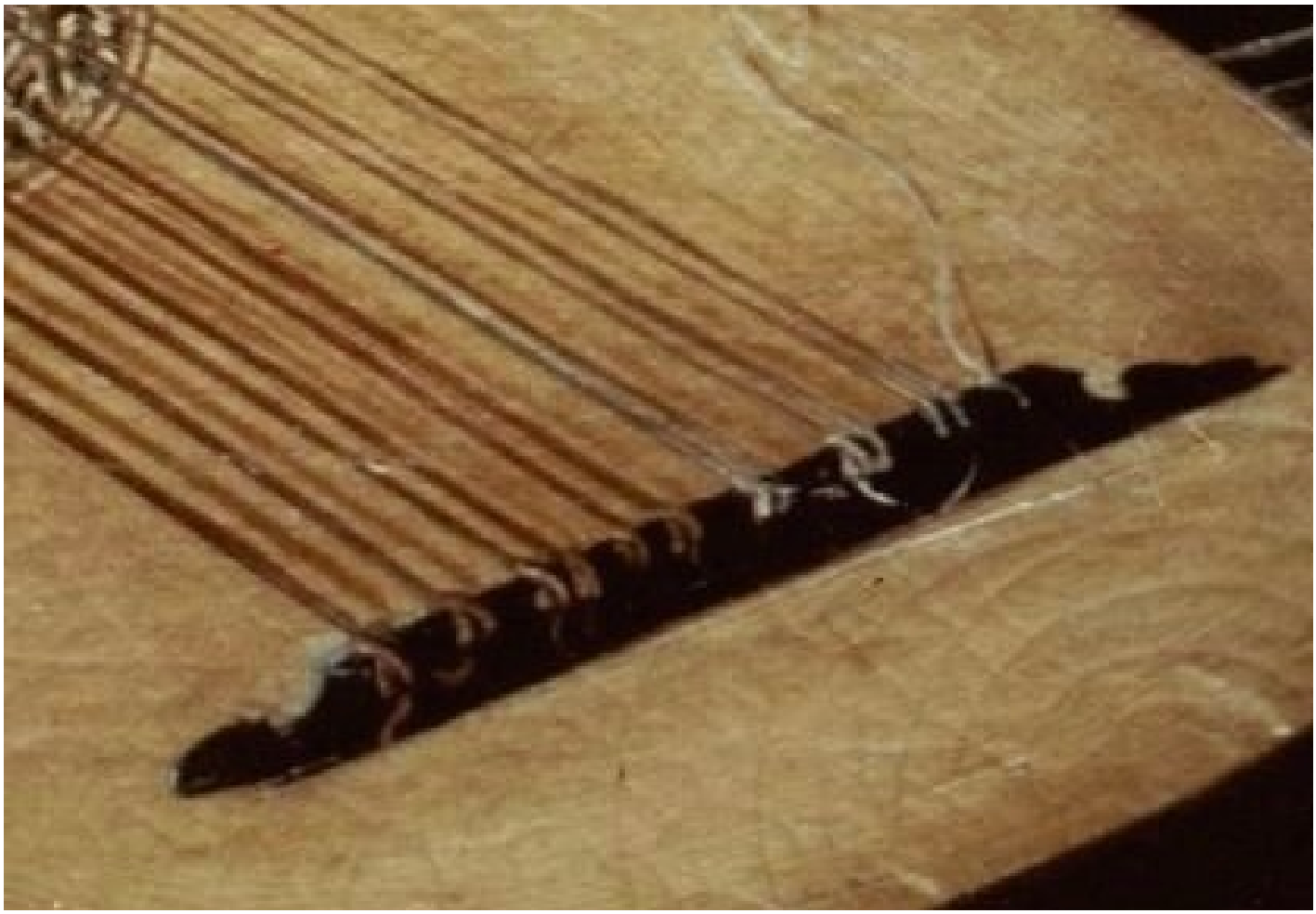
Painter's accuracy: see the Cister's roped bass wire string against the smooth bass Lute strings (Rutilio Manetti, Siena 1624).

The historical sources pointed out that the Cister bass strings were made with two metal wires twisted together like as rope (see Bacon 1627; Trichet 1640; Playford 1652; Talbot 1695 ca)

The two instruments both in the same painting

Cister's roped twisted wires

Lute smooth gut basses



Discussion

The question:

What type of string can satisfy all the above mentioned points at once?

The new solution devised by the string makers of the time must result into strings having the following features, as emerged from historical, iconographical and technological sources, as mentioned before:

a) Reduced string diameter, granting at the same time the same working tension (i.e. feel) as the higher strings (the equal feel of Mace, Dowland, Burwell L. T.)

b) Smooth surface

c) Low inharmonicity

d) Better acoustic performance than previous Basses (see Virdung's & Galilei complaints, 1511 & 1568)

e) Flexibility, allowing to roll them into a tight bundle

Going through the various possibilities we landed eventually on the only tenable hypothesis: only a gut loading treatment (to at least twice the starting weight) on smooth roped strings can satisfy all the above mentioned conditions.

(see Mimmo Peruffo: "*The mystery of gut bass strings in the sixteenth and seventeenth centuries: the role of loaded-weighted gut*", *Recercare*, v 1993, pp. 115-51).

Why the bass gut's density must be twice of those of the natural gut?

The acoustical performance of a gut string (as understood in the concept of Inharmonicity) is a function of type and amount of twist, working tension, diameter and material employed. The sum total of these parameters, obviously each carried out the best possible way, *resulted in the acoustical limit that was represented by the bottom string of the six course lute*. Now, if that was the lowest limit of acceptable sound quality, a string that is manufactured the same way and is expected to work **one fourth lower** (i.e. the new

acoustical limit) cannot exceed that same diameter. In order to achieve that - the calculation is quite simple - the specific weight of the material employed cannot be less than twice that of natural gut.

Modern loaded Bass strings that can achieve that can present different shades of dark red, brown or blackish colour, but also *light yellow* - depending on the oxides or sulphides employed.

Litharge

Red lead

Also metal powders like metallic-copper (*which is what we use on our loaded strings because is not toxic*) achieve the same goal: we still have ancient recipes describing how to produce the finest copper powder (we tried them quite successfully), like the one by Don Alessio Piemontese '*I secreti...*', printed in Venice in 1555: the resulting colour, too, looks very much like what we see on iconographical sources.

Incorporating finely insoluble powdered solid pigments into a matrix of different nature was *a fairly common practice* in the 16th and 17th centuries:

trementina, e anrho il maſtice con la cera biſogna dar li il fuoco lentiſſimo, et ſeguitare poi come è detto diſopra, delegando che ſiano le predette coſe, et auuertiſci che quãdo uorrai operare la ſopraſcritta miſtura, ſempre prepararai le due coſe che uorrai incollare a uno, cioè ſcaldandole bian piano tãto che ſe applichi, et facciano preſa con lo ſtuco. Et nota che la raſa di pino uol eſſer della negra e non biãca, ma ben di quella che ſta nelli barilli come la biãca, ma è piu beretina, et auuertiſce ſimilmente che quando pigliarai le doſe delle ſopradette coſe ſiano o tutte alla lib. groſſa, oueramente tutte alla ſottile &c.

A far un ſpecchio, o altra coſa luſtra di metallo. Cap. 122.

Piglia ℥. viij. di rame, ℥. ij. di ſtagno fino, ℥ ij. di mercurio congellato con il piombo. Piglia il rame & il ſtagno & fondi, et quando ſono fuſi battali il mercurio & ſubito gettali nella forma cotta et ben calda, & fatta di bona terra, e la terra ſi fa in queſto modo. Piglia delle padelle doue ſta il uedro in la fornace, & netta uia lo uetro talmente, dopoi piglia la terra & peſtala & ſetacciala per una pezza ſottile, & impaſtala con acqua comune, & impaſtata mettila all'humido coperta con una pezza bagnata murãdola ogni giorno almen per dieci giorni, & ſe piu ſarà piu perfetta, dopoi gettato che haurai il tuo lauoro dagli il ſmeriglio groſſo, et poi con piu ſottile, et queſto con un baſtone di ſaluce, ma prima amolato & gualuato, & poi dalli il ſtripolo, & poi il ſtagno calcinato, & diuentarà luſtro.

A far

A far corde da inſtrumento. Cap. 123.

Piglia li nerui della ſchiena del cauallo, liquali fa piſtare in un panno lino con un maglio di legno infino a tanto che ſiano uenute molle, dopoi ſalle filare polite, e ſiate lineali con colla forte & ſecca, e ſaranno corde fortiſſime & bone per inſtrumenti, & pareranno quaſi di ſeta.

A far cartelle da ſcriuere, & da far conti. Cap. 124.

Piglia biacca parte ij. cenere di oſſa bruſate parte una, ſiano ben peſte e meſcolate le ſopradette coſe inſieme, poi mettile a bollire in oglio di linoſa a fuoco lentiſſimo infino a tanto che ſia ben tegnizza, ouero che mettendoli dentro una penna con la piuma che ſe abruſi. Dopoi piglia carta peccorina, e li ſopradarai della detta colla ſottilmente, poi faralla ſciugare all'ombra, e liſciala con un dente, e dipoi dalli la uernice, cioe uernice da pittori, e ſaranno fatte belliſſime.

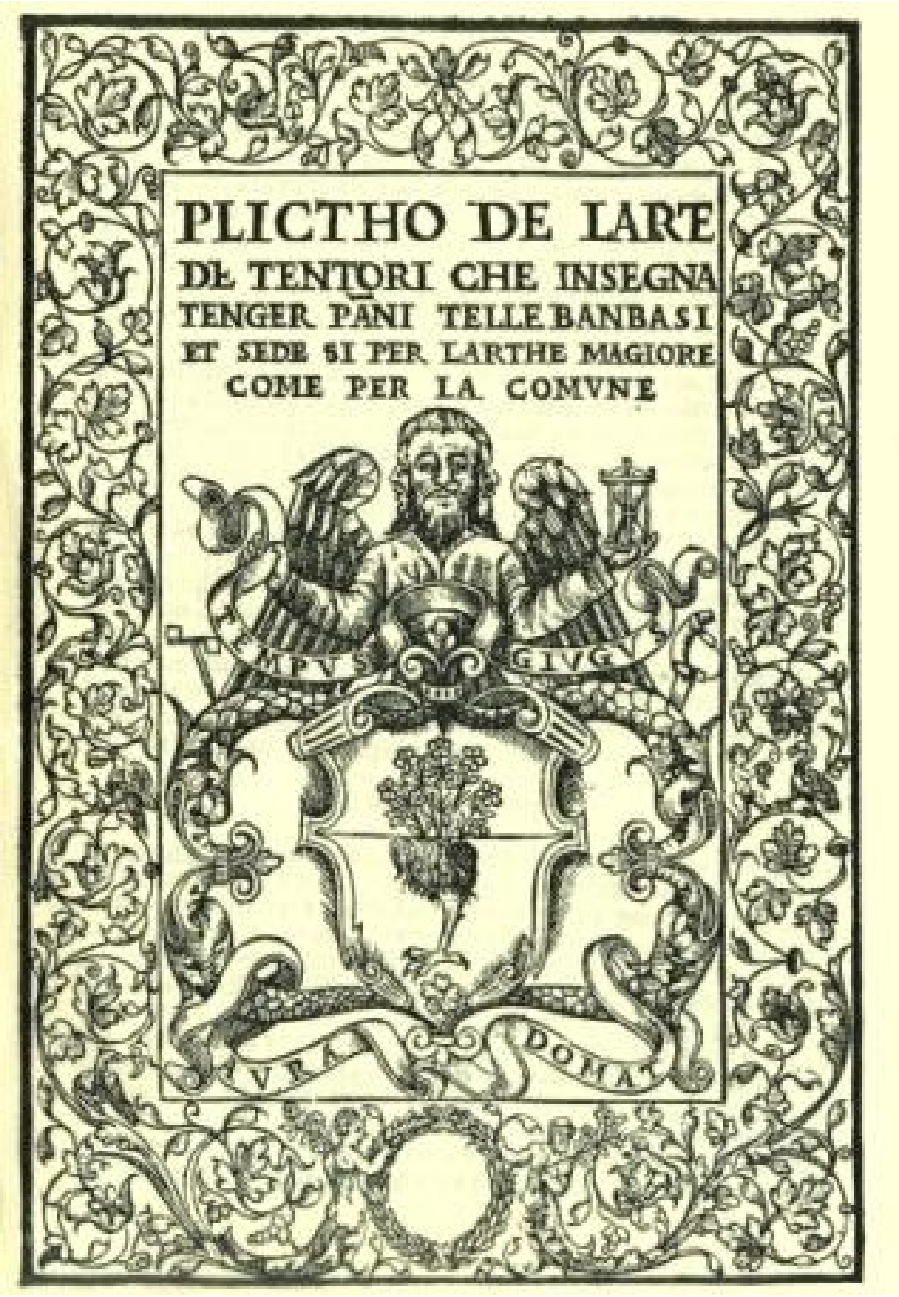
A far uino mirabiliſſimo contra ogni infirmità. Cap. 125.

