

PATRIZIO BARBIERI

Roman and Neapolitan Gut Strings 1550-1950

In a letter dated 1816, Beethoven asked a close Viennese friend—a dilettante cellist—for a reference on a servant he wished to hire. To compensate him for the inconvenience, he added jokingly,

'Don't be annoyed. I will soon send you my treatise on the four violoncello strings, worked out very systematically; the first chapter is about guts in general—the second chapter deals with gut strings—and so forth'.¹

I must confess that this unexpected humour from such an impressive figure had so far discouraged me from publishing the results of almost twenty years of archive and bibliographic research on the subject. I have decided to do so now because the current revival of gut strings is increasingly in need of documentary support, which would also help provide a truer rendering of the sound of Beethoven's compositions by performing them with the stringing of the period (see §6 below).

The material brought to light has been divided into two articles. The first—mainly concerning historical details of the Roman string-makers, whose products were in great demand throughout Europe—is about to be published in *Studi musicali* (see [B] in the table of 'Abbreviations'). It is accompanied by two appendices of documents which relate to purchases of strings, shop inventories (about twenty, from 1573 to 1821) and biographical details about 180 string-makers. The second, i.e. this present article, deals with the technology of string making. With this end in view, it also refers to some of the documents published in an appendix to the previous article [Bd], which provides, however, no technical assessment.

B	Patrizio Barbieri, 'The Roman Gut String-makers 1550-1950', <i>Studi musicali</i> , XXXV-1 (2006), pp. 3-127 text.
Bd	Idem, documents published in Appendices (the letters <i>Bd</i> are followed by the year of the document, e.g.: <i>Bd</i> , 1591).
C	<i>Catalogo di saggi de' prodotti della industria nazionale presentati nella solenne esposizione de' 30 maggio 1834</i> [...] (Napoli, Stamperia Comunale, 1834), pp. 38-40: 'Corde armoniche'. See Appendix 2 of the present article.
D	Nicola Giuseppe Durini, 'Delle corde di minugie', <i>Annali civili del Regno delle Due Sicilie</i> , (Sept.- Dec. 1835) pp. 5-9.
D'O	Verbal communication with the late Roberto D'Orazio, string-maker of Salle (Pescara) 1989.
L	Antoine-Germain Labarraque, <i>L'art du boyaudier</i> [...] (Paris: Huzard, 1822).
S	Philippe Savaresse, 'Cordes', <i>Dictionnaire des arts et manufactures</i> [...], ed. Charles-P.-L. Laboulaye, 3rd ed., vol. 1, (Paris: Lacroix, [1865]).
Sk	Philip Skippon, <i>An account of a Journey Made thro' Part of the Low-Countries, Germany, Italy and France</i> , in <i>A Collection of Voyages and Travels</i> [...], 3rd ed., VI (London: Lintot & Osborn, 1741), pp. 373-749: 545-546 (end of December 1663: 'Making of viol-strings' in Padua). See Appendix 1 of the present article.

(above) *Abbreviations used for works which are cited frequently in this article.*

¹ Emily Anderson (ed.), *The Letters of Beethoven* [...], vol. 2 (London: Macmillan, 1961), p. 596: Beethoven (Baden) to Nikolaus Zmeskall (Vienna), 5 Sept. 1816.

This article is divided into the following 10 sections:

- §1. Roman gut string-makers: an historical outline
- §2. The nature of the gut
- §3. String manufacture
- §4. Bass strings: roped vs overspun
- §5. Treble strings: from *cantini rinforzati* to modern steel chanterelles
- §6. Pitch and stringing
- §7. Violin family: scaling of diameters
- §8. Plucked string instruments
- §9. Appendix 1: String making in Padua, 1663 [SK]
- §10. Appendix 2: Gut string catalogue, Naples, 1834 [C]

§1. ROMAN GUT STRING-MAKERS: AN HISTORICAL OUTLINE

In order to provide historical context, this section summarises the salient steps of the development of string production. *These are comprehensively illustrated, with full bibliographic references, in the article referred to here as [B].*

Contrary to the opinion of several modern scholars, the profession of the string-maker does not originate in the fifteenth century, but was already established in the Middle Ages. Corporations of such craftsmen are mentioned at Florence and Venice in 1216 and 1329 respectively. At least until the beginning of the sixteenth century, however, Italian strings were unsatisfactory, being mainly 'false' because of their inconsistency which caused aperiodic vibrations. In a letter addressed to Isabella d'Este in the year 1500, the luthier Lorenzo da Pavia, who worked in Venice, complained that Italian strings caused a disturbing 'frying' sound due to their skimming on the frets (*friggere sui tasti*), so that he was obliged to use those made in Munich. This is the oldest evidence that strings from Munich were better than those produced in Italy, and anticipates a similar judgement given in the *Capriola Lute Book*, a manuscript written at Brescia c1517.

The Italian situation seems to have changed by 1574 when Adrian Le Roy states that the best lute strings come from Munich, together with those from Aquila in Italy. Abruzzo, whose chief town is still L'Aquila, was the centre of sheep-raising in Italy and could therefore supply large quantities of lamb gut which was needed to manufacture the most mechanically stressed strings, 'chanterelles'. The fame of strings produced in L'Aquila rapidly gave way to those produced in Rome, to where Abruzzese string-makers began to move in the second half of the sixteenth century. Reasons for this are suggested in [B, §I.2]. These craftsmen all came from three small villages in the mountains near Sulmona (Bolognano,

Musèllaro, Salle) and for at least three centuries they jealously guarded their profession. They also moved to other Italian towns where a considerable amount of lamb was consumed, particularly Naples, as well as to France (where they quickly established a monopoly) and Spain.

In Rome, these artisans' turnover appears unusually high to us: typical single orders and shop inventories comprise hundreds or thousands of dozens of strings. Furthermore, it appears that Lyons, Rome's greatest competitor in this sector in the mid-seventeenth century, replenished its stocks from Rome (at least during the period 1630-41) through a 'compagnia di corde di liuto a uso di Francia' set up there by two French merchants. These merchants commissioned work from the Papal States. Around 1639-40 they succeeded in exporting 300,000-400,000 strings of all types to France each year (see §8.1 below, and [B, §I.3]).

The number of master string-makers operating in Rome rose progressively from seven (in 1589) to twenty (in 1735). In 1735, however, the number was limited to twenty by law, due to the decline in sheep-raising and consequent decreasing availability of raw material [B, §II.1]. From the mid-eighteenth century we witness a progressive merging of these twenty firms, which, in less than fifty years, was to lead to a monopoly of the Roman market held by just two 'factories' (*fabbriche*). One of these was called 'Pica & C' and the other belonging to the Ruffini family (however, both the owners and the workers of these two firms came exclusively from the three Abruzzese villages mentioned above). From this time onwards, the Roman producers survived mainly through their production of delicate first and second strings for violins, because the viol consorts and many of the numerous plucked instruments that had been a feature of the Renaissance and Baroque periods had disappeared [B, §II.2].

Also in the mid-eighteenth century, the first company of Roman and Neapolitan string-makers was set up (1752) and, as we shall see below, this had an impact on manufacturing technology. The company was Messrs 'Pica, Angelucci, Tofani & C', whose Neapolitan member was Domenico Antonio Angelucci. The life of this company (today known to scholars only because it was mentioned in the 1769 publication of *Voyage d'un François en Italie, fait dans les années 1765 et 1766* by Jérôme de La Lande) was initially fixed for 18 years, but a suit concerning Angelucci's management occurred quite soon. In 1758 the 'Supremo magistrato di commercio' of Naples condemned him to refund as much as 3,000 *scudi*: from that year on, the company kept

its Naples branch, but this time with a Roman as a director. The Angelucci family, who were natives of Salle and were considered the most important string-makers at Naples, had amassed an immense fortune. In 1793 their last descendent (Maria Irene) managed to acquire the title of duchess, thanks to a marriage propitiated by a dowry of several thousand *ducati* [B, §II.2]. Then came the Napoleonic occupation (1793-1815), during which the string-makers suffered economic damage, first because of the closing of the frontiers as a result of the wars in Europe, and second because of the dissolution of corporations. This latter measure encouraged a fearsome French competitor to move to Rome: André Savarèse Sarra (1810-15), whose father Nicola was a native of Musellaro [B, §II.3]. This is the period that marked the rise of the firm of Andrea Ruffini. Andrea's son Pietro became distinguished as a patron of music in his *palazzo* (near the central Teatro Argentina), where he was responsible for the first Roman performance of Haydn's *Creation* (1812). He had business relationships with the publishers Peters and Breitkopf & Härtel [B, §I.4.1], among others. He also owned an interesting collection of musical instruments, including a dozen belonging to the violin family, an inventory (1815) of which is published in [B, §I.4.1].

After the Napoleonic occupation, industrial stagnation and the inexorable fall in lamb consumption in Rome favoured the string-makers' definitive transfer to Naples, where working conditions were more favourable thanks to the Bourbon monarchy's relaunching of the industry, the much greater consumption of lamb and a working season which lasted to October [B, §II.4]. The Roman Antonio Putti, who had married the Pica heiress, is indicated in 1841-44 as the best string-maker in Naples (his product catalogue for 1834 is included in [C]). In 1844 the firm Andrea Ruffini (then managed by Giovanni Battista Ruffini, although the firm retained the founder's name) also moved its production to Naples. At the 1873 International Exhibition in Vienna, the firm was awarded the prize as 'the best manufacturer of musical gut strings in the world'. Having reached the height of renown, the Roman-Neapolitan firms could not have imagined that their end was nigh. Their decline began with competition from the Venetian manufacturers (Bedin, Bella, Righetti, Venturini) and was followed by the much tougher competition of the Germans. As we shall

see in §5.4, the Germans had discovered how to standardise the diameter of their strings, enabling industrialised production of the 'perfect fifth' type which was suitable for professional players. The introduction of materials such as silk and steel had, however, already seriously undermined the entire gut industry (§5.5). Immediately after the Second World War, the success of nylon gave it the final blow. In any case, from the beginning of the twentieth century gut strings had become increasingly rare in Italy. Even the few *cordari* still operating in Salle had to search all over Italy to find dried and salted guts, often of inferior quality: see, for example, the correspondence of the string-maker Roberto Salerni [B, II.6].

In 1989 I visited Salle, where I had the pleasure of interviewing Roberto D'Orazio (1937-1996), the owner of a string factory for musical instruments (at one time also operating at Naples) which started operations during the first half of the nineteenth century. He informed me that up to about 1956 they had only used gut, after which nylon was adopted, first for some strings only and then, after 1985, for the whole production. He willingly provided me with precious details about the equipment used by his predecessors, which I used in compiling §3.

§2. THE NATURE OF GUT

The material for gut strings was mostly taken from sheep. These animals were categorised according to their age:²

- *Abbacchio*: before the creature was weaned. Its slaughter (*abbacchiatura*) took place between October and May
- *Agnello* (lamb): after weaning up to almost one year old, when it had already been shorn twice. In Rome, its slaughter (*agnellatura*) took place between Easter and the feast of St John (24 June), although in other Italian cities it took place all year round. In Rome, during the *agnellatura*, the lambs slaughtered were mainly those called *primaticci* (i.e. those born between 1 August and the end of September) and *mezzarecci* (born between 1 October and the end of January)
- *Ciavarro* (or *ciavarella*): from one to three years
- *Pecora* or *montone* (sheep or ram): the same as above, after three years of age
- *Castrato*: castrated sheep
- *Capra* (goat): at Rome mentioned only in 1617-18 [Bd, 1617a, 1618a]; it was, on the other hand,

² Filippo Chiappini, *Vocabolario romanesco*, postumous ed. by Bruno Migliorini (Rome, Casa Leonardo da Vinci 1933), pp. 1, 10, 80.

used much more at Naples, owing to the wider consumption of unweaned kids (*capretti*) practiced in southern Italy [D, 8]

A set of documents dated 1613-18 and relating to orders for strings by Cristoforo Del Forno (a luthier in Rome) provides us with details about the use of these materials according to the range of notes to be produced:³

- ♦ *Canti* or *cantini* (= chanterelles: in these documents the two terms appear to have the same meaning): *agnello* or sometimes *castrato*. For violins, the strings were composed of 2 strands (*fili*), rising to 4 in the nineteenth century (§5.3); they were also known generically as 'thin strings' (*corde sottili*)
- ♦ *Tenori* (middle range): *castrato* or even *pecora*; 2 strands
- ♦ *Bordoni* and *bassi* (low range): *pecora* or goat; 3, 4, or 5 strands

Another document (1660), mentions strings of *agnello* (6.6 *scudi* per 100 dozen) and *castrato* (4.5 *scudi* per 100 dozen), surprisingly specifying that '*agnello* strings must be for guitars, and those of *castrato* for violins' (*le corde d'agnello debbano esser per chitarre, e quelle di castrati per violini*) [Bd, 1660].

It is clear that lamb guts were the ones used to produce the strings most subject to tension, i.e. the chanterelles of lutes, guitars and violins, because they combined maximum thinness and mechanical resistance (this is confirmed by Philippe Savarèse (1865): see §5.3 below). Almost all documents distinguish between thin and thick strings by price. In contrast to the next two centuries, in the seventeenth century thick strings cost at least 50% less [Bd, 1631b, 1677b, 1687]. In a deed dated 1787 we read that the guts of *pecora* or *ciavarella* were used to manufacture 'second quality, or ordinary strings, that is the blondes and middle-range strings'.⁴ Unlike other European cities, the consumption of lamb in

both Rome and Naples was high, and since (unlike today) the fresh guts usually could not be exported, string production was high in both cities. In Rome, string manufacture lasted from Easter until the end of June, whereas in Naples it continued until the autumn. In seventeenth-century Italy, it appears that besides the above-mentioned materials, the guts of dogs and sinews of particular kinds of snake were also employed.⁵ In 1822 Labarraque describes practical experiments carried out — invariably with unsatisfactory results — on the guts of donkeys, dogs, horses, cats and pigs.⁶

§3. STRING MANUFACTURE

According to a report by the Papal administration, the string manufacturing process was divided into the following stages [Bd, 1825]:

<i>Raccogliatura</i>	Collection [of the guts from the butcher]
<i>Politura</i>	Cleaning
<i>Scarnitura</i>	Stripping [of the fatty membranes]
<i>Concia</i>	Tanning
<i>Strisciatura con detale</i>	Scraping with a thimble
<i>Rota</i>	Wheel
<i>Stufa con zolfo</i>	Stove with sulphur
<i>Ribattitura</i>	Rewinding [on the wheel]
<i>Strisciatura con cordelle di crino</i>	Rubbing with horsehair ropes
<i>altra Stufa</i>	another Stove
<i>Bagno di olio</i>	Oil bath
<i>Tagliatura</i>	Cutting
<i>ed Incannellatura</i>	and final Rolling

³ [Bd, 1613, 1617a, 1618a], Tables 1 and 2 below. On Del Forno see Patrizio Barbieri, 'Cembalario, organaro, chitarraro e fabbricatore di corde armoniche nella Polyanthea technica di Pinaroli (1718-32). Con notizie sui liutai e cembalari operanti a Roma', *Recercare* 1 (1989), pp. 123-209: 187.

⁴ [Bd, 1787b]: 'intestina di pecore, o ciavarelle, colle quali si fabricano le corde di seconda qualità, o siano ordinarie, cioè bionde, e mezzane'. For examples of 'blondes' (*bionde*), see Table 4.

⁵ See Francesco Lana Terzi, *Magisterium naturae* [...], vol. 2 (Brescia: Ricciardi, 1686), p. 433; on snake strings we read (p. 424): 'In secretis manuscriptis mihi ab amicis communicati inuenio, fieri posse chordas suavissimi soni, si serpentes quos vulgo *Cerbinos* vocamus, ex longioribus, ad collum funicolo ligati in aqua fluente immersi detineantur, donec omnia absumantur praeter nervos, ex quibus chordae praedictae facillè parantur'. For the guts of wolves and 'weathers' [i.e. wethers], see [Sk].

⁶ [L, 79-80, 127-8]. Michael Fleming draws my attention to a passage in Shakespeare's play *Cymbeline*, which seems to suggest that in England, sheep gut was not the only material used for strings: 'If this penetrate, I will consider your music the better; if it do not, it is a vice in her ears which horsehairs and calves' guts, nor the voice of unpaved eunuch

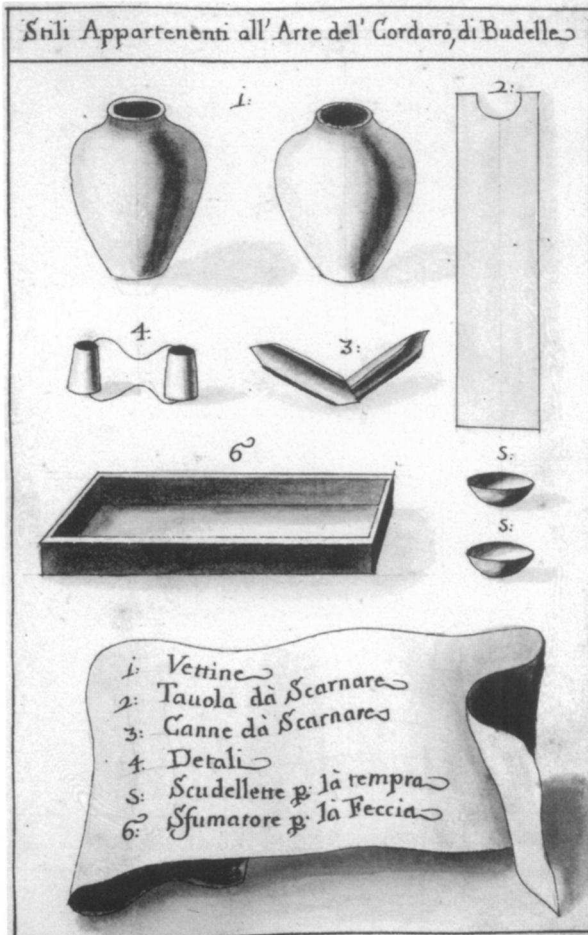


Figure 1a. Roman string-makers' equipment (Giovanni Pietro Pinaroli, *Polyanthea Technica* [...], [Rome, 1718-32]; Roma, Biblioteca Casanatense, Ms. 3006, f. 146).

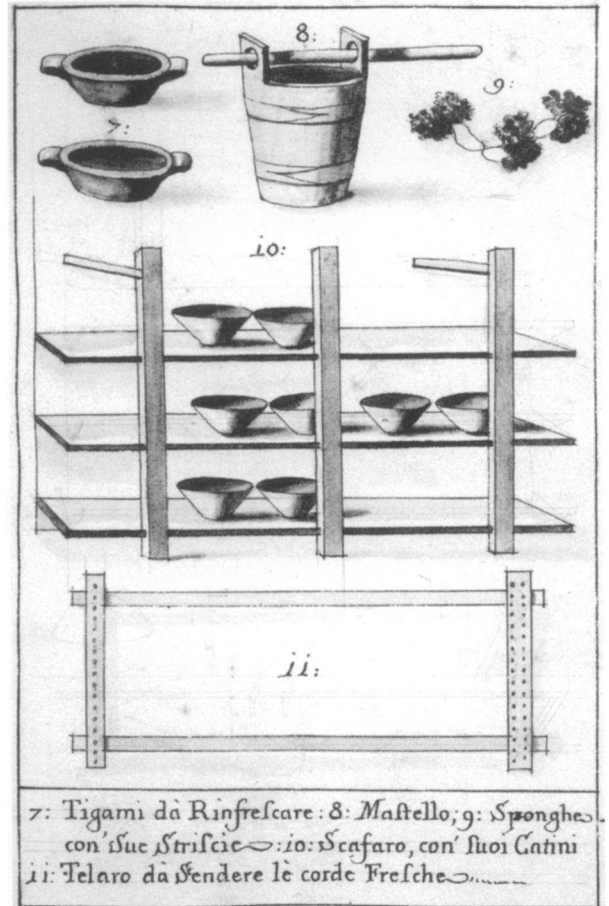


Figure 1b. Roman string-makers' equipment (Giovanni Pietro Pinaroli, *Polyanthea Technica* [...], [Rome, 1718-32]; Roma, Biblioteca Casanatense, Ms. 3006, f. 147).

The most complete information we have about the people in charge of such operations is from the Baron Durini (1835). His lands were at Bolognano which, as we have seen, together with Salle and Musellaro, was one of the three little Abruzzi villages where almost all the string-makers of Rome and Naples lived. According to Durini, factory hands were divided into six hierarchical levels, in the following order: *mastro* (manager of all the operations), *torcitore*, *capatore*, *strisciato*, *lavorante*, *mazziere* [D, 6-7; B, §I.1.1].

I shall now attempt to reconstruct the operations carried out by each, using the documents published in [Bd, 1573-1825] and the drawings illustrating the manuscript by the Roman G.P. Pinaroli from 1718-32 (see Figures 1a, 1b and 1c).⁷ Until a few years ago, the utensils shown in these pictures were still familiar to the last descendents of the string-makers

(*cordari*) considered in this study. In 1989 I showed these illustrations to Roberto D'Orazio, mentioned above, who — although they lack any comment — at once explained to me the use of each of the items, which he had himself used up to a few years before.

§3.1. COLLECTION AND CLEANING. The *mazziere* collected the guts from the butchers in bunches (*mazzi*) of 12 pieces, placing them in a bag to make them easier to carry [Bd, 1598a: *saccocchie da portar budelle*]. On his return to the shop, everyone without exception helped him turn out the evil-smelling contents and wash them. If this was not done immediately, the guts would remain permanently stained and their quality would also be compromised. In a purchase contract dated 1696 we read that the strings 'must all be white, except for a

⁶ (continued) to boot, can never amend.' (Act II, scene 3). Sinews from the backs of horses were also employed in Italy: Timoteo Rosselli, *De' secreti universali* [...], part II (Venice: Tivani, 1677), p. 237 (chapter 123: full description of the process, for musical instruments).

⁷ On the latter, see Barbieri, 'Cembalaro', pp. 123-4, 177.

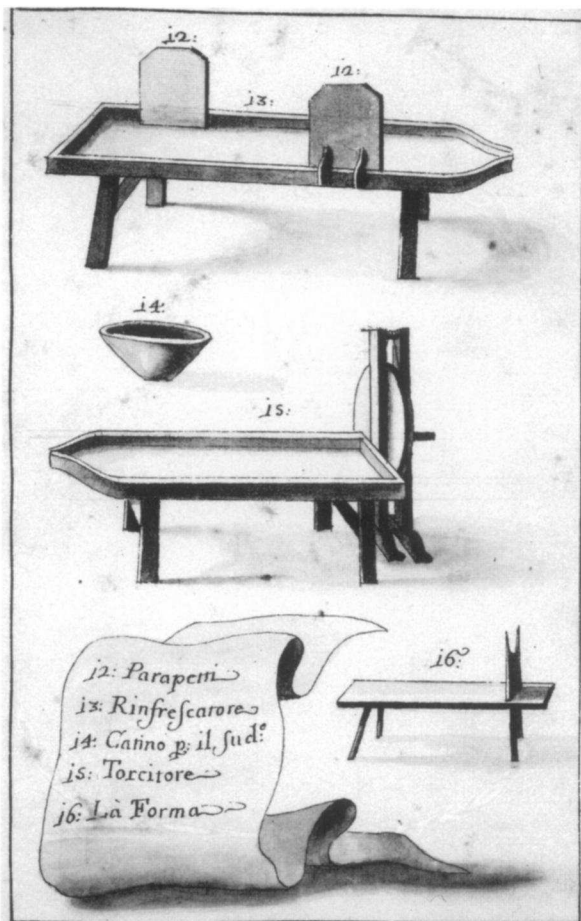


Figure 1c. Roman string-makers' equipment (Giovanni Pietro Pinaroli, *Polyanthea Technica* [...], [Rome, 1718-32]; Roma, Biblioteca Casanatense, Ms. 3006, f. 148).

few that by misfortune come out brown' [Bd, 1696a]. Every string-maker had to start by spending several years at the hard task of the *mazziere* [D, 6].

§3.2. SCRAPING AND TANNING. The gut is substantially composed of three membranes, of which only the very thin 'strong' membrane, about 5% of the total volume, is used for string-making: hence the name 'thread' (*filo*), which in slang was given to each of its component strands. The other two — the outer one ('serous'), and the inner ('mucous' and 'submucous') — were eliminated by scraping and decomposition. These operations, which will now be described, were the task of the

lavorante, as a rule assisted by the *strisciattore*.