Vino de roſmarino el quale ha tante uirtu che non ſi potria dire per lingua de huomo, dellequale dirò alcune principale, & piu diuulgate e prouate di queſto uino, ſi fa acqua di uita. Piglia lo roſmarino fuſto foglie & fiori, e menuzzali groſſamente, poi metti del ditto libre una, & piglia moſto libre noue a raſon de ſecchio, & fa bollir inſieme ſchiumando bene per un'hora, poi mettilo in uno botticello & laſſalo ſchiarire & beuaſi a degiuno la mattina uno dito, ouero

dui

Don Thimoteo Rossello "*Della Summa de' Secreti Universali*", Venice 1575

Several ancient recipes could have been easily employed for 'loading' gut (see, for instance, Giovanventura Rossetti's recipes for dyeing fabrics, silk and leather in his '*Plichto de l'arte de tentori che insegna tenger pani, telle, banbasi et sede si per larthe magiore come per la comune*', Venezia, 1548):



Some of these describe how to incorporate cinnabar (red mercury sulphide) or Litharge (yellow lead oxide) or Red lead (red lead oxide) into wax, leather, silk, wood, hair, inks &c.: indeed, only a short step away from gut:

Acqua verde.

℞. della sopraditta lissia doi lire & metti dentro onze doi de zaffaran & fal la boglir & se conuertira in color verde come e il smeraldo & adopera.

A fare acqua rossa.

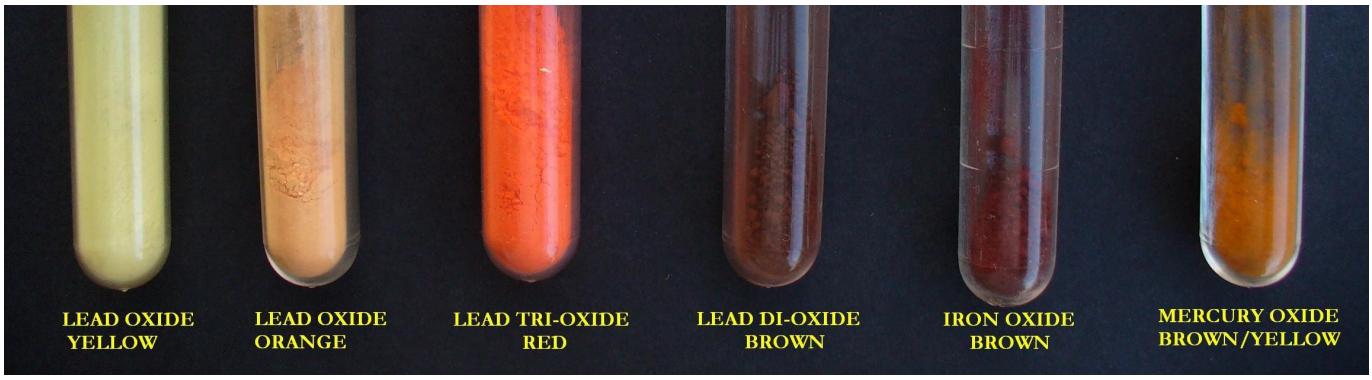
℞. Cenere de cerro & fanne lissia fortissima tanta che sia doi lire: & poneli dentro del sangue de boue & brasilio & dalli vno puocho de lume de rocha & adopera fredo.

Acqua rossa.

℞. Cenere de Cerro lire vna: & litrigerio rosso onze doi & fa boglire tanto che calli la mita & quando che vorrai saper se la e buona mettili dentro o coda de cauallo o capeli humani se fara operation cioe che tengia rosso.

Acqua che tengie in negro o veli o fazuolli o minzoletti.

℞. Galla lire vna & pestala ben & mettila a boglir in vno secchio de acqua & falla boglir tanto che la calli le doi parte: & come lhauera boglito metti dentro il tuo velo ouer faciol o quel drapo de seda o bauelle che vorrai: & lassa boglir per vna hora: & metti a star cosi sopra la cenere per vn giorno naturale o poco mancho & dapoi laua li tuoi veli & saranno negri.
Dapoi piglia limatura de ferro rugine lira vna: Gomma arabicha onze quattro: vetriol romano onze tre. Et pesta & metti a boglir per vna hora & lassa sfredir & caua fuora & laua dapoi che sara sfredido & lassa sugar.



Lead, Iron and Mercury oxides

The colours we see on the 17 th C. paintings are **dark red** (Thomas Mace's *Pistoys*?), **brown or blackish**: all colours that would point to the presence of heavy pigments like Mercury oxides or sulphides (brown, red, blackish), Lead (scarlet red, canary yellow, brown) or metallic Copper powder (reddish brown).

Anyway, it is possible to acheive a significant loading of gut (by the use of canary-yellow lead oxide) **without causing any noticeable chromatic changes** compared to the colour of natural gut.

Thus, the painter could only paint all the strings as being homogeneously the same colour (of natural gut). It is clearly a not negligible detail.

No trace, in the basses, of the green, blue or carnation: colours used to dye the thinner strings *for aesthetical reasons*, as described by Dowland and Mace. Why?

We discoverd that, in order to acheive a really efficient 'loading' process (in order to obtain a specific weight of no less than twice that of the natural gut), insoluble compounds must be employed, worked into a very fine powder and possessing a specific weight *of more than 8 - 9 gr/cm³*.

Now, none of the green, blue, pink etc. compounds known in the 16th and 17th centuries possess, simultaneously, all these qualities. Just to give an example: assuming that the volumes of the materials add one to the other perfectly (gut and copper powder, for example), in a loaded gut string made 2.1 times denser than a natural gut, a good 60-70% if its total weight (that is equivalent to 40 -50% of its volume) comes solely from the loading agent.

See here some tables concerning some Lead oxides:

Red Lead: http://www.gravitaindia.com/redlead.html

Yellow Lead: http://www.gravitaindia.com/litharge.html

Those bridge holes were certainly made by the lute-makers of the past to a size apt to accommodate any sort of bass gut strings then available on the market.

We are allowed then to assume that the technological matrix common to Lyons, Pistoys and may be, in Dowland's case, also the lowest Venice Catlins, may have been the loading of gut.

HYPOTHESES TO THE CONTRARY

-The first hypothesis against (Ephraim Segerman in FOMRHI Quarterly 77, October 1994 pp. 55-6: "On historical Lute Strings Types and Tensions") relates to the fact that the loaded gut strings made *today* are not translucent as Dowland seems to state talking about basses: '*This choosing of strings is not alone for Trebles, but also for small and great Meanes: greater strings though they be ould are better...they will be cleere against the light...*'

Our considerations

1) Dowland is not referring to the third Sort (i.e. Basses) at all. He is describing the Meanes and explains that even if they are thicker than Trebles they are still translucent. About Basses proper, which we shall treat later (*'For the greater sorts or Base strings, some are made at Nurenburge, and also at Straesburge...*) he says **absolutely nothing**.

2) We should not oversee the fact that when he describes a given Sort he always uses a capital letter (i.e. **T**rebles, **M**eanes, **B**asses). This is not the case when he mentions *'greater strings*', in the above passage, where he is referring to what comes just before the colon (and the colon, when it does not open a list of items, is explicative, to make clear a concept that has just been exposed), i.e. the Meanes.

3) It should be pointed out that such indications would be limited exclusively to the basses mentioned in the 'Varietie' (Strasbourg & Nurenberg- basses,Venice Catlines) To extend them to include also the mid XVII century's bass gut strings such as *Lyons & Pistoys* (which he never described), seems to be definitely a strained interpretation, totally lacking any historical supporting evidence.

4) It is worth noting that an unloaded roped string (the only alternative suggested instead of the loading of gut) , thanks to the special high double twisting of the paired strings (which do not have their fibers completely glued to each other), is in fact opaque and not translucent. to light.

5) The translucency question seems *purely speculative*, anyway: the real heart of the matter lies in the *small diameters* of historical lutes bridge holes and plausible working tensions.

-The second hypothesis against (Ephraim Segerman in FOMRHI Quarterly 98, January 2000 pp. 58: "Modern Lute stringings and beliefs about gut") concerns Mersenne.

In his *Livre II, Proposition II 'Des Instruments'* p.51 (*Harmonie Universelle*, 1636), he indicated the diameters of four lute strings, including the deepest bass. We know that the *ligne* is the 12th fraction of the royal inch, which corresponds to 2.3 mm, so it is easy to work out the following diameters:

11th string: 2.3 mm

7th: 1.5 mm

4th: .76 mm

2nd: .46 mm

Mersenne's statement seems to confirm that the lute bass strings were, indeed, pretty thick.

Our considerations

1) Mersenne is a theoretician: he is using the lute as a practical example to demonstrate what he has just been explaining, i. e. the direct relation between frequency and string diameter, tension being equal. Indeed, for the first time in history somebody explains the relation among tension, frequency and string diameter and enunciates the fundamental law concerning these parameters.

In another chapter Mersenne states that just about none of the players of his time followed in practice what he theorized. This should not surprise us, since the equal tension stringing he is proposing was a completely innovative concept to his contemporaries (and those to follow: the next one to talk about tension in terms of any unity of measurement will do so in mid 19th century), and would have caused an unbalanced *feel*, due to the different mechanical properties of the different string *Sorts,* and led to the exact opposite of what the treatises of his century insisted upon, namely the *homogeneity of feel*

2) Extrapolating the data given by Mersenne about equal tension stringing we infer that the treble should have a diameter of .34 mm: impossible to obtain from one whole lamb's gut, as already shown.

3) Assuming a 2.3 mm thick 11th string, and that to be 85% of the bridge hole diameter, the latter would turn out to be at least 2.7 mm: presently **we have no evidence** of such diameters on historical lute bridges.

We should also point out that, in his monumental and indispensable work, Mersenne made a few errors in evaluating the mechanical properties of materials employed in string making. For example, from his data we infer that the breaking point for a lute treble is only 19 kg/mm^2, against a mean value of 36 kg/mm^2 tested not only on modern trebles but also inferred from the string lengths of lutes from his own time and from the 18th century. In other words, by a breaking point as given by him a lute treble would not even reach as high a pitch as the second course. Similar anomalies were discovered about the breaking points of wire strings he deals with.

Some others considerations of his give us cause for concern: he wrote, for instance, that both the 6th string on the bass viol and the 10th on the theorbo are made of 50-60 gut strands; we leave it to the reader's imagination what the resulting diameter could be!

Athanasius Kircher (*Musurgia Universalis*, Rome, 1650) wrote that the thickest (10th) lute string is made of only 9 guts.

A last note concerning what said above, about the 11th string of a lute or theorbo (i.e. liuto attiorbato) being one line in diameter: should we conclude that both the theorbo and the lute, in spite of their different string lengths, were strung with the same strings?

-The third hypothesis against (Charles Besnainou: "La fabrication des cordes eten particulier commentrépondre aux questions posées par les cordes anciennes", lecture at Corde Factum, Puurs May 2008**):** the loading of gut tries to reconciliate the small hole diameters in historical bridges with the need of keeping a correct degree of tension (see equal feeling) on all strings, as maintained in the 17th century treatises.

The idea is to use an ordinary gut string, of sufficient length and fitting diameter to pass through a small bridge hole, half length, and then twist it into a roped string directly on the instrument. An alternative would be for the string maker to make the roped string and leave one end open and untwisted, enabling to tie that end on the bridge with some complex type of knot (the string must stay perfectly centred on the bridge in relation to the octave).

Our considerations

1) This hypothesis simply discards the technically easier solution: **why not simply drill slightly bigger holes in the bridge?** And what about the peg hole? It must necessarily be big enough for the resulting roped string: why make holes of different diameters when it is perfectly straightforward to have the same hole at both ends?

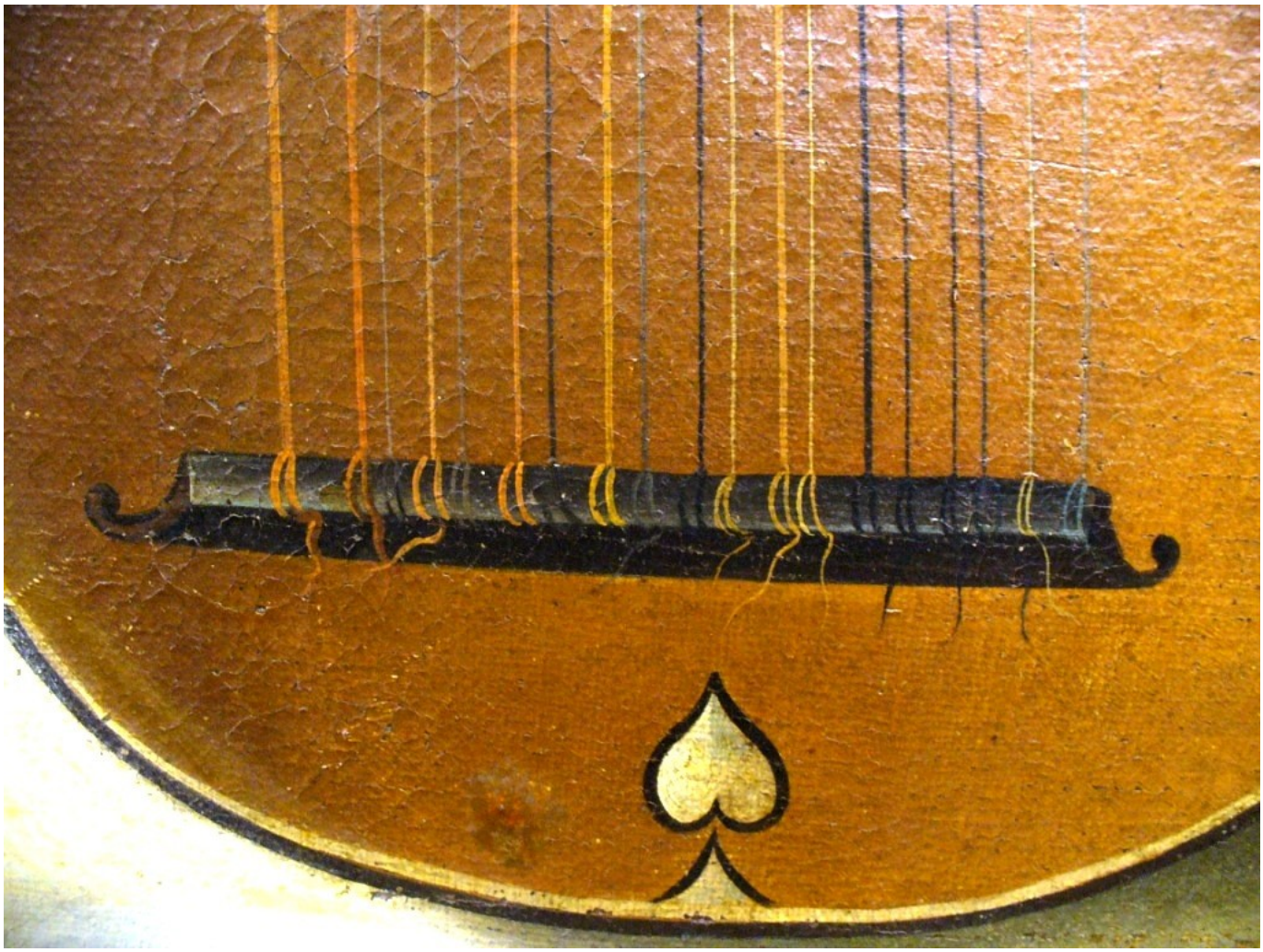
2) Were the strings to be twisted by the lutenist they would certainly present a knotty surface, since it would have been impossible to polish them on the instrument: historical iconography always shows bass strings, of any kind, smooth and never bumpy like a rope.

Twisting two strings into some sort of D-I-Y rope still requires the strings to be wetted beforehand and then carefully twisted *with some tool* in a perfectly regular manner: no treatise of the time ever mentions a lutenist needing such a complex know-how, nor that he should employ a long thin string and rope it himself, nor that he should sit still for an hour holding the string's end securely between his fingers waiting for it to be perfectly dry.

3) No iconographical source we know of ever shows any special type of knot at the back edge of the bridge as would be necessary to secure the string to it.

On the contrary, the knots used (the same we use today) never seem to consist of two ends knotted together:

Laurent de la Hyre: 'Allegory of music': detail (1649)



Bilcius (?), 2nd half of the 17 th C. detail of the bridge of a 12 course lute

4) Such a method of roping a string *still does not solve* the enigma of the remarkable acoustical qualities of gut strings on short lute extensions, as described in the Mary Burwell lute tutor and by Thomas Mace, which no gut string at its natural density can ever achieve.

Bowed instruments:

Some iconographical sources have led us to think that this way of fixing a string may have been in use, at least on bowed instruments. It is, in fact, a particular way of securing strings with a stop-knot between string holder and bridge, whose purpose is to get rid of the 'wolf' problem and to better balance the stress of the string on the bridge, keeping the latter from bending towards the holder under the string's pulling action. A string knotted in such manner between bridge and holder would present an elongated loop that can be so misleading.

-The fourth hypothesis to the contrary concerns coloured strings. Both Dowland and Mace mention strings that are coloured for aesthetical and commercial purposes. Therefore the coloured bass strings could be consequence of an aesthetical treatment and not of a gut loading process.

Our considerations

1) Such a hypothesis is not really convincing since it ignores more concrete arguments supporting the string loading theory, such as:

a) the small bridge and string holders hole diameters

b) the great acoustical exuberance of 17th century all-gut bass strings

The only colours mentioned by Dowland and Mace are **red, green and blue**. Both advise to choose the more lightly coloured strings. And that is the opposite of what we see in iconographical sources, where we find dark red, brown or blackish, and yellow.

As already stated in point **4)**, the bass strings colours are rather homogeneous, lacking any gradual chromatic transition from thinner to thicker and, besides, they appear exactly where we, today, resort to wound strings (i.e. from the 6th course down).

Wherever colours are employed for aesthetical purposes only they appear anywhere on the instrument, trebles included, with no discernible logic.

Here are two different examples

Dyed strings for aesthetical purposes

Red basses: they suggest a loading treatment

Miscellanea

To conclude this review we would like to mention other doubts raised. Although, these, in our opinion are devoid of any adequate analytical or organological support (see Annette Otterstedt: 'The Viol' 2002, p. 249):

a) the colour of the loaded strings today available on the market does not resemble the red of the basses as from 17th century paintings

b) bass strings from some iconographical examples from the 17th century seem to be darker close to the bridge and become gradually lighter and lighter towards the nut end: therefore such examples cannot support the hypothesis of string loading, which should give the whole string an even colour

c) gut strings, especially the unbleached and thicker ones, get darker over the years

d) very rarely can bridge holes on historical Lutes be considered to be original

e) modern reproduction of such strings implies such a substantial use of glue (to bind the gut fibbers together) that we end up, in fact, playing more on glue than on gut

Our considerations

1) Points **a)** and **e)** are completely irrelevant to the gut loading hypothesis. They simply criticize some physical properties of modern loaded gut strings. In any case it has to be pointed out that there are no problems in loading gut with red lead or iron oxide powders, which would give the strings the expected red hue.

Glue does not serve the purpose of binding gut fibres together but as means for distributing the powder in a more even and homogeneous way.

Incidentally, we would like to point out the presence of barrels of hide glue in some stringmaking workshops in the 17th century: *" Un barilozzo con dentro libbre 30 in circa di colla cerviona - a small barrel containing about 30 pounds of hide glue-"* (see Patrizio Barbieri: *Roman and Neapolitan gut strings*, 1550-1590, GSJ, May 2006, p. 97)

Containers with red-dye are also mentioned (but of course we can not know whether that was employed for staining or loading gut)

2) Point **b)** is not relevant in our case: as a matter of fact, we were very careful to select only iconographical examples where the colour of strings is homogeneous not only along the length of the string, but also between adjacent strings on the instrument under examination. We do agree that a string's uneven colour would give ground for doubt.

3) Concerning the point **C)**: there is no links to our iconographical examples. Saying that strings (especially the unbleached ones) become darker with time should be better qualified, i.e. if they have been oiled we can partly agree because of the oxidation process of oil. We must point to the *exclusively modern* practice of treating strings with linseed oil: in this specific case the strings acquire in a short time a reddish-brown colour that is due to the quick polymerization process of the siccative oil. This is not the case with the oils actually used in the past, olive or almond oil, which are non-siccative.

It is hard to understand, though, what kind of relevance this point could have in our theory: nobody can say how old the strings on the instrument were at the time the painting was done.

4) What stated at point **d)** was not supported by any detailed physical organological analysis of each of the examined bridges that could lead to an *objective* (and verifiable) conclusion. We examined about 70 bridges; some 50% were considered, on the basis of the elements produced by the museums staff, as *probably* original.

Modern solutions

Mid 17th century sources, as just seen, tell us that gut basses like Lyons and Pistoys possessed **a remarkable acoustic exuberance**, unknown on the six course lute Galilei and Virdung complain about - to the point of causing the serious problems of acoustical confusion, even on a lute with short extension, as described in the Mary Burwell tutor and by Mace, which had to be dealt with by giving up the extension and readopting the French lute without extension like the one in Charles Mouton's portrait.

Obviously the string makers of the time invested all their creativity and ability to produce the best possible all-gut bass strings.

Here we wish to advance our suggestions:

1) Applying the best suited chemical treatments (we follow the historical Italian string making tradition) to make the fresh gut strands as supple as possible before twisting (we regard it as the *1st dimension*)

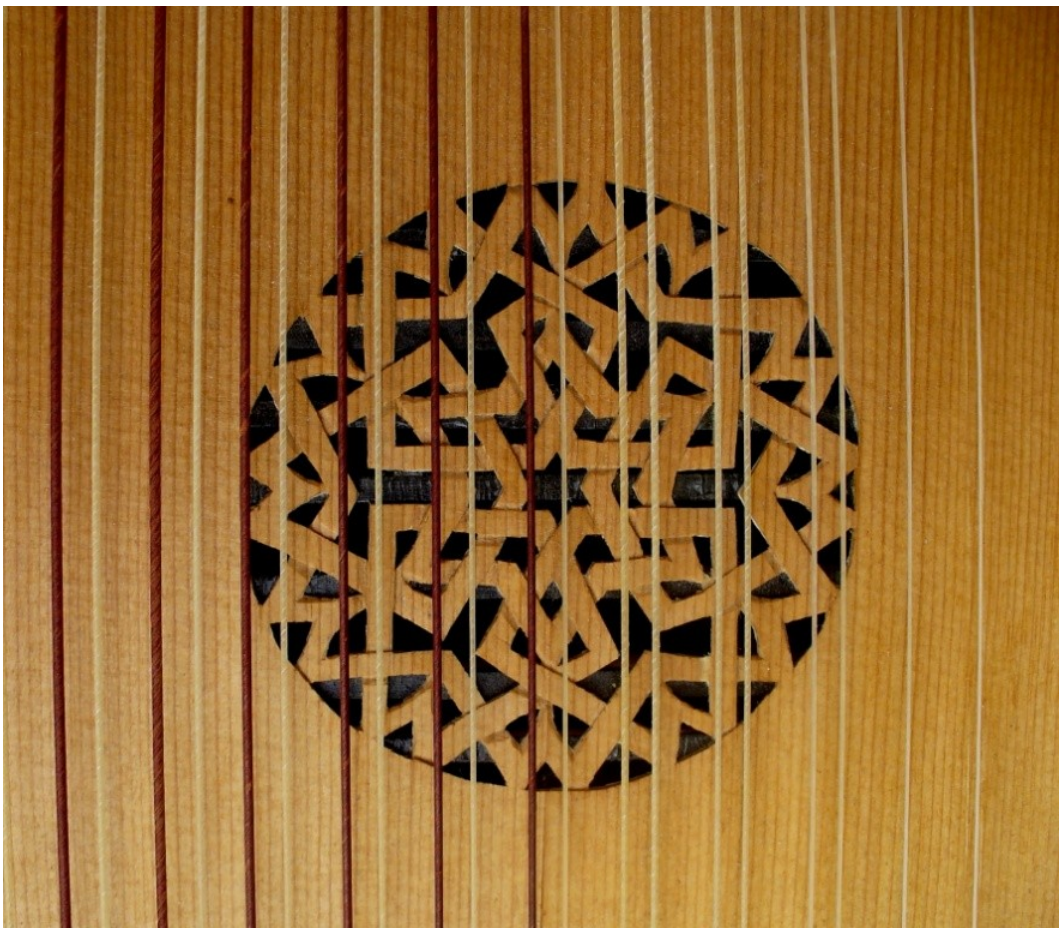
2) Finding the best suited twisting process to reduce the string stiffness to a minimum (*2nd dimension*)

3) 'Loading' the gut with mineral compounds (which we regard as the *3rd and last dimension*)

With the development of the *third dimension* (i.e. increasing at pleasure the specific weight of gut) made around 1570-80, it became possible to open a new musical epoch, through instruments more capable of providing the fundamental, the new role of the basses of both plucked and bowed instruments.