Figure 1b(8) shows the tub (*mastello*) from which the still whole gut was taken, using a pole (*stanga*) to carry it more easily [Bd, 1593b, 1638e]. It was passed through the mouth of the table shown in Figure 1a(2), where, using the scrapers in Figure 1a(3) (i.e. *cannucce* [D'O] fashioned from pieces of marsh cane), it underwent an initial scraping off of the fatty membranes on the outside of the 'strong' membrane [Bd, 1593b: *Tavole da scarnare*]. By means of an operation described in [L, 44], it was then turned inside out to remove the inner 'mucous' membrane. As we shall see, Italian strings were composed of tubular strands, i.e. intestines that had not been cut along their length. The guts were then divided according to quality and distributed among the bowls shown in Figure 1b(10) (*scodelle* or *catini*), about 12 for each bowl [Bd, 1593b: *scodelle di agnello*, *scodelle di castrato*; 1631d: *scodelle di budelle grosse*]. These containers were kept on a shelf (*scafare*), of planks (*tavole*) resting on a scaffolding of beams [Bd, 1585a: *tavole da scafare* and *scalette da scafare*]. The process of decomposition of the residual fatty membranes began here, facilitated by adding a special alkaline solution to the bowls (*tempra* or *lescia*). This solution was of a special kind of potash made by calcination in a small stove of the lees (*feccia*) from the bottom of wine barrels [Bd, 1581b, 1596a, 1678a: *cenere di feccia*].⁸ It was treated with water, probably in the wood *sfumatore* shown in Figure 1a(6) [Bd, 1622c, 1729, 1747: *tavoloni per sfumare*], then filtered through special canvas bags (*saccoccie*) [Bd, 1701: 344 *saccoccie da colar la feccia*]. The solution thus obtained (at Naples known as *ranno* [D, 9]) was kept in one of the amphorae shown in Figure 1a(1) [Bd, 1643: *vettine da tener lescia*]. The other amphora contained pure water. The cups (*scodellette*) in Figure 1a(5) were used to take the right quantity of liquid from each amphora, so as to obtain a *tempra* whose strength was established on each occasion by the shop's *mastro*. Baron Durini tells us that the string-makers always used this type of ash, adding that 'when by chance this was lacking and they were obliged to use soda or potash, the strings were always defective'.⁹ Roberto D'Orazio, who used

⁸ Mentioned as early as 1300-1350 by Francesco Balducci Pegolotti, *La pratica della mercatura*, published in [Giovanni Pagnini del Ventura,] *Della Decima* [...], vol. 3 (Lisbon and Lucca: Bouchard, 1766), p. 379 (*tartaro* and *cenere di grevella*).

⁹ 'ma i manifattori adoprano per il loro ranno le ceneri clavellate, ed ove per avventura queste mancassero, e sieno essi costretti a far uso della soda o potassa, le corde riescono sempre difettose' [D, 9]. Unfortunately, Durini does not describe the nature of the defectiveness. On the use of this kind of potash see Mimmo Peruffo, 'Italian violin strings in the eighteenth and nineteenth centuries: typologies, manufacturing techniques and principles of stringing', *Recercare* 9 (1997), pp. 155-203: 164-5.

commercial potash, told me that, up to about 1950, his father Donato used the ash obtained from wine lees (*fioccia*) in the traditional manner.

The bating (maceration) process lasted eight days. According to Durini, the concentration of the alkaline solution was progressively decreased during the first four days, and increased during the last four, so as to begin and end with pure *ranno*. He emphasises that this was justified by the need to degrease the gut vigorously during the first stage, facilitate the natural decomposition of the remaining fatty parts in the middle stage, and clean the gut thoroughly in the final stage [D, 9]. On the other hand, according to Skippon (1663) and La Lande (1769), as well as the process described in the *Encyclopédie* (1754), the concentration was gradually increased from beginning to end.¹⁰ The decomposition could be slowed by adding vinegar [Bd, 1585a, 1638e, 1643; L, 45]. When the weather was excessively hot and the muscular membrane itself was threatened by putrefaction, all the workers had to lend a hand [D, 6]. Needless to say, such work was a hazard to the health of those living in the area. Consequently Roman string-makers were obliged by law to live close to the Tiber, so that they could discharge their dangerous liquid waste into its flowing waters [B, §I.1.2].

Each *lavorante* looked after 12 bowls. Thrice a day [D, 9; D'O] the guts were passed to the *rinfrascatore* shown in Figure 1c(12-13), where the *lavorante* 'refreshed them' using the pan (*tegame*) in Figure 1b(7) [D'O] and removed the parts of the mucous membrane that had decomposed [Bd, 1585a, 1593b: *refrescatori*]. To do this, the gut was drawn between the index finger and the thumb, which was fitted with a special metal thimble shaped like a finger-nail (Figure 1a(4)), which was very smooth to avoid nicking the underlying muscular membrane [Bd, 1638e: *12 detali*; 1678a: *12 ditali d'ottone*; Sk, 1663: *thimbles of brass*]. To protect themselves from the inevitable splashes of *tempra*, the workers wore special aprons [Bd, 1585a: *zinali*] (they were also protected by the sliding parapets in Figure 1c(12) [Bd, 1678a: *sei parapetti*; 1821b: *17 parapetti di noce*]. The *rinfrascatori*, which were often lead-lined, were of different sizes so that several workers could work there at the same time [Bd, 1638e: *un rinfrascatore da due persone*; *un rinfrascatore a sei*

persone coperto tutto di piombo]. They also sloped slightly to facilitate drainage of the waste liquid into the *catino* in Figure 1c(14). The gut was passed from one bowl to another, each one containing an alkaline solution with a different concentration from the previous one.

§3.3. SELECTION AND TWISTING. If the strands were not to be used immediately they were kept in salt [L, 102]: this probably explains a 'case with salt' mentioned in a Roman inventory [Bd, 1678a: *una cassetta di sale*]. Otherwise, they passed to the *capatore* [D, 6] who sorted (*capare* = to select) the guts according to their intended use. The thinnest and most resistant were to become chanterelles for violins, lutes and guitars; those with a slightly larger diameter were used for the thicker strings, less stressed than the former, while the largest were used by hat-makers and cotton manufacturers.¹¹

In §3.1 we saw that some strings came out stained, rather than 'white' so, for aesthetic reasons, they were dyed [S; D'O]. The dyes used for this in Italy were litmus for deep blue (*turchino*, i.e. turquoise) and cochineal for red [Bd, 1821b: *tinta detta tornasole*, *tinta di fondo di cocciniglia*]. 'Strings dyed deep blue and red' are recorded at Rome at least as early as 1591. The colour functioned not only to conceal staining, but also to mark the strings for use on particular instruments, such as harp, lute or guitar [Bd, 1591b: *corde colorite turchine et rosse*; 1654: *una vettinella con tinta rossa dentro*]. Colour was also employed to distinguish quality, but so far no key has come down to us. In an inventory we find, mixed together, 'blond' treble strings (i.e. '*cantini*' from a *castrato*, see §2), 'white' and 'deep blue' [Bd, 1785b].

The guts to be twisted were lined up on the *rinfrascatore* (in Rome), or on special frames (in Padua: [Sk]). It is reported that some makers impregnated them with alumina-based salts, whose astringent effect made the strings harder and more rigid, though also more fragile [S]. String-makers in Padua (1663) are reported adding a small quantity of 'roach allum' to the alkaline solution employed to control the above described process of decomposition of the fatty membranes of the gut [Sk]. Baron Durini also mentions this additive, but in a rather evasive and inconclusive manner [D, 9: *allume*]. Such salts do

¹⁰ [Sk]; Jérôme de La Lande, *Voyage d'un François en Italie, fait dans les années 1765 et 1766* [...], vol. 6 (Venice and Paris: Desaint, 1769), p. 410; Denis Diderot, 'Cordes à boyau', *Encyclopédie ou dictionnaire raisonné des sciences, des arts et des métiers* [...], ed. Denis Diderot and Jean Le Rond d'Alembert, vol. 4 (Paris: Briasson et al., 1754), pp. 205-207. The same also in [L, 113] and [S].

¹¹ See, respectively: [Bd, 1720: *cordoni ad uso di cappellaro*]; Table 1: *cordoni da battere bambace*. For the manufacture of those for hat-makers, see [L, 95, 107].

not appear in any of the thoroughly compiled Roman inventories that have come to light: only one of them records *alume di feccia* and *cenere di feccia*, probably two different terms for 'gravelled ashes' [Bd, 1596a]. Roberto D'Orazio confided that, for this purpose, he used rock-alum and paraffin [D'O].

The strands were then removed from the *rinfrescatore*, each time taking a suitable amount to produce the string required: from only one to a hundred, according to Skippon [Sk]. In order to twist them, one end was fixed to a peg of the frame in Figure 1b(11) [Bd, 1598a: *telaro*], while the other was fastened to the hook (*fuso*) of the twisting frame (Figure 1c(15)), its axis rotated rapidly by a reduction gear driven by a wheel of much larger diameter [Bd, 1593b: *la rota e renfrescatore e torcitore*]: see also Figures 2a and 2b. Roman and Neapolitan documents are silent about the details of these operations, so we must refer to the accurate description provided by [L, 116-7]. As in France [S], so too in Rome during the nineteenth century we encounter twisting machines with two hooks for the simultaneous production of two strings [Bd, 1821b: *Quattro rotoni da torcere le budella con due fusi per cadauno di ferro, e maniglie di legno incassate nel ferro*]. In Rome, this device is reported in the factory of Andrea Ruffini, the first to implement any modernisation of the production processes; for example, they already used lead piping to convey water directly to the vessels used for the processes [Bd, 1821b]. It should be remarked, however, that the process of twisting with a two-hook machine was already employed by the makers operating in Padua, and is described by Philip Skippon in 1663 [Sk].¹²

It is important to emphasise that, contrary to the ancient French practice and the one that manufacturers are obliged to follow today, artisans in this business were forbidden by statute from slitting (*spaccare*) the intestines longitudinally, under pain of a heavy fine in Naples and even expulsion from the corporation in Rome, together with 'frusta e galera', i.e. 'whip and jail' [B, §II.1; Bd, 1589a, 1599c, 1642b]. A test carried out in 1822 on a Neapolitan chanterelle by a French competitor made it possible to ascertain that it was composed of three tubular strands, each a few millimetres in diameter.¹³ Again

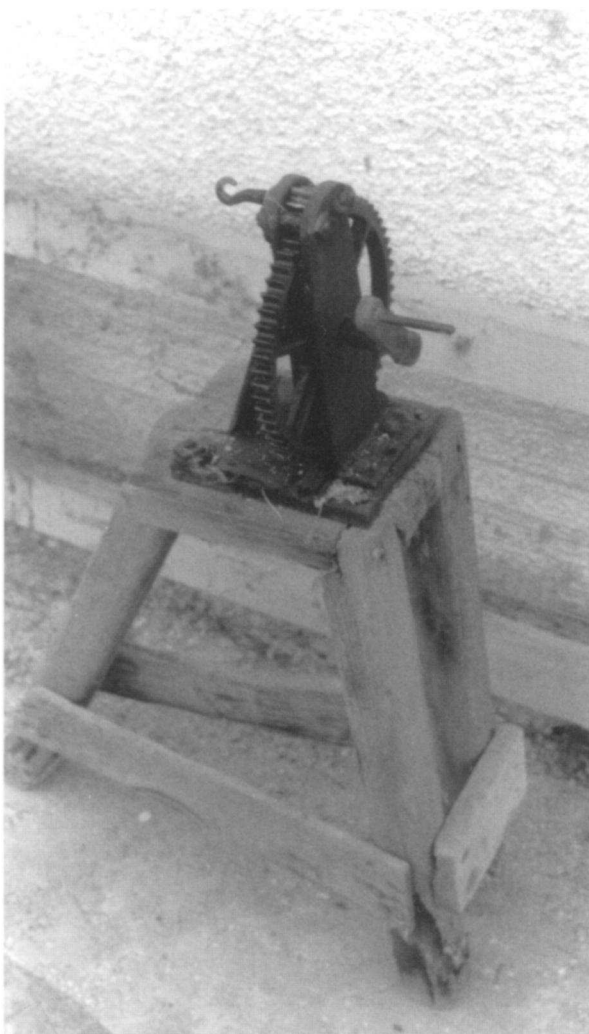


Figure 2a. Tool (no longer extant) used by Roberto D'Orazio, one of the former string-makers of Salle: *torcitore*. (photo by the author, 1989)

in 1873, in a report presented to the Naples Chamber of Commerce, in this connexion Alessandro Betocchi states explicitly:¹⁴

In Italia e specialmente a Roma e a Napoli, gli agnelli si uccidono dopo tre, quattro o sei mesi dalla nascita: le budella quindi non essendo tanto grosse e forti da poterle fendere in tutta la loro lunghezza, le corde italiane hanno il pregio di essere composte di fila o budella sane e tonde – i Francesi le direbbero rondes – e quelle che vengono dichiarate come aventi tre o quattro fila, tante ne hanno, intere e non spaccate,

¹² A two-hook system was illustrated by Christoff Weigel, *Abbildung Der Gemein-Nützlichen Haupt-Stände...* (Regensburg, 1698).

¹³ The diameter was so small that the examiners thought that 'the Neapolitans might even have special processes or chemical agents to make the gut shrink, as it were: we attempted to guess or do the same' [L, 121]. It was evidently a section of the so-called 'small' intestine. See also V. Beltrandi, 'Corde armoniche', *Enciclopedia delle arti e industrie*, ed. Raffaele Pareto, vol. 2 (Turin: Unione Tipografico-editrice, 1880), pp. 964-969: 967.

¹⁴ Alessandro Betocchi, *Forze produttive della provincia di Napoli*, vol. 2 (Naples: De Angelis, 1874), p. 292.