The appearance of wound strings, in the second half of the 17th century, **was no real revolution**: seen from a technical point of view **it was only a different and more efficient way to increase the weight of gut.**

The all-gut bass strings we reconstruct today (in practice a *smooth roped string* loaded with insoluble metallic copper powder) is not only *the perfect synthesis* of the two different opinions shared by researchers in the field of all-gut bass strings, but also represents *the logical evolution* of the technological know-how of 16th century string makers, which we believe, at least in part, to understand.

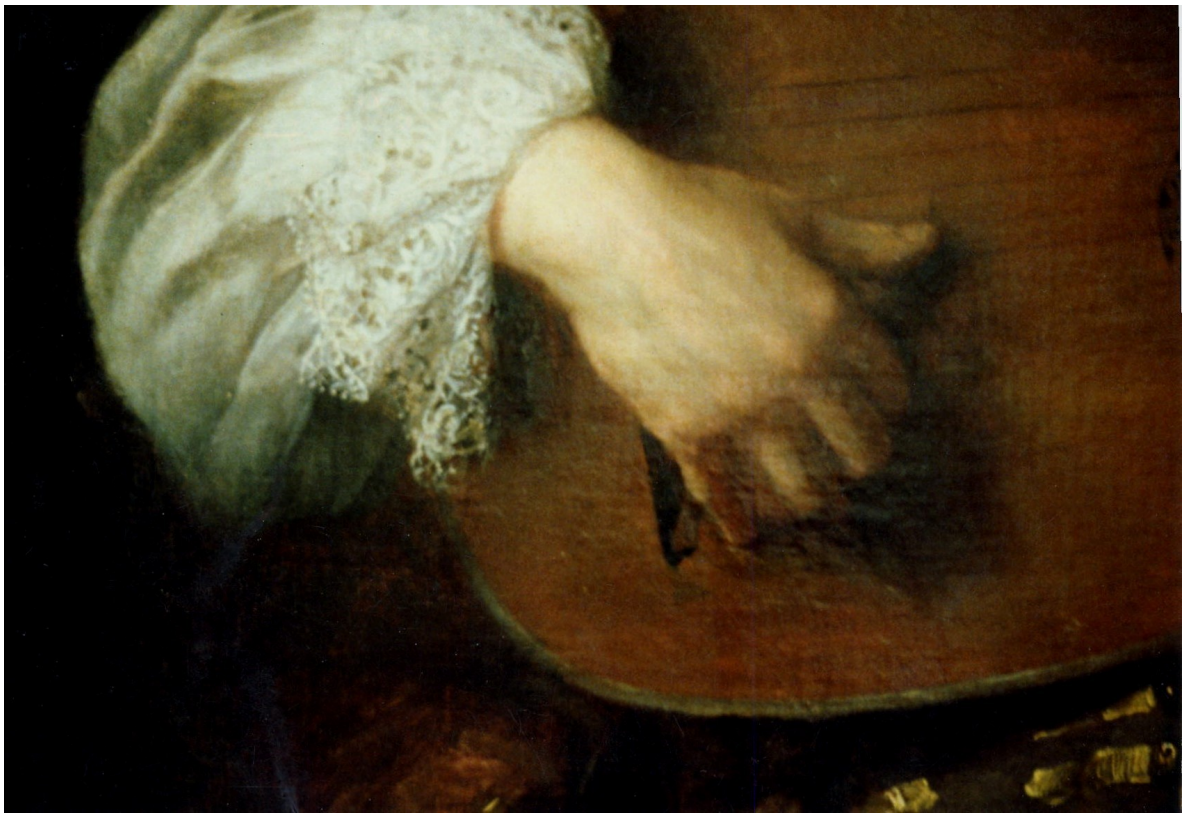


Modern reconstruction of the Mace's *deep dark red colour*'s Pistoys (2008 year)

(the 11th bass string gauge is of 1.30 mm = 2.00 mm of equivalent solid gut. Working tension: 3.0 Kg; standard pitch: 415 Hz)

Right hand positions

Note: *On a modern lute completely strung with gut at 3.0 Kg tension per string (1-3 courses + octaves plain gut; 4-5 courses Venices; 6-11 basses loaded gut strings) the best performance was achivied when playing closer to the bridge and with the thumb out; as suggested by old lute treatises and some paints:*



F. Le Troy (1690 ca): portrait of Charles Mouton, detail

...and by the finger- marks that are on some original d- minor 11 course lutes (that had never been restored) of the Kremsmünster (Austria):

Hans Frei in Bologna; Matthias Fux/Röm 1683'

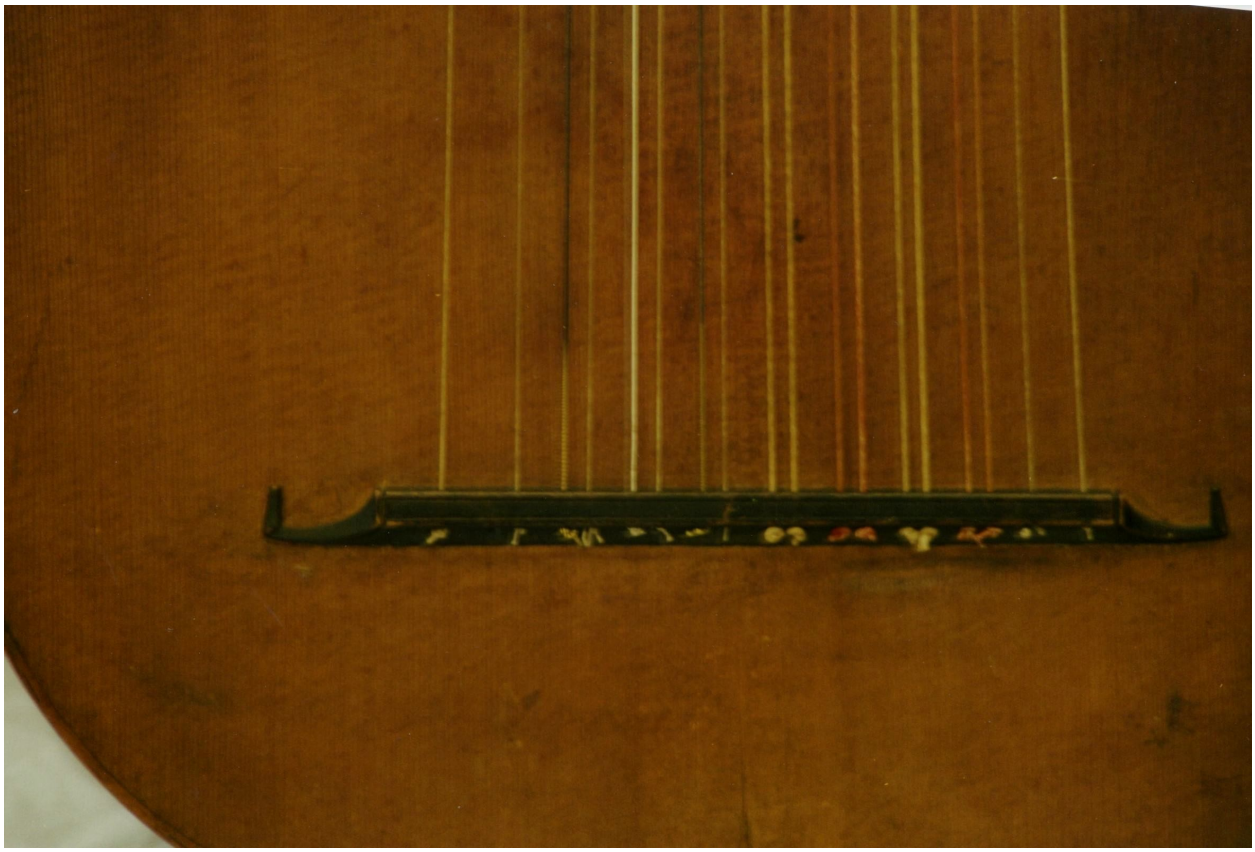
'*Magno dieffopruchar a venetia/1604 Matthias Fux/Röm.* Kays. May- / *Hoff-Lautenmacher in Wien 1685/ zuegericht*'

(no label)

'*Jakob Weiβ/Lauthen-und Gei-/17 genmacher in Saltzburg*'. 13 course lute with broken bass rider

Examples of the finger mark behind the bridge

Here is a Laux Maler's lute modified in a 11 course d minor lute (Wien, Kunstistorisches Museum, C. 32) with a deep finger mark behind the bridge:



...and again the Hans Frei lute (Wien, Kunstistorisches Museum, C.33) with a deep finger mark behind the bridge:

Archlutes, theorbos, extended d-minor lutes

All considerations so far expressed regarding the lutes without extension apply also to those with extension. The only difference lies in what sort of strings we choose for the extended basses. Let us consider **two basic types** of instruments:

a) Theorbos and archlutes with long extension and single diapasons

The purpose of very long extensions is twofold: on the one hand we reduce the string diameters for a better acoustical performance (string length and thickness are inversely proportional), on the other hand - and this is probably *the more precious advantage* - we obtain *a noticeably better sustain*, an indispensable factor for continuo playing.

No document gives us any clues about what kind of strings might have been used as diapasons (apart from Piccinini, who mentions using silver wire for 5th, 6th and extended basses, but calls the instrument Bandora), but we feel we can exclude loaded gut strings, both on organological (bridge holes diameters) and iconographical grounds.

Here are some 5th and 6th fingerboard's course bridgeholes diameters:

-Chitarrone /archlute "Magno Diefopruchar a Venetia", (C45) Vienna, Kunsthistorisches Museum: 5th course 1.7mm gauge both string holes of the course; 6th 1.9 mm both string holes of the course. Vibrating string lengths: 6x2=67 cm; 8x1=142 cm.

-Theorbo "1611/Padoua Vvendelio Venere", (C47) Vienna, Kunsthistorisches Museum: 5th course 1.3 mm to the bass side string; 1.4 mm for the octave. 6th course: 1.5 mm for the bass side, 1.3 mm for the octave side. Vibrating string lengths: 6x2=76 cm; 8x1=121 cm.

-Chitarrone "Matheus Buechenberg/ Roma 1614", (190-1882); London, Victoria and Albert Museum; 5th and 6th course string-holes: no.64 drill (*****) both strings of each course. Vibrating string lengths: 6x2=89 cm; 8x1=159 cm.

-Chitarrone /archlute "Andrea Taus, Siena 1621", (5989-1859); London, Victoria and Albert Museum: 5th course both string-holes no.58 drill (*****). 6th course: 1/16 of inch (~1.58 mm) to the bass side hole; no.58 drill (*****) for the octave side. Vibrating string lengths: 6x2=67 cm; 8x1=143 cm.

-Chitarrone by anonimous, (7755-1862); London, Victoria and Albert Museum; 5th and 6th courses: all string-holes no.58 drill (*). Vibrating string lengths: 6x2=70 cm; 8x1=148 cm.

-Chitarrone "Christoph Koch zu dem Gulden Adtler/ in Veneding Jul. 1650", (Kat. Nr. 3581); Berlin, Staatliches Institut […], from a letter sent to me by Dr. Annette Otterstedt in 1996 year: "The holes in the bridge look rather wide for metal strings…". Vibrating string lengths: 7x2=83 cm; 7x1=167 cm.

***** *The equivalent gauge, in mm, was not specified*

The choice falls between strings with natural specific weight, like our Venice or the traditional high twist. It is worth remembering that the Inharmonicity limit of the thickest diapason on a theorbo or archlute was pretty much the same as the 6th on the 6 course lute. In other words, the product of frequency by string length results in a similar Acoustic Quality Index and long diapasons **need not be of the third Sort.**

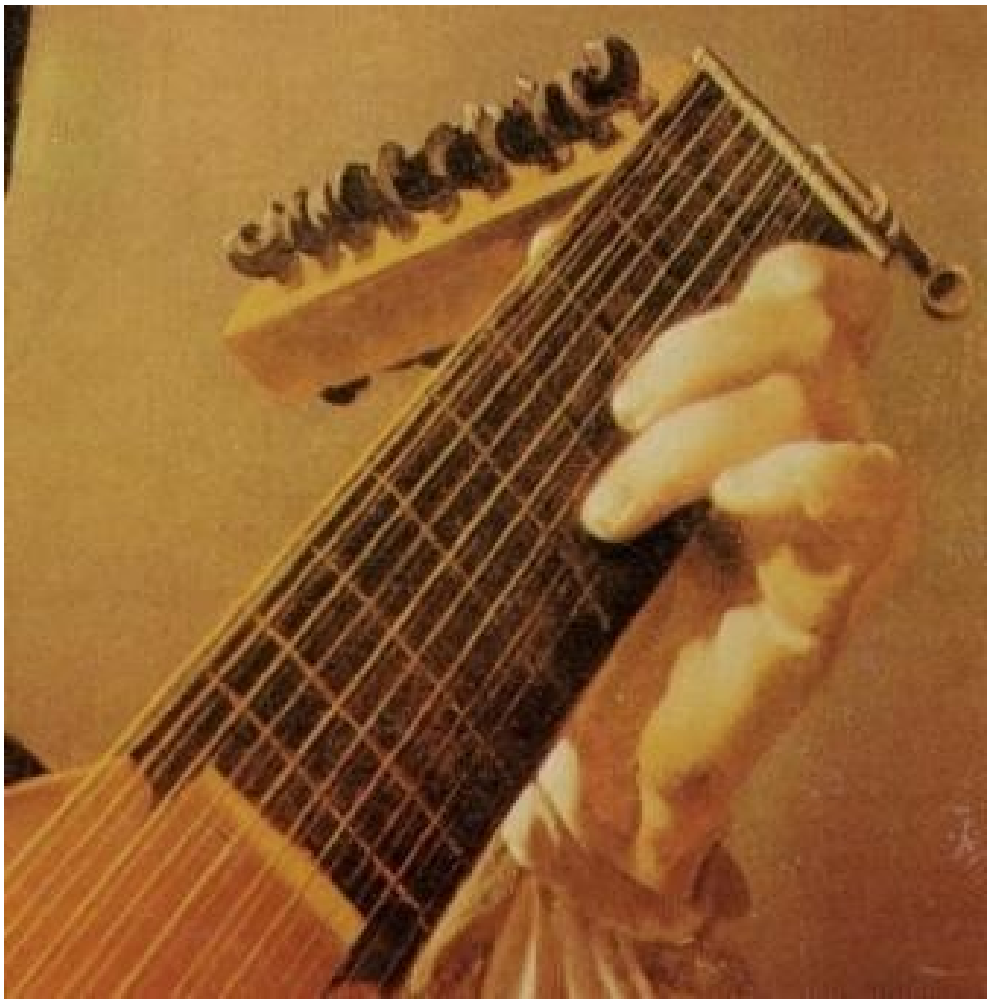
b) Archlutes and d-minor lutes with short extension and paired octave basses

We have no historical sources to suggest what strings ancient lute players used as diapasons, we must therefore proceed by exclusion.
The use of octaves on extended basses would suggest that it was necessary to remedy a loss of acoustical quality. Logic would suggest **non-loaded gut strings**, at least as long as the string diameters fall within about 1.4 mm (i.e. an average 6th on a 6 course lute).

The octave vs. unison question on 4th, 5th and 6th courses

a) 7, 8, 9 and 10 course lutes

Information about the string disposition on 4th, 5th and 6th courses is very scanty (courses below the 6th always had a paired octave). Dowland prescribes unisons down to the 6th course included. Iconographical sources, on the other hand, show the use of an octaved 4th course even on 10 course lutes; see Terbruggen, ca. 1624, in the National Gallery in London:



whereas some rare sources show a unison 4th, while 5th and 6th have octaves (see Rutilio Manetti, ca. 1624, in Dublin).

William Barley (A New Booke of Tabliture, 1596) recommends using octaves on 4th, 5th and 6th. John Johnson, Francis Cutting and Anthony Holborne hint that, in the second half of the 16th century in England, the use of octaves was not at all uncommon.

b) 11, 12 and 13 course D-minor lutes (with and without extension)
All historical evidence we know of (e.g. Perrine's *Pièces de luth*, 1680: '*...les 3. 4. 5. sont doublées d'unissons, et 6. 7. 8. 9. 10 et onze sont doublées d'octaves*'. Wenzel Ludwig Edler Von Radold -1701- also), both written and iconographical, show that octaves were in use from the 6th course (included) down. Presently we have no evidence whatsoever of unisons having been used on the 6th course.

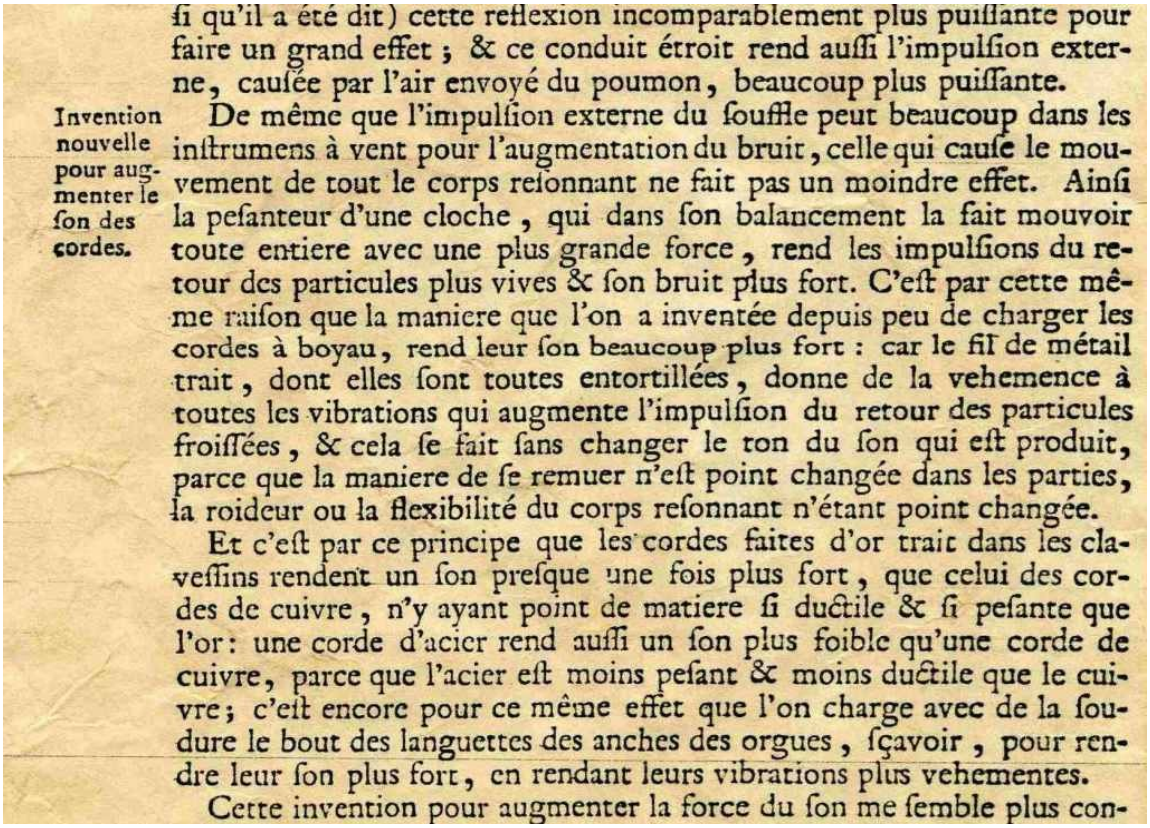
c) Double strung theorbos
To our knowledge, there are no written sources on the subject. A survey carried out on bridge holes shows that both holes on 5th and 6th courses have the same diameter. Unisons would be expected.

d) Archlutes with both long and short extension
Again, no written sources on the subject, as far as we know. Iconographical sources show both octaves (e.g. Anton van Dyck's portrait of a lute player, ca. 1630 in the Prado museum in Madrid) and unisons on 5th and 6th courses (e.g. anonymous portrait of a lute player, North Italian School, ca. 1720, in the article by Robert Spencer).

Anton van Dyck (ca. 1630): archlute's player; details of single treble and octaves on 5th and 6th courses. See also the long thumb-nail

Lute bass strings in the 18th century

We believe that the late 17th century lute *was not affected*, as a rule, by the appearance of wound strings, which were developed in the second half of that century: the earliest mentions known to us of wound strings dates back to 1659 (Hartlib Papers Project; Ephemerides: "*Goretsky hath an invention of lute strings covered with silver wyer, or strings which make a most admirable musick. Mr Boyle. [...] String of guts done about with silver wyer makes a very sweet musick, being of Goretskys invention"*) and 1664 (John Playford: "*An Introduction to the Skill of Musik...*").



ſi qu'il a été dit) cette reflexion incomparablement plus puiſſante pour faire un grand effet ; & ce conduit étroit rend auſſi l'impulſion externe, cauſée par l'air envoyé du poumon, beaucoup plus puiſſante.

Invention nouvelle pour augmenter le ſon des cordes.

De même que l'impulſion externe du ſouffle peut beaucoup dans les inſtrumens à vent pour l'augmentation du bruit, celle qui cauſe le mouvement de tout le corps reſonnant ne fait pas un moindre effet. Ainſi la peſanteur d'une cloche, qui dans ſon balancement la fait mouvoir toute entiere avec une plus grande force, rend les impulſions du retour des particules plus vives & ſon bruit plus fort. C'eſt par cette même raiſon que la maniere que l'on a inventée depuis peu de charger les cordes à boyau, rend leur ſon beaucoup plus fort : car le fil de métail trait, dont elles ſont toutes entortillées, donne de la vehemence à toutes les vibrations qui augmente l'impulſion du retour des particules froiſſées, & cela ſe fait ſans changer le ton du ſon qui eſt produit, parce que la maniere de ſe remuer n'eſt point changée dans les parties, la roideur ou la flexibilité du corps reſonnant n'étant point changée.

Et c'eſt par ce principe que les cordes faites d'or trait dans les claveſſins rendent un ſon preſque une fois plus fort, que celui des cordes de cuivre, n'y ayant point de matiere ſi ductile & ſi peſante que l'or : une corde d'acier rend auſſi un ſon plus foible qu'une corde de cuivre, parce que l'acier eſt moins peſant & moins ductile que le cuivre ; c'eſt encore pour ce même effet que l'on charge avec de la ſoudure le bout des languettes des anches des orgues, ſçavoir, pour rendre leur ſon plus fort, en rendant leurs vibrations plus vehementes.

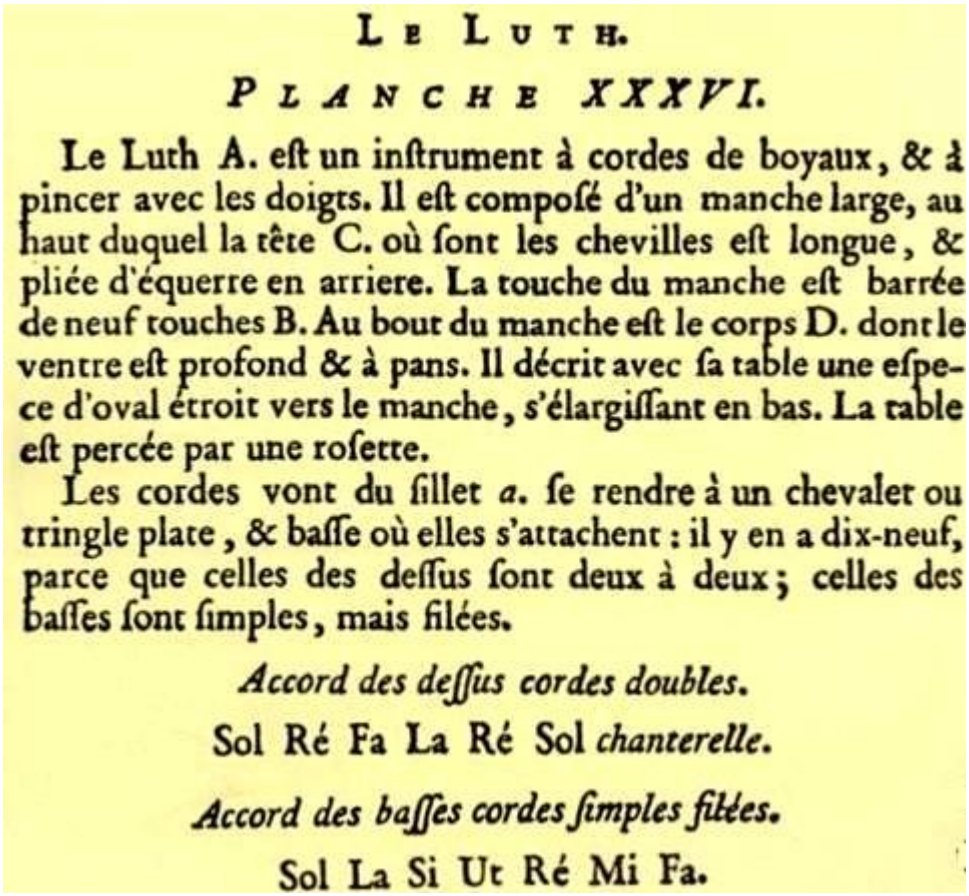
Cette invention pour augmenter la force du ſon me ſemble plus con-

Claude Perrault "Ouvres de Pysique" , Amsterdam 1680

Surviving treatises (Thomas Mace, 1676, and James Talbot, ca. 1690, amongst others) point towards all-gut basses.