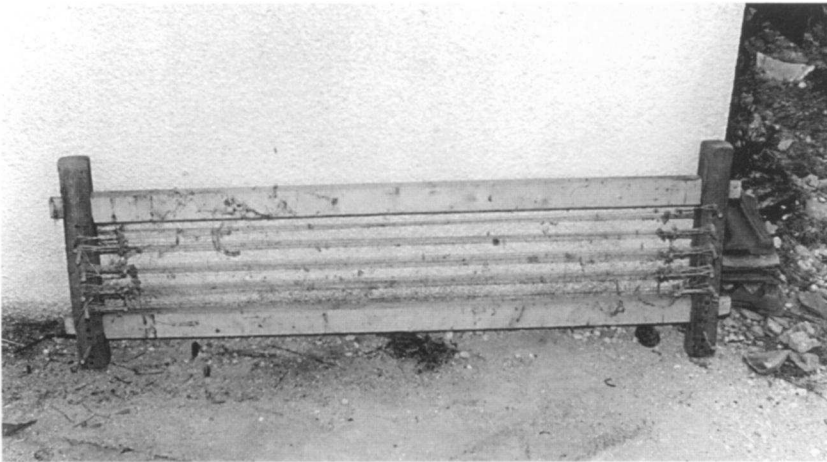


Figure 2b. Tool (no longer extant) used by Roberto D’Orazio, one of the former string-makers of Salle: frame with violin chanterelles still mounted. (photo by the author, 1989)

mentre quelle fabbricate all'estero non hanno che la metà delle fila promesse. Al presente anche in Germania fendono le budella de' castrati in tre parti per tutta la loro lunghezza allo scopo di ottenere fila più sottili, e farne cantini.

In Italy, and particularly at Rome and Naples, lambs are slaughtered three, four or six months after birth. Since their intestines are not large and strong enough to slit lengthwise, Italian strings have the merit of being made of whole round strands or guts – the French would call them *rondes* – and those stated as having three or four strands actually have them whole and not split, whereas those manufactured abroad have only half the strands stated. At present, even in Germany they split the intestines of *castrati* in three throughout their entire length so as to obtain thinner strands and make *chanterelles* of them

Probably some manufacturers were still using this same technique, which they called ‘whole gut’, as late as 1925 (unless by this phrase they meant a gut opened out into a ribbon, but still ‘whole’).¹⁵ Today we have not yet managed to identify the process for eliminating air bubbles inside tubular gut, which could make them blow up like a balloon in various places during twisting.

§3.4. SULPHURIZATION AND SCRAPING. Once the twisting operation was completed, the frames were placed in a small chamber, where sulphur was burned. In Padua (1663) this operation lasted for ‘an hour or two’ [Sk]. The mortars for pulverising sulphur

are mentioned as early as 1593 [Bd, 1593b, 1598a, 1638e; 1678a: *un mortaro col pestello da solfo*]. The purpose of the sulphuric anhydride thus produced was not only to bleach and deodorise the gut, but also, as noted by the *Encyclopédie* in 1754, to make it ‘elastic’.¹⁶ To optimise elasticity, sulphurization had to be kept within certain limits. This was shown by Labarraque’s experiments in 1822. He compared three chanterelles with the same diameter and same number of strands, and concluded that the breaking load

dropped when sulphurization was above or below a certain optimal value [L, 130]. Sulphurization is now considered superfluous, and strings are merely bleached with peroxide.

Next came a second twisting operation [Bd, 1825: *Ribattitura*], followed by *strisciatura* (rubbing). The *strisciatore* used the horsehair ropes shown in Figure 1b(9), repeatedly rubbing a group of strings attached to the frame, so as to smooth and clean them thoroughly [Bd, 1638e: *10 pezzi di striscie da cordaro* and *un strisciatore*; 1678a: *un istrisciatore*; 1825: *cordelle di crino*]. During this operation, at regular intervals, the sponges (*sponghe*) in Figure 1b(9) were passed over the strings, soaked in *tempra*. That these ropes were of horsehair is first mentioned in 1663, by Skippon. In Padua the *strisciatura* was preceded by oiling [Sk]. In Rome this stage was completed with a second sulphurization [Bd, 1825: *altra stufa*] and further slight twisting. Some nineteenth-century authors also mention a final polishing, by rubbing the strings (still fixed to the frame) with a cloth soaked in oil and powdered pumice stone [S]. In Rome this must have been performed as early as the second half of the eighteenth century, since this kind of abrasive material is mentioned in several inventories of the time.¹⁷

§3.5. OILING AND CUTTING. Before being removed from the frame, the oft-quoted Roman document of 1825 mentions an ‘oil bath’, which explains how strings reached the purchaser packed

¹⁵ Alberto Bachman, *An Encyclopedia of the Violin* (New York - London: Appleton & C, 1925), p. 152: ‘Some string-makers do not split the intestines, but specialize in what they call *whole gut* strings’.

¹⁶ Diderot, ‘Cordes à boyau’: ‘à la vapeur du soufre, et y prendre de l’élasticité’. This elasticity is now thought to be due to the formation of sulphide links between the long chains of collagen of the gut: Peruffo, ‘Italian violin strings’, p. 166.

¹⁷ [Bd, 1786: *libbre 1500 circa lapis bianco*; 1821b: *smeriglio in pietra*]. To this end, the ‘finely powdered pumice

in 'paper so soaked in oil that it might be said that they were swimming in the liquid'.¹⁸ This lubricant is mentioned in many shop inventories [*Bd*, 1654: *due vettine da olio*], but animal fat (*unto*) was probably also employed for this operation [*Bd*, 1638e: *una libbra d'onto* and *un pezzo d'onto di 9 o 10 libbre in circa*; 1643: *tre mezzi pezzi d'onto*]. The use of such a quantity of lubricant would explain why strings became rancid when old. This happened to Andrea Ruffini as a result of the economic depression following the Napoleonic wars (§1): many of his more than 100,000 strings were inventoried as 'unusable' because they were 'rotten' [*Bd*, 1821b]. To prevent such fermentation, Savaresse (1865)

used a 1% laurel extract as an additive. Roberto D'Orazio, on the other hand, used to grease the strings with a light layer of seed-oil, having found by experiment that it did not become rancid (he also told me that, with olive oil, the coils eventually tend to stick together). Lastly, the strings were removed from the frame using special knives [*Bd*, 1678a: *due cortelli da ricogliere le corde*] and wound in skeins (*gavette*) on the *forme* shown in Figure 1c(16), which incorporated a bench [*Bd*, 1671: *dui banchetti usati di albuccio per ingavettar le corde con le sue forme*]. The latter, known also as *forfecchie* or *torcoletti*, were made either of wood or stone [*Bd*, 1678a: *cinque forfecchie d'incavettar cantini, due pietre da ingavettare corde*; 1821b: *10 torcoletti di legno di busso usati per incavettare*].

§3.6. LENGTHS AND PACKAGING. At Rome, as early as the sixteenth century, distinctions were made not only between thin and thick strings,

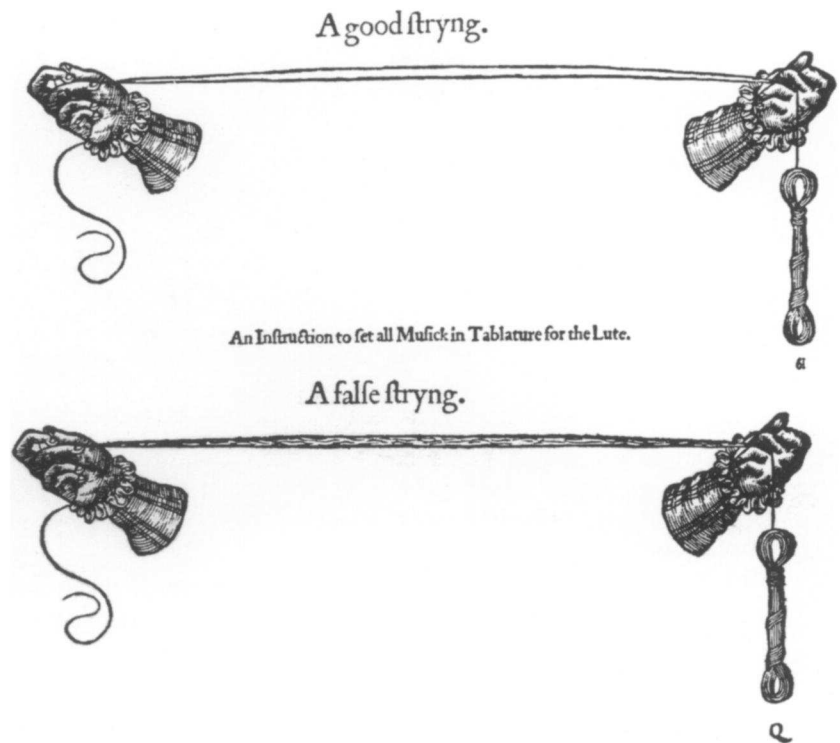


Figure 3. Testing the 'trueness' of a gut string, from Adrian Le Roy, *A briefe and plaine instruction* (London: 1574). The string's great flexibility should be noted.

but also between long and short. The former were packaged in hanks 'of 18 twists' (*de 18 pieghe*), whereas the short ones had only '12 twists' and cost about half the price of the longer ones [*Bd*, 1573a,c]. To the purchaser, their appearance was as sketched in Figure 3.¹⁹

Until 1642 long strings were manufactured mainly in Rome, while short ones came from other towns in the Papal States, whence the names *corde romanesche* and *corde forastiere*, which are documented from the sixteenth century [*Bd*, 1597c]. This distinction was optional before the 1642 statute. In Rome, the frames had to be at least 10 *palmi* long (= 223 cm), so as to distinguish the *romanesche* strings, which were more valuable, from the *forastiere* (which had to be shorter, usually between 6.5 and 8 *palmi* (= 145-179 cm). Later, however, this standard was often not observed [*B*, §II.1]. At least from 1726 these two kinds of strings were sold with a lower number of twists than the previous standard, i.e. 8 and 7 twists

¹⁷ (continued) stone' (*polvere impalpabile di pomice*) is also mentioned by Francesco Galeazzi, *Elementi teorico-pratici di musica con un saggio sopra l'arte di suonare il violino* [...], vol. 1 (Rome: Pilucchi Cracas, 1791), p. 74 (the same operations are described later in [S]).

¹⁸ 'Le commerce français ne fait venir d'Italie que des chanterelles, qui arrivent par paquets de trente cordes ployées dans du papier tellement huilé, qu'elles nagent pour ainsi dire dans ce liquide' [*L*, 110].

¹⁹ Figure 3 is taken from Adrian Le Roy, *A briefe and plaine instruction* (London: 1574); also published in Mimmo Peruffo, 'Le corde per chitarra tra il Settecento e l'avvento del nylon. Tipologie, tecniche manifatturiere e criteri di scelta. Parte seconda', *Il Fronimo* 30 (April 2002) pp. 50-61: 57.

respectively.²⁰ Towards the end of the sixteenth century, wholesale strings were sold in packs of 10 dozen (each one of them known as a *grosso*) or 5 dozen.²¹ Due to the increasing popularity of the violin, during the *Seicento*, we find only packs of 60 strings (for lute or guitar) or 30 (for the violin, which did not have double strings), known as *corolle*, *gavette* or simply *mazzi*.²² From 1787, at least as far as the Roman and Neapolitan firms are concerned (see §1), the above specifications for length disappear. They were replaced by rules for the number of *tirate*, i.e. the number of instruments that each string could be used for [*Bd*, 1787b, 1821b]. This practice is probably Neapolitan in origin since La Lande mentions it as early as 1769.²³ Its meaning is made unequivocal in a Neapolitan price list dated 1834 [*C*], which states, for the violin: ‘length 8 *palmi*, i.e. 84 English inches, i.e. 4 *tirate*’. The same price list also shows that, for each type of string, the price was rigorously proportional to the number of strands employed and the number of *tirate*.²⁴

As packaging methods developed, the old twisted hanks were abandoned. The modern manner of packaging in coils is first found in Naples in 1765–66.²⁵ It also occurred in Rome at least by 1785.²⁶ This type of packaging is nowadays employed exclusively: if the old-fashioned, narrow ‘bents’ in Figure 3 were to be used, the strings would be damaged irremediably. Indirectly, this shows that during the Renaissance and Baroque periods, strings were less rigid (and therefore less inharmonic), which is the

main problem for manufacturers today, at least when recreating the strings used during these historical periods. A possible explanation of the need for packaging in coils may be the fact that towards the mid-eighteenth century Roman and Neapolitan exports focused mainly on chanterelles for violins, which required high tensile strength (as we shall see in §5.3), with consequent additional stiffness. This shows how an apparently insignificant detail like packaging can provide important information about construction technology.