On the ground of circumstantial evidence, though, we believe that, as from about the beginning of the 18th century, the German 13 course lute might have been strung with this new type of string. In a document from 1731 Gianbattista Martini, in Augsburg at the time, mentions keyboard instruments strung with '*...corde ramate, come il Leutto...*' - **coppery strings, like the lute's** (see Patrizio Barbieri's *Roman and Neapolitan Gut Strings,* GSJ May 2006, pp. 176-7).

Another source mentioning wound strings on the lute is François Alexandre Pierre de Garsault's *Notionnaire...*, Le Luth, Planche XXXVI - '*Accord des basses cordes simples filées...*', Paris, 1761:



LE LUTH.

PLANCHE XXXVI.

Le Luth A. eſt un inſtrument à cordes de boyaux, & à pincer avec les doigts. Il eſt compoſé d'un manche large, au haut duquel la tête C. où ſont les chevilles eſt longue, & pliée d'équerre en arriere. La touche du manche eſt barrée de neuf touches B. Au bout du manche eſt le corps D. dont le ventre eſt profond & à pans. Il décrit avec ſa table une eſpece d'oval étroit vers le manche, s'élargiſſant en bas. La table eſt percée par une roſette.

Les cordes vont du fillet *a.* ſe rendre à un chevalet ou tringle plate, & baſſe où elles s'attachent : il y en a dix-neuf, parce que celles des deſſus ſont deux à deux ; celles des baſſes ſont ſimples, mais filées.

Accord des deſſus cordes doubles.

Sol Ré Fa La Ré Sol *chanterelle.*

Accord des baſſes cordes ſimples filées.

Sol La Si Ut Ré Mi Fa.

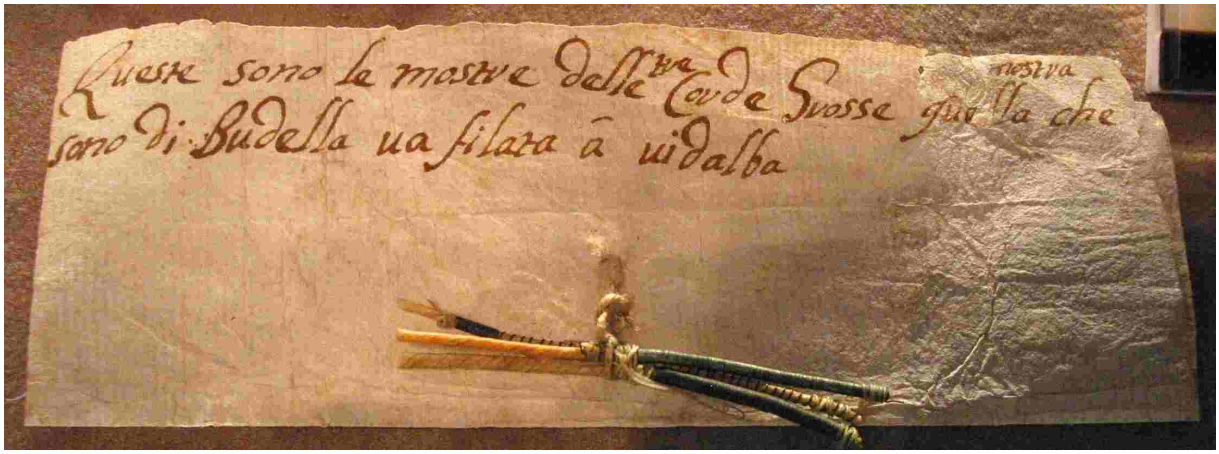
In the 18th century, wound strings can be grouped into **three categories**, all built around a gut core (at least up to the second half of the century - the earliest mention of wound on silk known to date is after 1760):

1. **double wound (i.e. a first winding is covered by a second one)**
2. **close wound**
3. **open wound (called *demifilé* by the French)**

Open wound & close wound strings

Type 1. was probably used for bowed instruments with particularly short string length and low pitch (Cello da spalla, Viola da Spalla &c.).

Type 2. would seem to be the right one for the 13 course lute:



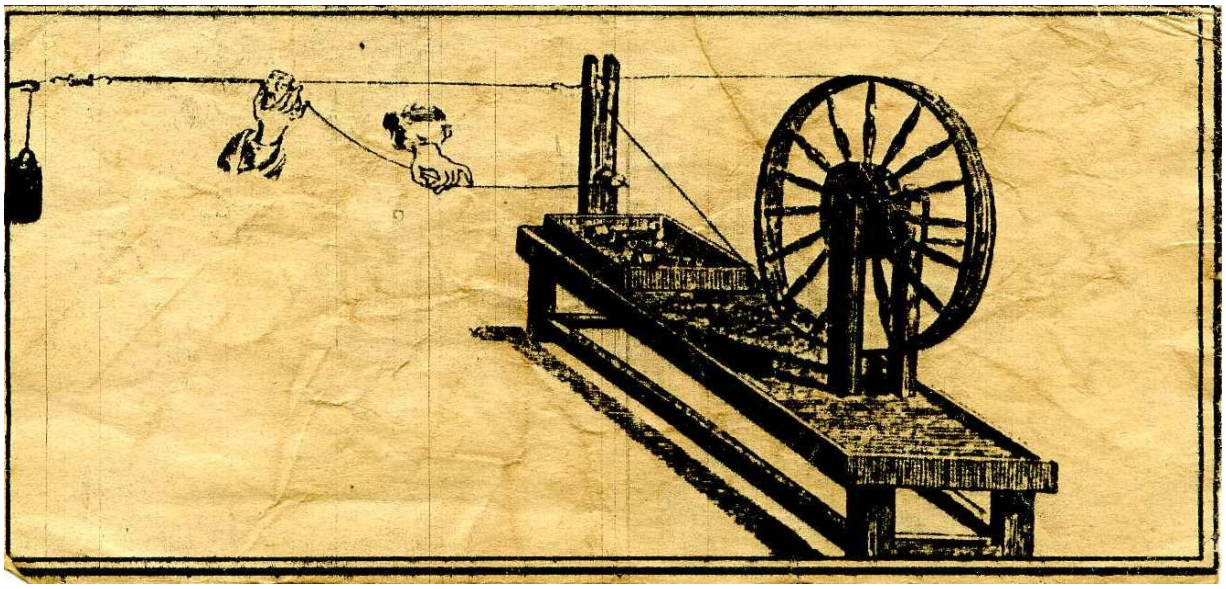
Stradivari wound strings, Museo Stradivariano Cremona: '*Queste sono le mostre delle corde grosse, quella che mostra (che) sono di budella va filata a vidalba*'

(These are the examples of the thick strings; the string that show the gut core between the wire- turns must be wound like the Vitalba's plant):

The Vitalba's plant

but we would rather opt for **type 3.** upon an important consideration: from what we know about the metallurgic technology of the time it seems that it was not possible, *at least in the common practice*, to produce wires thinner than about .12 mm (see for example James Grassineau " *Musical Dictionary*" London, 1740 under the world '*wires*'; see also the Cryselius's wire gauges and the 18th Nuremberg's wire gauge tables).

As a consequence we think that it was not possible to produce wound strings for the 6th, 7th and 8th courses for the d-minor lute, even if we reduced the gut core to the point of completely unbalancing the Metallicity Index and the mechanical stability of the string.



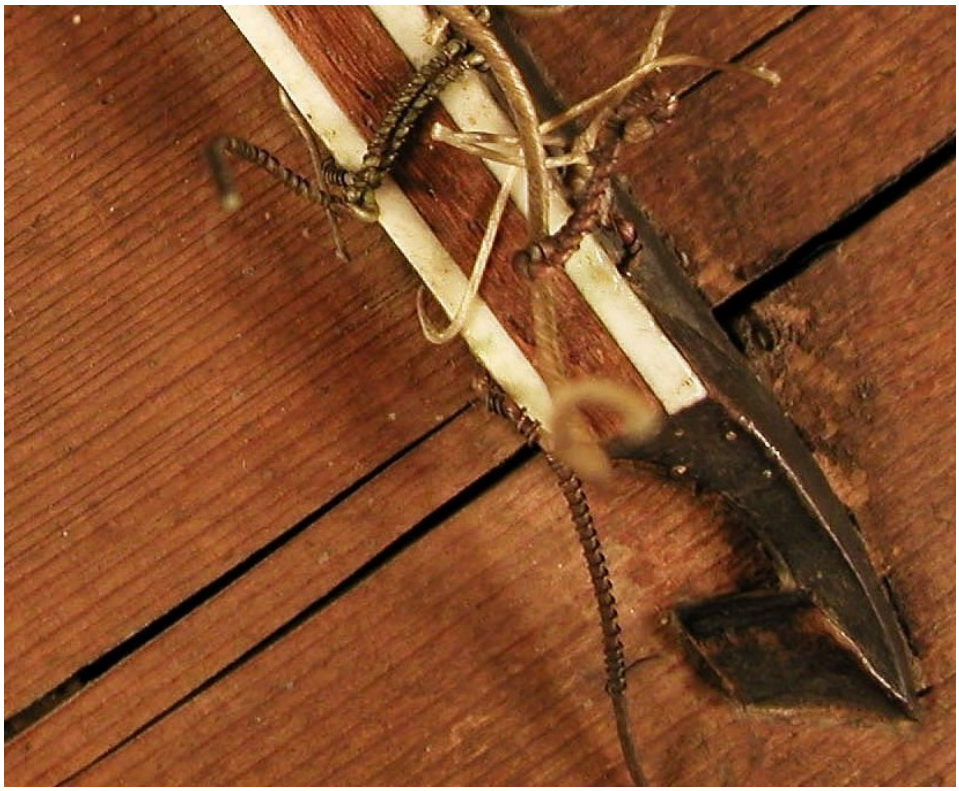
The manual machine for making overspun strings. "Encyclopédie, ou Dictionnaire raissonné des sciences, des arts et des metier [...]", Briasson et al., Paris 1751-80.

An open wound string was simple and efficient: by spacing the winding it was possible *to get around* the wire diameter problem, with one limitation: here, too, it was the thinnest available wire that had to be employed in the production of the 6th string.
What we are saying here is that open wound strings were not a transitional phenomenon, in the sense of bridging over the gap between all-gut and close wound strings, they were *a clever stratagem* that made it possible to come around the technological limitations of the wire manufacture of the time.

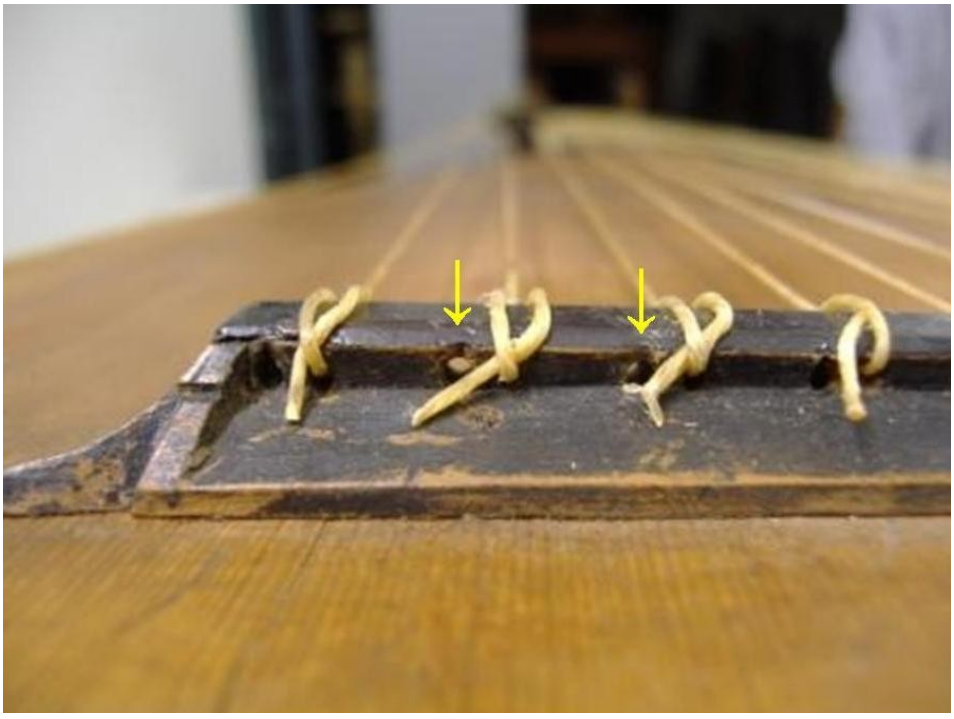
How do we know that open wound strings were really used in the 18th century lutes?