§4. BASS STRINGS: ROPED VS OVERSPUN

§4.1. THE PROBLEM. A string of a given length, subjected to tension T , has a vibration frequency f proportional to the square root of the ratio of T to its mass M , i.e.: $f \propto (T/M)^{1/2}$. For bass strings, this ratio needs to be low, which is achieved by lowering T and/or raising M . Compared to chanterelles, T can only be lowered a little (to avoid the string becoming too slack, as we shall see in §7.1), so the only option is to raise M , which can be achieved in various ways:

1. By increasing the diameter. Such an increase creates a high degree of inharmonicity owing to the increased stiffness. The sound is consequently dull, of brief duration, and delayed with respect to the attack of the bow. Furthermore, when fingered, the frequency of such a string is increasing at a greater rate than a thinner one fingered at the same point (which

²⁰ Jacques Savary des Brulons, Philemon-Louis Savary, *Dictionnaire universel de commerce*, 6th edn., vol. 1 (Amsterdam: Jansons, 1726), coll. 1502-1503. The same number of twists in 1754: Diderot, ‘Cordes à boyau’.

²¹ [*Bd*, 1585a, 1591b]. In 1593 the *grosso* is also reported in Florence: Elio Durante, Anna Martellotti, *Un decennio di spese musicali alla corte di Ferrara (1587-1597)* (Fasano di Puglia: Schena editore, 1982), p. 33 (‘per grossi vinti di corde fatte venire da Firenze’).

²² The use of this terminology is documented in [*Bd*, 1585a, 1656, 1677a, 1821b]. On the number of strings, see Savary, *Dictionnaire universel de commerce*, coll. 1502-1503; Diderot, ‘Cordes à boyau’; La Lande, *Voyage* (see footnote 10). Also according to the Statute of the Neapolitan string-makers dated 1685 the *mazzi* for violin included 30 strings, and 60 for the guitar: Naples, Archivio di Stato, *Cappellano Maggiore, Statuti e Congregazioni*, b. 1182, inc. 54.

²³ La Lande, *Voyage*, pp. 413-4: ‘Le mazzo, composé de 30 cordes à deux fils, ou chanterelles, de six palmes, c’est-à-dire, de *tirata forestiera*, coûte 5 carlins, le autres à proportion’.

²⁴ As also stated by La Lande (see footnote 23). This is confirmed by a document relating to the said Roman-Neapolitan firm [*Bd*, 1787b] and, in 1865, also by [S]. In §2 we saw that, in contrast, in the two previous centuries thicker strings cost less than thin ones.

²⁵ La Lande, *Voyage*, p. 412: ‘on les plie autour d’un mandrin, ou cylindre de bois, appelé *Bussolotto*, pour en faire de petits paquets, qu’on assemble ensuite sous différentes formes, et auxquels on donne différens noms; on les appelle, par exemple, *Favetta*, quand l’assemblage des paquets a une forme cylindrique’. In France, in 1822, Labarraque also states that the strings (removed from the frame) were placed *en rond et en paquets*, i.e. wound in coils [*L*, 118].

²⁶ Indeed, a Roman inventory dated 1785 lists various hanks of strings, in only one case stating that they were ‘bent’ (*piegate*), a clear indication that at that time the others no longer were [*Bd*, 1785b]. Perhaps the large strings for the basses were packaged in coils already in 1678, when a document mentions them as preserved in a ‘round box’: see Table 1 below [*Bd*, 1678a].

would have to be compensated by angling the frets or the bridge)²⁷

2. By increasing the diameter and decreasing the stiffness by using a high-twist string or, better, by twisting two or more thin strings together. In 1976, Abbott and Segerman suggested that this latter solution had been adopted by the end of the sixteenth century, i.e. a 'roped-gut string', which they term a 'Venice catline' (a name retained in their commercial price lists).²⁸ So far, however, this solution had been documented by only one source, in 1588.²⁹ In §4.2 we shall see that it was already in use in the first half of the fifteenth century and, in any case, at Rome during the next two centuries
3. By soaking the gut with finely powdered heavy metals (e.g. copper) in order to increase its density and thus make possible the use of smaller diameters. This hypothesis was put forward by Mimmo Peruffo in the 1990s, but there is no evidence to confirm it³⁰
4. By adopting a small-diameter gut string and twisting around it a spiral of thin metal wire, so as to make it heavier without greatly affecting its stiffness. In §4.3 we shall see that this fourth solution was introduced in Rome as a substitute for the second: towards 1676 for the *violone*, and at least 70 years later for the violin.

§4.2. ROPED. The earliest clear evidence in this connexion is provided by Ugolino of Orvieto (c1380-1452), a musical theorist working permanently at Forlì and Ferrara, two towns close to Bologna. Around 1430-40, in writing about musical instruments, Ugolino makes a distinction between the *corda aenea* (= string of copper alloy) and various kinds of *nervus contortus* (= gut string).³¹ He classifies the latter as follows:

1. *Nervus rotundus uniformiter*, when the string's diameter is constant, like (he adds) copper alloy wire drawn on the drawing bench
2. *Nervus rotundus uniformiter difformiter*, when 'its thickness swells at equidistant intervals' ('*Latitudo uniformiter difformis est latitudo cuius est aequalis excessus graduum inter se aequidistantium*'). It produces a 'less sharp' sound than the one described in point 1 ('*causat sonum remissioris acuminis quam uniformis nervus subtilis*')
3. *Nervus rotundus difformiter difformiter*, i.e. a false string.

Number 2 clearly belongs to the category of roped strings, now generically designated, following Abbott and Segerman, as 'catlines'. Ugolino adds some theoretical evaluations in order to explain their acoustic features, which are clearly based on Aristotelian theory.³² Until recently, it was

²⁷ The fact that two gut strings of different diameter that sound in unison when plucked unstopped, are not in unison when fingered at the same fret, is already mentioned, for example, by Giambattista Doni, *Compendio del Trattato de' generi e de' modi della musica* (Rome: Fei, 1635), pp. 45-6. On historical problems of compensation see Patrizio Barbieri, 'The inharmonicity of musical string instruments (1543-1993): With an unpublished memoir by J.-B. Mercadier (1784)', *Studi musicali* 27 (1998) pp. 383-419: 407-08. In machinery applications, the earliest valuations of string stiffness are found in Guillaume Amontons, 'De la resistance causée dans les machines, tant par les frottemens des parties qui les composent, que par la roideur des cordes qu'on y employe, et la maniere de calculer l'un et l'autre', *Histoire de l'Académie royale des sciences, avec les memoires de mathematique et de physique* [...], année 1699 (ed. Paris, 1718), pp. 206-227.

²⁸ Dilda Abbott, Ephraim Segerman, 'Gut Strings', *Early Music* 4 (October 1976) pp. 430-437: 431.

²⁹ John Downing, 'Roped Gut Bass Strings - A 16th C Reference', *FoMRHI Quarterly* 78 (January 1995), pp. 22-23 (Comm 1318). The reference was found in a translation of a treatise by Agostino Ramelli, *Le Diverse et artificiose machine*, (Paris, 1588).

³⁰ See e.g. Mimmo Peruffo, 'The mystery of gut bass strings in the sixteenth and seventeenth centuries: the role of loaded-weighted gut', *Recercare* 5 (1993), pp. 115-151. Up to now, the only traces of metallic salts have been found in silk strings manufactured by Baud in the late 19th century: Albert Cohen, 'A Cache of 18th-century Strings', *Galpin Society Journal* 36 (1983), pp. 37-48: 48. Before being covered with a solution of arabic gum, they were coloured: the red was found especially rich in mercury, and the blue with significant traces of lead. The downside of this treatment is that the strength of the fibre is significantly reduced: John Downing, 'Silk Strings? - Putting Another Spin on Interpretation of the Sources', *FoMRHI Quarterly* 106 (January 2002), pp. 38-42 (Comm. 1796): 39.

³¹ Ugolinus Urbevetanus, *Declaratio musicae disciplinae*, ed. Albert Seay, vol. 3 ([Rome]: American Institute of Musicology, 1962), Liber quintus, Capitulum IX ('De cordarum seu nervorm instrumentalium subtilitate et grossitie'), pp. 112-118.

³² Patrizio Barbieri, 'Galileo's' coincidence theory of consonances, from Nicomachus to Sauveur', *Recercare* 13 (2001), pp. 201-232: 223.

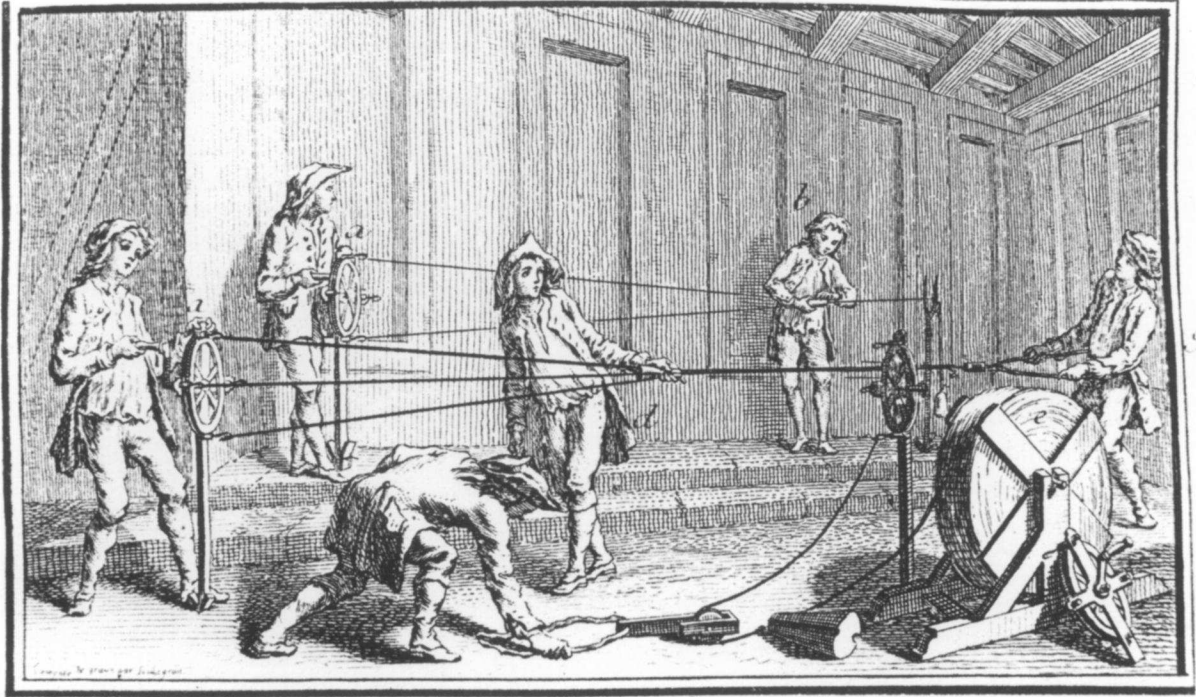


Figure 4. Tools for making a rope (*ourdir une corde*). The figure shows the making of hemp ropes with three (a-g) and two (a-b) strands (Henri-Louis Duhamel du Monceau, *Traité de la fabrique des manœuvres pour les vaisseaux ou l'art de la corderie perfectionné*, 2nd edn. (Paris: Desaint, 1769), p. 145).

thought that ‘catlines’ were an invention of the late sixteenth century, which led to the hypothesis that they had made it possible to extend the bass range of some instruments by half an octave.³³ Ugolino’s evidence could, however, lead to a revision of this hypothesis, in view of the fact that this innovation was not based merely on the overcoming of technological barriers.

The ropes were constructed on special machines, known as *orditori*, that twisted a certain number of strings together in a stable fashion, relying on their own elasticity, so as to produce a thicker string that did not curl up once removed from the mill. Some old devices (possibly called ‘warping mills’) for making hemp ropes are illustrated in Figure 4.³⁴ They were also used for gut, since they are recorded in two Roman gut string-makers inventories:

- ◆ [Bd, 1598a]: ‘Uno orditore’.
- ◆ [Bd, 1624b]: ‘Una rota con le fusa et l’orditorio per far cordoni’, i.e. a wheel with its hook (= *torcitore*) for making *corde* (= ordinary strings) and ‘an *orditore* for making *cordoni* (= roped strings)’.

In other Roman inventories of the sixteenth

and seventeenth centuries, both thick and thin ropes seem to be distinguished from other strings (*corde*) by the terms *cordone* and *cordoncino* (or *cordonetto*). They were employed in cotton production (i.e. *per batter bambace*), for decorating hats (Table 1, year 1720), and in musical instruments (violone, viol, violin, harp, trumpet marine, the strands for the snare head of the drum). In fact, from Table 1 we see that these two terms are treated differently:

- ◆ *corde*, also the large ones for the basses, are listed by the dozen or the number of bunches, whereas *cordoni* by the number of individual strings.
- ◆ in both types the size can be ‘large’ or ‘thin’, e.g.: *cordoni grossi e piccoli* [Bd, 1678a], *corde grosse* and *sottili*, even mixed with *cordoni* [Bd, 1585d]; see also [Bd, 1586, 1638e, 1654].
- ◆ *cordoni piccoli* for the violone, and *bassi da violino* [= *corde grosse*] appear in the same list [Bd, 1678a].

There was no good reason to use the etymologically contradictory term *cord-on-cino* (or *cord-on-etto*) unless it was to indicate a particular type of

³³ Ephraim Segerman, ‘Strings through the Ages’, *The Strad* (January 1988), pp. 52-55: 53.

³⁴ From Henri-Louis Duhamel du Monceau, *Traité de la fabrique des manœuvres pour les vaisseaux ou l’art de la corderie perfectionné*, 2nd edn. (Paris: Desaint, 1769), p. 145.

Bd, 1581c	1000 <i>cordonorum</i> (ut dicitur) da batte bambace.	1000 <i>cordoni</i> , 'for beating cotton' (as they say).
Bd, 1585d	800 <i>dozzene de corde sottile da leuto</i> , item 400 <i>dozzine de tenori</i> , 800 <i>cordoni da battere</i> , 1000 <i>pezzi de corde grosse</i> .	800 dozens of thin strings for the lute, idem 400 dozens of tenors, 800 <i>cordoni</i> for beating, 1000 pieces of large strings.
Bd 1586	1000 <i>cordoni da battere bambace</i> [...] 1200 <i>dozzine di corde piccole</i> [...] 1300 <i>pezzi di corde grosse</i> .	1000 <i>cordoni</i> for beating cotton [...] 1200 dozens of little [= thin] strings [...] 1300 pieces of large strings.
Bd, 1591b	<i>grosse 30 di cordoni di violoni</i> .	30 <i>grossi</i> of <i>cordoni</i> for the violone.
Bd, 1597c	149 <i>cordoni fatti a gavetta</i> [...] 104 <i>cordonetti da batter bambace</i> [...] 130 <i>dozzine di corde di tenore; c[o]rolle, tra tenori e cordonetti, n° 28</i> .	149 <i>cordoni</i> in the shape of <i>gavetta</i> [...] 104 <i>cordonetti</i> for beating cotton [...] 130 dozens of tenor strings; 28 <i>corolle</i> , both in tenors and <i>cordonetti</i> .
Bd, 1597d	105 <i>cordonetti da battere bambace</i> [...] <i>corolle di tenori, e cordoni</i> [...] 150 <i>cordoni fatti a gavetta</i> .	105 <i>cordonetti</i> for beating cotton [...] <i>corolle</i> of tenors, and <i>cordoni</i> [...] 150 <i>cordoni</i> in the shape of <i>gavetta</i> .
Bd, 1599b	100 <i>dozzine di corde di leuto, cioè tenori e canti rinforzati</i> ; 52 <i>cordoni grossi e piccoli da batter bambace</i> .	100 dozens of strings for the lute, that is tenors and reinforced <i>canti</i> ; 52 <i>cordoni</i> , large and small [= thin], for beating cotton.
Bd, 1616c	<i>cordoni 330 grossi</i>	330 <i>cordoni</i> , large.
Bd, 1617a	<i>le budelle delli castrati [the string-maker] li debba fare ò tenori di doi fili overo corde sottili</i> [...] <i>et delle pecore et capre farne bordoni et bassi di tre ò quattro fila</i> .	with the <i>castrato</i> guts [the string-maker] must make two-thread tenors or thin strings [...] and with sheep and cows make <i>bordoni</i> and basses of three or four threads.
Bd, 1618a	<i>delle capre, et pecore esso ms. Rosato debbia fare li bordoni e bassi di 3, di 4 et di 5 et 200 dozzine di tenori di pecora di due fila</i> .	with cows and sheep, <i>mastro</i> Rosato has to make <i>bordoni</i> and basses of 3, 4, and 5 [threads], and 200 dozens of two-thread tenors of sheep.
Bd, 1638e	<i>cordoni 39; 4 settime per arpa</i> [...] 2 <i>cordoni da tamburro</i> [...] 28 <i>corolle di bassi forastieri</i> [...] 14 <i>corolle di tenori e mezzane</i> [...] 13 <i>cordoni ordinari</i> ; 800 <i>duzzine di corde di grosso romanesco</i> [...] 500 <i>duzzine di corde forastiere, cioè mezzane sottili e tenori</i> ; 20 <i>cordoni da arpa, cioè settime romanesche</i> [...] 400 <i>duzzine di bassi forastieri</i> .	39 <i>cordoni</i> , 4 'sevenths' for the harp [...] 2 <i>cordoni</i> for the drum [...] 28 <i>corolle</i> of <i>forastieri</i> basses [...] 14 <i>corolle</i> of tenors and <i>mezzane</i> [...] 13 ordinary <i>cordoni</i> ; 800 dozens of Roman large strings [...] 500 dozens of <i>forastiere</i> strings, that is thin <i>mezzane</i> and tenors; 20 <i>cordoni</i> for the harp, i.e. Roman 'sevenths' [...] 400 dozens of <i>forastieri</i> basses.
Bd, 1639c	2 <i>cordoni di tamburro, et 12 settime diverse</i> .	2 <i>cordoni</i> for the drum, and 12 various 'sevenths'.
Bd, 1654	<i>una scatola con 40 pezzi di corde dette settime</i> [...] 5 <i>mazzi di corde diverse fra corde grosse e sottili</i> .	a box with 40 pieces of strings called 'sevenths' [...] 5 'bunches' of various strings, both large and thin.
Bd, 1675	<i>un cordone di viola</i> [...] <i>un cordone di una tromba marina</i> .	[from the bill of a luthier:] a <i>cordone</i> for viol [...] a <i>cordone</i> for a marine trumpet.
Bd, 1676b	<i>un telaro piccolo per fare cordoni</i> [...] 60 <i>mazzi di corde sottile bianche</i> ; 30 <i>mazzi di bassi romaneschi</i> ; 20 <i>cordoni di tromba marina</i> ; 50 <i>cordoncini da violino</i> ; <i>un cordone da tamburo</i> ; 85 <i>coppie di cordoncini da stiringare</i> .	a small frame for making <i>cordoni</i> [...] 60 'bunches' of thin white strings; 30 'bunches' of Roman basses; 20 <i>cordoni</i> for the marine trumpet; 50 <i>cordoncini</i> for the violin; a <i>cordone</i> for the drum; 85 couples of <i>cordoncini</i> for <i>stiringare</i> .

Bd, 1677a	n° 17 settimane.	no. 17 'sevenths'.
Bd, 1678a	15 corolle de basse da violino [...] 30 cordoni da violone tra grossi, e piccoli [...] 139 cordoni da battere di marsilia [...] 5 mazzi de bassi da violino dentro una scattola tonda.	15 corolle of basses for the violin [...] 30 cordoni for the violone, both large and small [= thin] [...] 139 cordoni for beating, Marsilia type [...] 5 'bunches' of violin basses inside a round box.
Bd, 1701	103 cordoni da battere [...] 19 mazzi di bassi [...] n° 36 cordoni.	103 cordoni for beating [...] 19 'bunches' of basses [...] no. 36 cordoni.
Bd, 1720	appalto della gabella di tutte le corde di chitarra, leuto et altri istromenti, ed anche cordoni ad uso di cappellaro.	contract of the customs agent for all the strings of guitar, lute and other instruments, and even for cordoni employed by the hat-makers.

Table 1. Roped strings: the original Roman documents.

construction.³⁵ The same principle applies to the term *viol-on-cello*.³⁶

From 1678 Roman inventories record *cordoni* only for non-musical uses. No later Italian document is known which unequivocally records the use of roped strings for musical instruments, not even for the

plain-gut G of violins. In France, on the contrary, the *Encyclopédie* (1754) says — referring to musical instruments — that the process was the same for *grosses cordes* of gut as for hemp.³⁷

Before closing this section, it is worth mentioning a particular type of gut rope ringing in the sealing



Figure 5. The centre scale shows millimeters. (left) Gut-rope ringling in the wax seal of a pope Clement VIII bolla, preserved in Rome, Archivio di Stato, 30 Notai Capitolini, uff. 31, vol. 59, f. 801, 1 June 1602 (found detached, between the pages of the volume). Rope diameter = 2.80-3.10 mm, strand diameter (free) \approx 1.20, rope twisting angle (with its axis) = 30°-40° (medium twist). (right) Another similar rope (same dimensions), in its original wax sealing: *idem*, vol. 80, f. 66, 17 November 1612 (bolla by Paulus V).

³⁵ In current Italian, the meaning of the term *cordone* is not equivalent to 'big string': see e.g. the order of knighthood of the *Gran Cordone* or the *cordone* with knots used by the Franciscan friars as a belt. In Spanish the meaning is the same: Sebastian Covarruvias Orozco, *Tesoro de la lengua Castellana, o Española* (Madrid: Sanchez, 1611), f. 238v, entry 'Cordon' ('ciñeuse con estos los religiosos de S. Francisco, y algunos otros'), adding that the *cordones* were made by the *cordonero*. As far as musical instruments are concerned, in later times the term *cordone* was in one case (1791) employed to designate the fourth string (overspun) of the violin: Galeazzi, *Elementi teorico-pratici di musica*, vol. 1, pp. 64, 74-5, 83.

³⁶ On the origin of the term *violoncello* see the famous article by Stephen Bonta, 'From Violone to Violoncello: A Question of Strings?', *Journal of the American Musical Instrument Society* 3, (1977) pp. 64-99: 95-6.

³⁷ Diderot, 'Cordes à boyau' (section 'Des cordes à boyau propres à la lutherie'), p. 207: 'C'est de la même manière que se preparent les grosses cordes à boyau, avec cette différence [...] qu'on les tord et file comme la chanvre'.

wax of a 1602 Papal *bolla* preserved in the Rome State Archive (Figure 5).³⁸ This string is obtained by twisting together clockwise three strands, each one of them pre-twisted anticlockwise. Thus, the three components being not in reverse twist, this type of rope could be made without the need for any kind of *orditore*, but simply with an usual twister-hook. This sample proves that even workshops whose inventory does not list any *orditore* could have produced ropes. Strings of this nature, for musical instruments, are currently made by Mimmo Peruffo in Vicenza (since 1994) and George Stoppani & Oliver Webber in Manchester.³⁹

§4.3. OVERSPUN. In 1618 Praetorius first mentions metal strings wrapped in parchment, used for the basses of the *Geigenwerck*.⁴⁰ He does not state whether this was intended to improve the grip of the rotating bow or whether the function was the same as the silk-covered metal strings employed by Johann Christian Dietz in his *claviarpa* (1814-19): i.e. to produce a 'soft and harmonic' sound like the gut of a harp.⁴¹ There is no mention of gut strings weighted with metal winding until 1659.⁴² In Italy, in Rome to be precise, they appear in 1676, when a silver-wound string was employed for a violone.⁴³ The fact that around that time inventories cease mentioning *cordoni* (§4.2) confirms that they were being replaced by covered strings. For the violin, at least up to the middle of the following century, the fourth string of plain 'white' gut survived in Rome (Table 2). The documents do not specify whether they were 'high-twist' or roped, and the inventories in §4.2 also mention, beside the *cordoncini da violino*, ordinary *bassi da violino*.

Bd, 1677a	<i>mazzi quattro [di] terze e quarte di violino bianche romane.</i>	four 'bunches' of violin thirds and fourths, white, Roman.
Bd, 1677b	<i>le corde grosse fatte di castrato, e pecore siano tenuti essi venditori di farne primieramente corde dette mezzane di chitarra, e tenori à due fila, et anco bassi grossi per quarte di violino.</i>	with the large strings made of <i>castrato</i> and sheep, the sellers have above all to make guitar strings called <i>mezzane</i> , and two- and even three-thread tenors, and even large basses for violin fourths.
Bd, 1729	<i>cantini bianchi [...] seconde bianche [...] terze e quarte bianche.</i>	white <i>cantini</i> [...] white seconds [...] white thirds and fourths.
Bd, 1743	<i>mazzi di cantini bianchi [...] mazzi di seconde [...] mazzi di terze [...] mazzi di quarte tutte bianche.</i>	'bunches' of white <i>cantini</i> [...] 'bunches' of seconds [...] 'bunches' of thirds [...] 'bunches' of fourths, all white.
Bd, 1747	<i>idem.</i>	<i>idem.</i>

Table 2. Violin stringing, all-gut: the original Roman documents.

In Roman workshops, the *corde d'argento* and equipment for manufacturing them appear only in the late eighteenth century:

³⁸ Rome, *30 Notai Capitolini*, uff. 31, vol. 59, f. 801, 1 June 1602: *bolla* by pope Clement VIII (Fig. 5: measurements have been possible by the fact that the thin rope was found, detached, between the pages). Other similar sealings can be found in other volumes of the same *ufficio*, e.g.: vol. 80, f. 66, 17 November 1612 (*bolla* by Paulus V: reproduced in Fig. 5), and vol. 90, f. 147, 29 April 1616. The Roman *cordari* were also making very thin 'split' strings for bookbinding [Bd, 1598b]; some ancient volumes of the same archive are actually bound with these strings, e.g. *30 Notai Capitolini*, uff. 28, vol. 34 (of the year 1595: this is the same notary who assisted many string-makers of the district; a deed of one of them is registered in this volume).