One piece of evidence and several probative elements point in that direction:

a) The direct evidence comes from the pieces of strings on a Lute by Raphael Mest. Half wound strings were in use only in the 18th century and it is hard to imagine a later addition of this particular kind of string on an instrument that had already fallen into disuse:



b) A strong vertical ovalization of bass bridge holes and signs of abrasion on the upper plate edges on original 18th century bridges: an open wound string **does not run smoothly** (not as smoothly as a close wound does) but acts like some kind of file on the hole edges. We hardly find this kind of wear on modern lutes, for instance, where we use close wound basses.



Example of vertical wear in the bridge of a 13 course lute of the Germanische National Museum of Nuremberg

c) The diameters of bass bridge holes on 13 course lutes with bass 'rider' are rather compatible with open wound strings, while holes for the noticeably thinner close wound strings would be expected to be smaller (a half wound string for the 13th course with a working tension of about 3 kg presents a diameter of about 1.6 mm against a statistical average of 1.8-1.9 of hole- diameter as measured on original lutes). Unfortunately, this evidence does not work with the swan-neck lutes.

Table 1

Lute	Disposition	Course	maximum passing diameter
"*Leonhard Pradter in Prag 1689*" 45 / N.E. 49 Kunsthinstorisches Museum Sammlung Alter Musikinstrumente Wien, Austria	Thirteen courses lute (2x1, 9x2. 2x2) v.l. 71.6 cms 76.0 cms	11th 12th 13th	1.85 mm 1.60 mm **!** 1.75 mm **!**
"*Hans Burkholtzer, Lautenmacher in Fiessen/ 1596*" (Edlinger 1705) SAM 44/NE. 48 Kunsthinstorisches Museum Sammlung Alter Musikinstrumente Wien, Austria	Thirteen courses lute (2x1, 9x2; 2x2) v.l. 68.0 cms 73.0cms	11th 13th	1.40 mm **!** 1.45 mm **!**
"*Vendelio Venere 1626*" (Thomas Edlinger 1724) SAM 616 Kunsthinstorisches Museum Sammlung Alter	Thirteen courses lute (2x1, 9x2, 2x2) v.l. 72.0 cms 76.0 cms	11th 12th 13th	1.85 mm **!** 1.80 mm 1.95 mm

Musikinstrumente Wien, Austria			
"*Jakob Weiß/Luthen-unnd Gei-/ 17 genmacher in Saltzburg 14…(*1714)" Kremsmünster Austria	Thirteen courses lute (2x1, 9x2; 2x2) v.l. 71.5 cms (76,0cms?)	10th 11th 12th 13th	1.70 mm 1.75 mm 1.75 mm **!** 2.05 mm

Maximum passing hole diameters on some d-minor German lutes with bass rider

Table 2

Lute	Disposition	Course	maximum passing diameter
"J.Tielke Hamburg 1713" N° 5249 Staatlisches Institut für Musikforschung Preussischer Kulturbesitz Berlin, Germany	Thirteen courses lute (2x1, 6x2; 5x2) v.l. 72.5 cms 104.5 cms	13th 6th	1.40 mm **!** 1.40 mm **!**
"Martin Hofmann, Leipzig 1692" MI 245 Germanische National Museum Nüremberg, Germany	Thirteen courses lute (2x1, 6x2; 5x2) v.l. 69.6 cms 97.3 cms	13th 12th 11th 10th 9th 8th	1.75 mm 1.85 mm 1.70 mm 1.70 mm 1.55 mm 1.45 mm
"Sebastian Schelle, Nürnberg..." 	Thirteen courses lute (2x1, 6x2; 5x2) 	13th 12th 	1.70 mm 1.90 mm

MI 46 Germanische National Museum Nüremberg, Germany	v.l. 72.6 cms 96.5 cms	11th 10th 9th 8th	1.45 mm 1.45 mm 1.30 mm 1.55 mm
"Sebastian Schelle, Nürnberg 1721" MIR 902 Germanische National Museum Nüremberg, Germany	Thirteen courses lute (2x1, 6x2; 5x2) v.l. 70.5 cms 93.3 cms	13th 12th 11th 10th 9th 8th	1.75 mm 1.95 mm 1.90 mm 1.65 mm 1.65 mm 1.90 mm
Johann Cristian Hoffman, Leipzig 1708" Inv, N° 925 Germanische National Museum Nüremberg, Germany	Thirteen courses lute (2x1, 6x2; 5x2) v.l. 72.0 cms 98.5 cms	10th 9th 8th 7th 6th	1.40 mm **!** 1.45 mm **!** 1.45 mm 1.40 mm 1.40 mm
Leopold Widhalm MI 903 Germanische National Museum Nüremberg, Germany	Thirteen courses lute (2x1, 6x2; 5x2) v.l. 74.0 cms 99.8 cms	13th 12th 11th 10th 9th 8th	1.90 mm 1.65 mm **!** 1.75 mm 1.65 mm 1.60 mm 1.60 mm
Koch MI 55 Germanische National Museum	Thirteen courses lute (2x1, 6x2; 5x2) v.l. 69.8 cms 95.5 cms	13th 12th 11th	1.75 mm 1.85 mm 1.70 mm

Nüremberg, Germany			
Leopold Widhalm	Thirteen courses lute	13th	2.05 mm
	(2x1, 6x2; 5x2)	12th	1.75 mm
MI 51	v.l. ?? cms	11th	1.60 mm
(soundboard only)	?? cms	10th	1.85 mm
		9th	1.85 mm
Germanische National Museum		8th	1.55 mm
Nüremberg, Germany			
Leopold Widhalm	Thirteen courses lute	13th	1.85 mm
	(2x1, 6x2; 5x2)	12th	1.55 mm **!**
MIR ??	v.l. 73.6 cms	11th	1.55 mm
	99.5 cms	10th	1.45 mm
Germanische National Museum		9th	1.45 mm
		8th	1.75 mm
Nüremberg, Germany			

Maximum passing hole-diameters on some swan neck d-minor German lutes

d) German d-minor lutes with the bass rider or with swan-neck keep their octaves on the basses: half wound strings, experimentally produced according 18th century instructions for guitar strings (core of the same diameter as the octave and spacing between the spires the same as, or slightly more than, the diameter of the wire - see Le Cocq, 1724), present an average specific weight **comparable** to that of the basses we think previously in use, i.e. about twice that of natural gut. Such strings do not produce a particularly bright sound, nor do they possess a good sustain: hence the use of octaves.

e) No original intabulation expressly requires damping the basses. It is reasonable to deduce that the strings did not possess a good sustain.

f) In rare cases, iconographical sources from the 18th century show lutes with *white basses* (silver wound?) as opposed to the yellowish colour of the upper courses and, at least in one case, we see something clearly looking like a half wound string:

Joahn Kupezky (1667-1740): luteplayer. In the original the last bass string seem to be an half wound type

13 course lute with bass rider: detail on the white bass strings

(Courtesy of David van Edwards)

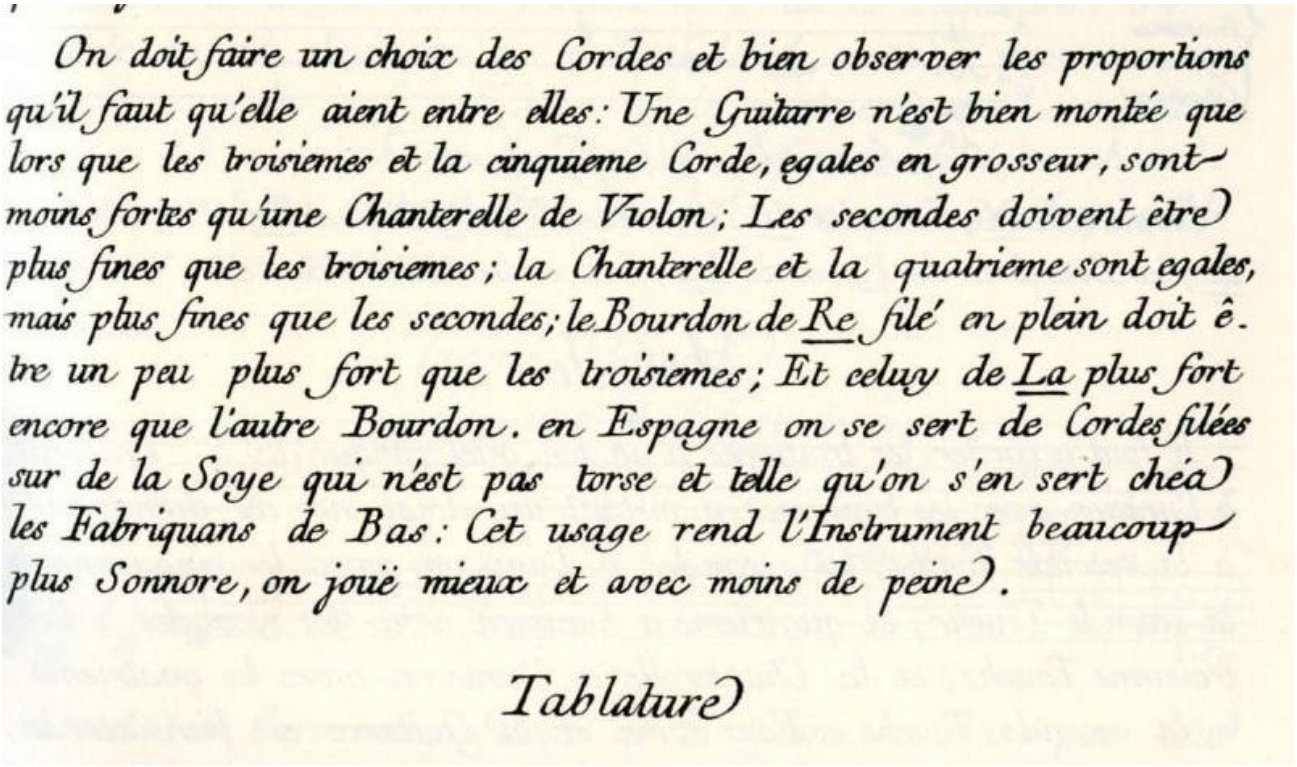
Antoine Pesne (1678-1758): portrait of Eleonoire von Kayserlingt, 1740 ca: the bass strings are dyed deep red.

It must be noted that the use of half wound strings *fell into disuse* exactly at the time when some specific types of instruments did, like the 5 course guitar, the 7 string bass viol and probably also the lute. Half wound strings simply became unnecessary on bowed

instruments tuned in 'large' intervals, i.e. in 5ths, where it was possible to switch directly from a plain gut to a close wound string.

Compared with its Baroque predecessor, the 6 string guitar underwent a string length reduction of about 10-12 cm, while the working tension of each single string was increased to about the same as the sum of the two strings in a course (thus, incidentally, keeping also the feeling just about the same) and gave access, for the first time, to a close wound 4th string, this time on a silk core.

These were, we believe, the decisive steps towards modern close wound guitar stringing as we know it, and brought the use of half wound strings to an end. The adoption of a silk core, a superior material to gut both according to the sources of the time and to modern practice (being more supple and more resistant than gut, silk makes the use of thicker wire possible) opened, in our opinion, the way to the guitar's 6th string.



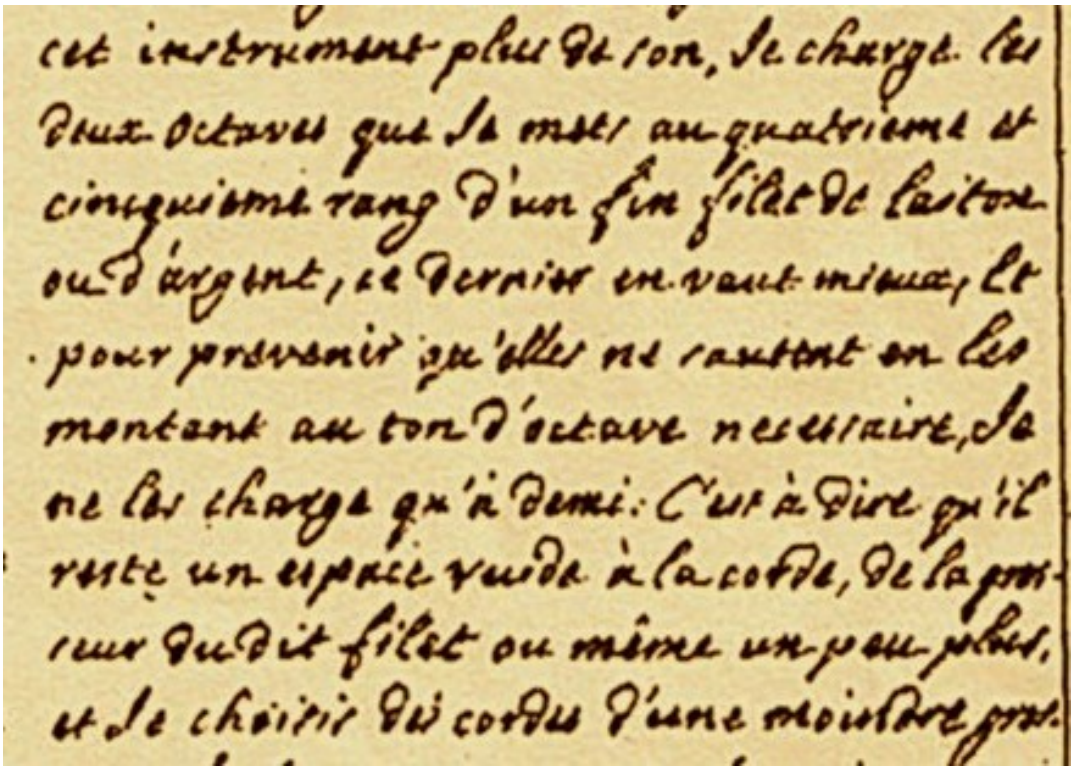
On doit faire un choix des Cordes et bien observer les proportions qu'il faut qu'elle aient entre elles: Une Guitarre n'est bien montée que lors que les troisiemes et la cinquieme Corde, egales en grosseur, sont moins fortes qu'une Chanterelle de Violon; Les secondes doivent être plus fines que les troisiemes; la Chanterelle et la quatrieme sont egales, mais plus fines que les secondes; le Bourdon de Re filé en plein doit être un peu plus fort que les troisiemes; Et celuy de La plus fort encore que l'autre Bourdon. en Espagne on se sert de Cordes filées sur de la Soye qui n'est pas torse et telle qu'on s'en sert chéz les Fabriquans de Bas: Cet usage rend l'Instrument beaucoup plus Sonnore, on joüe mieux et avec moins de peine.

Tablature

Juan Guerrau, Paris 1760 : the silk wound bass strings are better than those made with a gut-core

But what were the typical features of a half wound string?

Again, let's have a look at historical sources:
a) The space between the wire spires was the same as, or slightly wider than, the diameter of the wire used for the winding - hence demi : half. Here is Le Cocq's description (Recueil des pièces de guitare composées paer Mr. François Le Cocq, Brussels, Bibliothèque du Conservatoire Royal de Musique, Ms Littera S, n. 5615, 1730. Ch. Des chordes, 1724): *Se charge les deux octaves que se mets au quatrieme et cinquieme rang d'un fin filet de laiton ou d'argent, ce dernier en vaut miex ... se ne les charge qu'à demi: c'est à dire qu'il reste un espace vide à la corde, de la grosseur dudit filet ou même un peu plus...*'.


cet instrument plus de son, Je charge les
deux octaves que Je mets au quatrieme et
cinquieme rang d'un fin filet de laiton
ou d'argent, ce dernier en vaut mieux, Et
pour prevenir qu'elles ne sautent en les
montant au ton d'octave necessaire, Je
ne les charge qu'à demi: C'est à dire qu'il
reste un espace vuide à la corde, de la gros-
seur dudit filet ou même un peu plus,
et Je choisis des cordes d'une moitiere gros-

Le Coq, Paris 1724

b) The gut core of the fundamental was the same string used for the octave (see above).

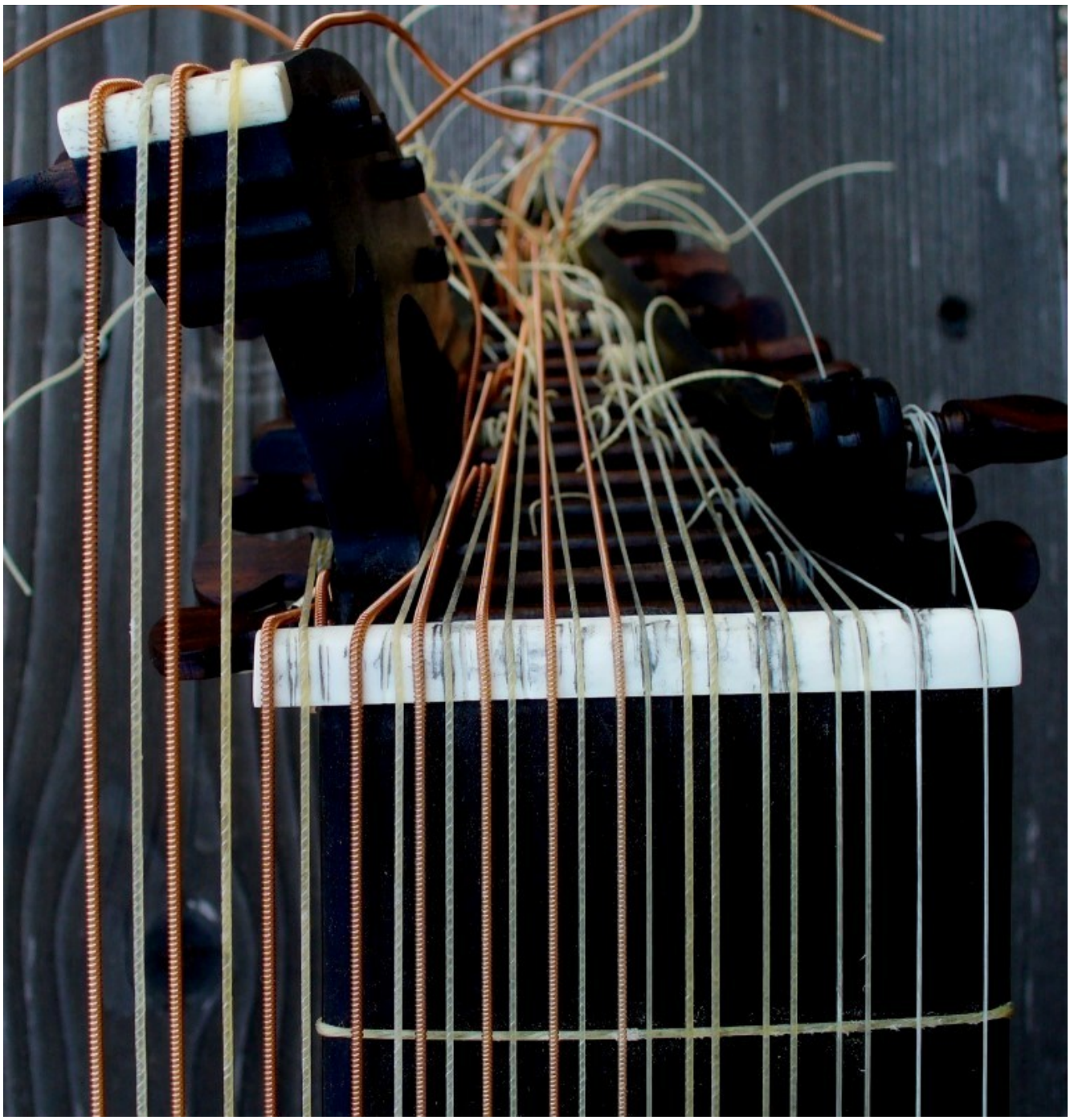
c) The wire was wound on the gut core, never embedded in it (as far as we know there is no evidence of the latter).

These few but important indications fit perfectly the half wound string leftovers on Raphael Mest's lute. Therefore strings with very open winding and/or embedded wire

in the gut core have no historical justification.

Wound on silk basses for the lute

Wound on silk basses could have been used after 1760, provided they were half wound, but unfortunately we have no historical evidence for that. In any case the limit set by the metal wire technology of the time is still valid even when a silk core is employed.



13 course d-minor lute with half wound bass strings

Conclusions

The discovery of what we believe is the 'true' meaning of the role of the string Sorts led to a better understanding of what a correct lute stringing should be like.

The most remarkable point, certainly worth emphasizing, is the frequent lack of a correct and smooth passage from one string type to another when synthetic stringing is used: strings of the third (wound) type 'invading' the space pertaining to the second type, long theorbo diapasons strung with strings of the third (again, wound) type, mid register strung with strings produced with a method pertaining to the first type, i.e. rather stiff, which cause a noticeable loss of acoustical quality. Not to speak of the indiscriminate use of strings of the third Sort as octaves. In one word, if we exclude aluminium wound strings and carbon strings (with which we try to fill the mid register gap), present synthetic lute stringing lacks an appropriate string type for the mid registers.

In the case of all-gut stringing we must once more stress that strings of different Sorts and their manufacturing processes are absolutely not interchangeable.

The string maker has very limited leeway indeed: putting together a good set of gut string for the lute looks more like *a tricky narrow path* than a wide and easy highway.

After all, hasn't this always been part of the fascination of the *Dolce Strumento*?

Vivi felice

Mimmo Peruffo 2008

Thanks to Ivo Magherini & Antony Hind for the English translation from the Italian original

§ Appendix

There are some organological curiosities concerning the German 13 course lute in D minor both with the bass rider or with the swan- neck. One of them is certainly its string length, generally within the 70-73 cm brackets.
Tuned at the 1727 Baron's *kammerton F* (in practical terms corresponding to A at 420 Hz) **the treble works close to breaking point** (the Working Index- range is of 233-243 Hz/mt): exactly like the Renaissance lutes of the 16th century.

But, whereas the scope of it in Renaissance times was the reduction of the diameters of the *inefficient* gut bass strings, what reason could it have at a time where wound strings were easily available? Wouldn't one wish to finally work more comfortably, and without risking *expensive* trebles, now that the problem of poor acoustical performance (with the wound strings) was solved once and for all, adopting a shorter string length?

We would like to propose what we consider a plausible hypothesis, concerning, once again, a problem of acoustical performance: not that of the basses, this time, *but that of the 5th course*, which is in this case the lowest strung with plain gut.

From practical experience we know that the acoustical performance of this course is poor, when compared with the 4th or a wound bass. The Index of Acoustical Quality is about 97-100: somewhere between the 4th and 5th courses on a Renaissance lute.

Any shortening of the string length (easily practicable thanks to the improved sound of wound basses) **would have caused an increase in diameter** (tension remaining equal) which on the 5th course would have meant a further loss of sound quality (string length and diameter are inversely proportional).

The adoption of a wound string to come around this problem would have been technically not practicable: as we said, in our opinion the 6th bass string represented the technological limit for the metal wires of the time. Therefore, only sticking to the old Renaissance lute design (i.e. maximum possible string length for thinnest possible bass diameter) could grant the acoustical performance of the 5th course.

Let's now consider the question of swan-neck extension: lutes with this sort of extension began to appear about 1730 and, in the light of our present knowledge, we believe the bass strings used *were not* plain gut but wound ones.

Zophany, 1770 ca: detail of the Sharp family; see the 'white' basses

Here the question arises: if basses were really made of plain gut, why was the extension limited to 95-100 cm, why did they not make them longer for better performances; say 120-130 cms?

We can only put forward a hypothesis (lacking historical evidence *solely based on experimental data*) connected again with the string question: it was within this range that it was possible to use *the same wound strings* already employed on the 6th, 7th and 8th courses. And that would give a feeling of stiffness equal to the fretted courses; only for the 12th and 13th basses new wound strings had to be added on.
As we said, the bass string on the 6th course was probably wound with the thinnest wire available. An extension longer even by a small amount would have raised the problem of what string would have been available for the first extended (i.e. 9th) bass, since it could not have been a wound one anymore and plain gut would have been very unbalanced with the lower wound- extended basses.

Vivi felice
MP, October 2008