³⁹ My thanks to Michael Fleming for the reference to Stoppani's & Webber's construction practice.

⁴⁰ Michael Praetorius, *Syntagma musicum, II, De Organographia*, transl. and ed. by David Z. Crookes (Oxford: Clarendon Press, 1986), pp. 70-72: 'The heavier strings are made from thick brass or steel, wound with fine parchment; the bottom ones are nearly as thick as those of the great bass viol [...]'. See also Ephraim Segerman, 'Response to Comm 1744 - "Strings of Silk and other Textiles"', *FoMRHI Quarterly* 104 (July 2001), pp. 30-31 (Comm. 1767).

⁴¹ *Nuovo dizionario universale tecnologico o di arti e mestieri [...] compilato dai signori Lenormand, Payen [...] prima traduzione italiana [...]*, vol. 5 (Venice: Antonelli, 1832), p. 27.

⁴² They appear to have been invented by a certain 'Goretsky': Peruffo, 'Italian violin strings', p. 159.

⁴³ Barbieri, 'Cembalaro', p. 198 (by the luthier Alberto Platner, of German origin): 'due corde di violone, una di argento et un'altra semplice'. See also note 122 below.

Bd, 1785b	<i>un ordegno di ferro per coprire le corde ramate [...] n° 29 quarte d'argento.</i>	An iron tool for covering the wound strings [...] n° 29 fourths of silver .
Bd, 1821b	<i>diverse cavette di corde d'argento [...] filo di Bologna d'argento [...] corde di seta, e filo d'argento [...] un ordegno da filare le corde di seta, con suo piede di albuccio e noce.</i>	Many hanks of silver strings [...] silver wire of Bologna [...] silk strings and silver wire [...] a tool for covering the silk strings, with its foot made of poplar and walnut.

The 29 covered strings mentioned in the first document were given by the *cordaro* Donato Vincenti to his colleague Andrea Ruffini. In Vincenti's shop, only firsts, seconds, and thirds of plain gut are listed. This suggests that, at least in those early times, the covered strings were only made by order.

It should be noted that in Rome and Naples [C] only 'silver' (*argento*) is mentioned for overspinning the gut or silk strings.⁴⁴ At Florence the use of overspun strings, both on violin and violoncello, seems to be indicated as early as about 1685 in paintings by Antonio Domenico Gabbiani that show musicians at the Medici court.⁴⁵ In less fashionable milieus, however, plain gut is still recorded around 1710-15. Cristoforo Munari, a painter working both in Rome (1695-1707) and Florence (1707-1715), has left works depicting a violoncello (1710) and violins (1710-15) strung with a thick, plain-gut 4th string.⁴⁶

§5. THE TREBLE STRINGS: FROM *CANTINI RINFORZATI* TO MODERN STEEL CHANTERELLES

§5.1. PORPHYRY AND RÉAUMUR ON TWISTED STRINGS. In §4.2 we saw that roped strings were recorded as long ago as the early fifteenth century. We shall now see that an even more unexpected consideration of 'high twist' acoustic features dates from as far back as Graeco-Roman antiquity, from Porphyry to be exact (born c232-3 C.E., died in Rome c305 C.E.). Comparing the human voice with stringed instruments and wind instruments made of animal horn, he observes:⁴⁷

Nam siquis spiritum intendit violentius, statim et vox fit durior propter vim, etiamsi mollior ante fuerit. [...] Perspicuum et idem est in instrumentis. Nam et contortae chordae, ut dictum est, voces faciunt duriores; et assata cornua; et siquis chordas tangat manibus violenter, non molliter: Necessario item è contrario, cum istae sonum emittant duriozem, illae quae minus sunt contortae, et cornua crudiora, voces faciunt molliores.	Therefore if the breath is emitted more violently, at once the [human] voice also becomes more penetrating owing to the [extra] force, whereas before it was softer. [...] The same clearly occurs in musical instruments. Indeed even the twisted strings, as we have said [on p. 250], make more penetrating sounds, and [well-] dried horns too, as also touching the strings violently, and not softly. Since they emit a more penetrating sound, those [strings] that are less twisted and horns less dried will, on the contrary, emit softer sounds.
--	---

Even then, they noted that by increasing the amount of twist, the string emitted a livelier sound.⁴⁸ Now we know that this is because by so doing it acquires flexibility, becoming less inharmonic. The problem was only tackled experimentally in 1783 and resolved analytically in 1848.⁴⁹

⁴⁴ The term *argento* was customarily used to mean a silver-plated copper wire: Galeazzi, *Elementi teorico-pratici di musica*, vol. 1, pp. 74-5.

⁴⁵ Reproduced in John Walter Hill, 'Antonio Veracini in context: new perspectives from documents, analysis and style', *Early Music* 18 (Nov. 1990) pp. 545-562: 547 (violin) and 549 (violoncello).

⁴⁶ Reproduced in Francesca Baldassarri, *Cristoforo Munari* (Milan: Motta, 1998), pp. 29, 45, 52, 58, 85, 86, 87.

⁴⁷ Porphyrius, *In Harmonica Ptolomaei commentarius, nunc primum ex Codd. Mss. (Graece et Latine) editus*, published in John Wallis, *Operum mathematicarum*, vol. 3 (Oxford: at the Sheldonian Theatre, 1699) pp. 183-355: 251.

⁴⁸ The statements concerning fresh horns are due to the mistaken belief (of Aristotelian origin) that sounding pipes whose walls are less hard or are damp emit a 'softer' sound: see Patrizio Barbieri, 'Alchemy, Symbolism and Aristotelian Acoustics in Medieval Organ-Pipe Technology', *The Organ Yearbook* 30 (2001) pp. 7-39: 9.

⁴⁹ Barbieri, 'The inharmonicity of musical string instruments', pp. 388-94.

Bd, 1599b	100 dozzine di corde di leuto, cioè tenori e canti rinforzati.	100 dozens of strings for the lute, that is tenors and reinforced <i>canti</i> [or 'reinforced both tenors and <i>canti</i> '?].
Bd, 1615a	1000 dozene di canti di violino di 2 fili.	1000 dozens of two-threads <i>canti</i> for the violin [see below].
Bd, 1619a	canti rinforzati di violino di 2 fila [...] alla misura di Roma.	reinforced two-threads <i>canti</i> for the violin [...] of the Roman length.
Bd, 1636b	1000 dozzene di cantini da violino rinforzati.	1000 dozens of reinforced <i>canti</i> for the violin.
Bd, 1638a	corde romanesche, cioè 3000 [dozzine] sottili, et 2000 [dozzine] cantini rinforzati.	Roman strings, that is 3000 [dozens] thin ones, and 2000 [dozens] reinforced <i>cantini</i> .
Bd, 1638b	corde di violino, et corde de rinforzate [...] di lunghezza alla misura di Roma.	violin strings, and reinforced strings [...] of the length prescribed in Rome.
Bd, 1638c	[1000 dozzine] di cantini rinforzati di Perugia, et dell'Aquila tutte di agnello.	[1000 dozens] of reinforced <i>cantini</i> of Perugia and L'Aquila, all of lamb.
Bd, 1638d	[1000 dozzine di] cantini rinforzati [dell'Aquila].	[1000 dozens of] reinforced <i>cantini</i> [of L'Aquila].
Bd, 1638e	1800 duzzine di corde romanesche tra sottile e canti rinforzati.	1800 dozens of Roman strings, both thin and reinforced <i>canti</i> .
Bd, 1642a	cantini di violino rinforzati.	reinforced <i>cantini</i> for the violin.
Bd, 1642b	[prohibition of making or selling] tenori canti rinforzati di un filo solo, ma debbiano essere di due fila.	[by Roman statute, ch. 8: prohibition of making or selling] reinforced tenors [and] <i>canti</i> of a single thread, but they have to be of two threads.
1657: Ms cited in note 140 below	[ordered by the Spanish court:] dos docenas de bordoncillos para segundas y terceras del violin [...] para el violin medio mazo de cuerdas renforzadas, otro medio de bordoncillos gordos y delgados.	[ordered by the Spanish court:] two dozens of <i>bordoncillos</i> to serve as violin seconds and thirds [...] half 'bunch' of reinforced strings for the violin, another half ['bunch'] of <i>bordoncillos</i> fat and delicate [= not stiff?].

Table 3. 'Reinforced' strings: the original Roman documents.

We now jump forward to the early Renaissance. Hemp strings in non-musical use were known, by 1460, as 'reinforced' (*rinforzate*) strings.⁵⁰ This term was still used in the late nineteenth century, and several lexicographers explain that *spago rinforzato* (reinforced twine) is 'strongly twisted'.⁵¹ At that time it was thought that twisting gave string greater mechanical strength: see, for example,

Fabri (1669), Lana Terzi (1686) and Bellini (1696).⁵² It was believed that by twisting the string, first its diameter increased and secondly the individual strands, owing to their inclination, were not put under traction by the entire applied force, but only by the normal component for their section, while the tangential component served to compress them together. In 1711 Réaumur demonstrated

⁵⁰ Gabriele Giacomelli, Enzo Settesoldi, *Gli organi di S. Maria del Fiore di Firenze. Sette secoli di storia dal '300 al '900* (Firenze: Olschki, 1993), p. 328, year 1460: 'chorda rinforzata'; Carlo Grigioni, 'Maestri organari della Romagna', *Melozzo da Forlì - Rassegna d'arte romagnola* (1937-1938, n° 5) pp. 271-273, year 1499: 'octo cavelotine [= gavette] de filo renforzato'; Rome, Archivio Doria Pamphilj, *Filza dei mandati 1667-68*, organo di S. Agnese in Agone, spese mese di settembre 1667: 'libbre 33 corda di canape rinforzata'; AS, *Miscellanea statistica*, busta 26, fasc. 'Delegazione di Spoleto. Industria manifatturiera', year 1843, between *corde di canapa*: 'Spago e rinforzato assortito'.

⁵¹ 'Rinforzato', *Vocabolario della lingua italiana già compilato dagli accademici della Crusca, ed ora corretto ed accresciuto da Giuseppe Manuzzi*, 2nd edn., vol. 3 (Florence, Stamperia del vocabolario, 1863), p. 839: 'Corda, spago, e simili, rinforzato, dicesi quello ritorto, e fortemente stretto'.

⁵² Honoré Fabri, *Physica, id est, scientia rerum corporearum*, vol. 1 (Lyons: Anisson, 1669), p. 528, prop. XIII; Lana Terzi, *Magisterium naturae*, vol. 2, p. 488, §XXI; Lorenzo Bellini, *Opuscula aliquot [...] de motu cordis* (Leyden: 1696), republished in Idem., *Opera omnia* (Venice: Hertz, 1732), pars II, pp. 106-136: 121 (Propositio V).

that twisting actually produced the opposite effect, explaining the weakening by the facts that first, the single strands are already under traction even without an external load, and secondly that when the weakest strand gives way, all the applied force contributes to overloading the remaining ones, triggering a runaway effect.⁵³ He concluded that such strings should rather be called ‘weakened strings’.

§5.2. ROMAN ‘CANTINI RINFORZATI’. Between 1599 and 1657 Roman documents often mention – in connexion with lutes, viols and violins – *canti*, *cantini* and *tenori*, all of them *rinforzati* (Table 3). As we have seen in §5.1, these were most probably high-twist strings for medium and high registers. They sometimes appear with others classified simply as ‘thin’ (*sottili*), a term that also included the chanterelles (Table 3, 1638a, 1638e).

Among these we may remark the ‘2-strand reinforced *canti* for violin’, requested by the luthier Cristoforo Del Forno as early as 1619, which must have been similar to the strings he ordered in 1615 (Table 3, 1615, 1619). They were probably chanterelles (not 2^{nds}) because in Roman documents the four violin strings are respectively known as *cantino*, 2nd, 3rd, 4th (or *basso*).⁵⁴ The specification ‘reinforced’ is again found in an order placed in 1657 by Antonio de Zulueta, *violero de la Real Capilla* of Spain, also including ‘corde di Roma’ (Table 3, 1657). This term is abandoned in later documents. In the above-mentioned deeds, the chanterelles for violin always have two strands; those with three strands are found first in 1729 and continue to be mentioned, together with two-strand strings, throughout the century.⁵⁵ Table 4 shows that violinists had a very wide choice of both diameters and quality-price range.

§5.3. ROMAN-NEAPOLITAN ‘CANTINI A 4 FILI’. We have seen that violin chanterelles increased from two strands (1615) to three (1729). When the

string-maker Andrea Ruffini took over from his father Francesco in 1786, he found only three-strand ones [*Bd*, 1786], inheriting a situation like the one in Table 4. At the time of his death in 1821, the shop also had four-strand strings: Table 5 provides the first notice of this innovation, although we do not know whether it was introduced by him or was the result of collaboration between Roman and Neapolitan manufacturers (§1). The fact remains, however, that in 1821 his shop inventory shows the following changes since 1785 (Table 4):

- ◆ four-strand chanterelles
- ◆ the description ‘long’ and ‘short’ disappears and is replaced by the number of *tirate* (§3.6); this latter term was still in use in 1904 (pricelist of the firm Carlo Schmidl of Trieste), and in 1931 (pricelist of Roberto Salerni of Salle).⁵⁶
- ◆ violin strings are no longer distinguished by colours.

<i>Cantini</i>	Seconds	Thirds
2 strands, red, short	3 strands, dark blue, short	3 strands, blonde, short
2 strands, dark blue, short	3 strands, blonde, short	—, red, short
2 strands, dark blue, long	3 strands, white, short	6 strands, —, —
2 strands, white, short	4 strands, white, short	7 strands, dark blue, short
2 strands, white, long	4 strands, white, long	7 strands, white, short
3 strands, white, short	5 strands, white, short	8 strands, white, short
3 strands, white, long		

Table 4. [*Violin*] strings: from the Donato Vincenti inventory, Rome, 1785 [*Bd*, 1785b]. (Dark blue = turchini.)

⁵³ René-Antoine Ferchault de Réaumur, ‘Experiences pour connoistre si la force des cordes, surpasse la somme des forces des fils qui composent ces memes cordes’, *Histoire de l’Academie royale des sciences, avec les memoires de mathematique et de physique* [...], année 1711 (ed. Paris 1714), pp. 6-16.

⁵⁴ [*Bd*, 1678a, 1729, 1743 1785b]. Towards the mid-18th century, in the Veneto, the 2nd was, on the other hand, called a *canto* (and the adjacent two *cantino* and *tenore*): Giordano Riccati, *Delle corde ovvero fibre elastiche* (Bologna: Stamperia S. Tommaso d’Aquino, 1767), p. 130. In 1606 the chanterelle of the guitar was also called *canto*: Monica Hall, ‘Translation of the tuning instructions in Girolamo Montesardo, *Nuova inventione d’intavolatura per sonare li balletti sopra la chitarra spagniuola* (Florence, 1606)’, *FoMRHI Quarterly* 16 (Jan. 2002) p. 43 (Comm. 1797).

⁵⁵ [*Bd*, 1729, 1785b; Table 4]. The ones made in Naples in 1765-66 also had three strands: La Lande, *Voyage*, p. 410.

⁵⁶ *Prezzo corrente della fabbrica e deposito di strumenti musicali, corde armoniche* [...] della casa C. Schmidl & C° [...] (Trieste: 1904), pp. 34-37 (‘Corde armoniche’). As far as Salerni is concerned, see [B, Table II]. These two documents are very rare, and have been brought to my attention by Renato Meucci (Schmidl catalogue) and Giancarlo Rostirolla (Salerni catalogue), whom I thank.

Cantini	Seconds	Thirds
3 strands, 3 <i>tirate</i>	4 strands, 3 <i>tirate</i>	8 strands, 3 <i>tirate</i>
3 strands, 4 <i>tirate</i>	4 strands, 4 <i>tirate</i>	12 strands, <i>di grosso</i>
4 strands, 3 <i>tirate</i>		—, <i>grosso</i> , 4 <i>tirate</i>
4 strands, 4 <i>tirate</i>		—, one <i>tirata</i>

Table 5. [Violin] strings: from the Andrea Ruffini inventory, Rome 1821 [Bd, 1821b].

This is confirmed by Table 6, which summarises the samples of three of the best-known manufacturers operating at Naples in 1834 (the best of these, as we have seen in §1, was of Roman origin: Antonio Putti).

Cantini	Seconds	Thirds	Fourths
VIOLIN			
3 strands, 1 <i>tirata</i>	4 strands, 1 <i>tirata</i>	5 strands, —	silver on gut core
3 strands, 3 <i>tirate</i>	4 strands, 3 <i>tirate</i>	7 strands, —	
3 strands, 4 <i>tirate</i>	5 strands, —	8 strands, —	
4 strands, 3 <i>tirate</i>			
4 strands, 4 <i>tirate</i>			
VIOLONCELLO			
5 strands (= 3 rd of the violin)	12 strands	silver on gut core	silver on gut core
7 strands (= 3 rd of the violin)			
8 strands (= 3 rd of the violin)			

Table 6. Violin and violoncello strings: from the price lists of Antonio Putti, Avallone Bros, Giuseppe de In Guida, Naples 1834 [C].

the eighteenth and nineteenth centuries it was already known that a string's breaking point could be raised by increasing the number of guts, which did not necessarily mean a string would be thicker.

In 1786, the luthier Giovanni Antonio Marchi observes:⁵⁷

La natura stessa ci dimostra, che l'abete di vena fina è più forte, perchè è composto di più linee, e così pure la tela benchè sia sottile è di maggior durata, come pure una corda, che parimenti sia composta di più fili, di quello sia un'altra della stessa grossezza, ma di meno fili [...]	Nature itself shows us that fine-grain spruce is strongest, being made up of a great number of lines, just as a piece of cloth, although very thin, lasts longer, as does also a string made up of many strands rather than another of the same thickness but with fewer strands [...]
---	--

And in 1865, the string-maker Philippe Savarès [S] states:

La grosseur d'un intestin n'en fait pas la force; il y a autant de résistance dans un petit que dans un gros. Cela explique pourquoi les chanterelles à trois fils sont meilleures que celles à deux, et explique encore comment les deuxiemes à trois fils sont meilleures que celles à six.	The thickness of the gut does not determine strength: a small one has the same resistance as a big one. This explains why three-strand chanterelles are better than those with two strands, and also explains why 2 nd strings of three strands are better than those of six.
---	--

Maker	Diameter (mm)	Breaking load (kg)
Rufini (Naples)	0.72	16
	0.69	13
Giuseppe Bedin (Vicenza)	0.70	16
	0.69	15
Venturini (Padua)	0.69	17
	0.68	13
Girolamo Trevisan (Bassano)	0.70	12

Table 7. Chanterelles for violin presented at the Paris Industrial Exhibition in 1881 by four Italian manufacturers: contemporary technical survey [Chouquet, 1881].

⁵⁷ In a manuscript published in Roberto Regazzi, *Il manoscritto liutario di G.A. Marchi. Bologna 1786* (Sala Bolognese: Forni, 1986), pp. 68-71.

A few lines earlier, Savarèse had remarked that because the 2nd and 3rd of the violin were less tense, they were manufactured at Naples during the early months of the year when the guts were less resistant, being taken from animals that were still very young. This was not only advantageous from an economic point of view, but also, he states, because the strings were less stiff and consequently less inharmonic.

Four-strand chanterelles were still in use in 1877.⁵⁸ It is probably to them that the Paris International Exhibition scientific tests of 1881 refer (Table 7).⁵⁹ One and a half centuries earlier (1729) the Dutch physicist Petrus van Musschenbroek had carried out a similar survey, comparing the diameter (D) and breaking load (T_b) of two gut strings ‘used by musicians’, although the instrument was not specified. Converted into modern units, his experimental data gives the following results:⁶⁰

1 st string:	$D = 0.78 \text{ mm}$	$T_b = 13.34 \text{ kg}$
2 nd string:	$D = 1.31 \text{ mm}$	$T_b = 20.75 \text{ kg}$

We may therefore conclude that the tensile strength of the first of the two strings was a little lower than the average for the chanterelles in Table 7, even though it was considerably thicker.

As far as the sound output of the chanterelles is concerned, in about 1804-06 Conte Cozio di Salabue makes the following statement, referring generically to instruments of the violin family:⁶¹

Anime — Gli Amatis, Stradivari e gli loro scolarì le facevano piccolissime, per dove una voce più fina e frizzante ai loro stromenti che non piace più, e perchè allora si usavano corde assai fine; e si collocava ordinariamente l’anima fuori del ponticello cui per donde poco brillante il cantino e la seconda [...]

Sound posts — The Amatis, the Stradivari and their followers made them very small, to give their instruments a sharper and more piercing sound, which is no longer popular, and because then very thin strings were used, and the sound posts were usually placed outside the bridge, for which reason the cantino and second were not very brilliant [...]

Although Salabue cannot be treated as a reliable witness, this tallies with the *cantini* of only two strands that were still being used in the early eighteenth century (Table 4). In Italy, the tendency to increase the diameter of the first string in order to achieve greater volume started with Giuseppe Tartini before 1743 and Giordano Riccati, whose 1767 surveys led to a diameter of 0.69 mm, i.e. practically the same as in Table 7.⁶² This development is confirmed by the fact that in 1785 an unknown columnist stigmatised ‘some young people’ who put ‘very thick strings on their instruments, seeing that Signor [Gaetano] Pugnani did the same’, warning that this required a hand with some strength, which they unfortunately did not possess.⁶³ When Nicolò Paganini arrived at Lucca (c1801-06), the thickness of his strings caused amazement, but at his concerts in Paris (c1831) they were deemed to be ‘below average size’.⁶⁴ When

⁵⁸ ‘Cantino’, *Nuova enciclopedia italiana* [...] ampliata da Gerolamo Boccardo, 6th edn., vol. 4 (Turin: Unione tipografico-editrice, 1877), p. 985 (with three and four strands, mentioning particularly the ones in Naples).

⁵⁹ Data published in Gustavo Chouquet, ‘La musica all’Esposizione di Parigi (contin.)’, *Gazzetta musicale di Milano* 36 (1881) pp. 59-77: 67. Measurements were taken using a micrometer invented by the Parisian string-maker J. Thibouville-Lamy, accurate to one hundredth of a millimeter.

⁶⁰ Petrus van Musschenbroek, *Physicae experimentales, et geometricae de magnete, tuborum capillarum vitreorumque speculorum attractione, magnitudine terrae, coherentia corporum firmorum dissertationes* [...] (Leyden: Luchtmans, 1729), pp. 523-4, Experimentum C: ‘Chordarum [ex intestinis] coherentiam etiam explorare annisui fui, eas elegi quibus Musici utuntur; una, cuius diameter erat 0.03 pollicis gestavit, antequam frangebatur, libras 27, altera crassior et diametri 0.05 pollicis, sustinuit ante rupturam libras 42.’ From the context of the book, we may deduce that he was using the *livre ancienne* of Amsterdam (= 494.1 grams) and the *pieu du Rhin* (= 313.85 mm); the conversion factors are taken from Horace Doursther, *Dictionnaire universel des poids et mesures anciens et modernes* [...], reprint of the 1840 edition (Amsterdam: Meridian Publ., 1965), pp. 213 and 415 respectively.

⁶¹ Cozio di Salabue, *Carteggio*, transcription by Renzo Bacchetta, ed. Giovanni Iviglia (Milano: Cordani, 1950), p. 90.

⁶² Patrizio Barbieri, ‘Giordano Riccati on the Diameters of Strings and Pipes’, *Galpin Society Journal* 38 (1985) pp. 20-34: 26.

⁶³ ‘Quale, e come esser dee lo strumento’, *Giornale delle Belle Arti e della incisione, antiquariato, musica e poesia* (Rome, issue 1785) pp. 245-247 (§III. ‘Delle corde’): ‘Vedeansi un tempo alcuni giovani forniti di poche forze, di minor giudizio, e di molta presunzione, armar di corde grossissime i loro stromenti, veggendo così fare il Sig. Pugnani. Ma in vece che questo grand’uomo ne cacciava fuori un suono limpido pieno pronunziato, essi non ne traendo che un borbottio mutolo spento arrocchito, rinnovavan la fama del ranocchìo, che gonfiandosi per gareggiare col buè scoppia nei vani suoi sforzi’.

⁶⁴ Francesco Regli, *Storia del violino in Piemonte* (Turin: Dalmazzo, 1863), pp. 98-9.

ordering chanterelles from Naples in 1829 (probably supplied by the manufacturers advertised in the 1834 pricelist [C]) he states, 'I wish them very thin [...]. Although very thin, they must be made of four strands to endure'.⁶⁵ This is explained by the facts that:⁶⁶

- ◆ he sometimes raised the tuning of the four strings by a semitone, and the G even by a minor third: this implies thinner strings (to avoid the tone becoming 'hard and strident') and, at the same time, a G of great mechanical strength. The idea was to be able to use open strings as often as possible, so as to obtain a more brilliant sound. Raising all the strings by a semitone allowed him, for example, to play in D and A when the orchestra was in E flat and B flat⁶⁷
- ◆ unlike other violinists, he frequently played in the highest position
- ◆ in high-pitched positions, the tone quality — especially of the harmonics obtained with double-fingered string, known as 'artificial' — is more agreeable with smaller diameters
- ◆ with thick strings, the 2nd, 3rd and 4th fingers are not strong enough for the *pizzicato*, which he frequently used.

Notwithstanding the fact that his violin was considered 'very thinly' strung, an English critic reported in 1831 that he managed to produce a 'round' sound.⁶⁸ The adoption of thin strings had

other drawbacks, since the E, particularly in damp weather, tended to whistle. This often happened to Paganini and, according to Guhr, always had a damaging effect on the boldness of his performance.⁶⁹ Later, however, according to the *Gazzetta musicale di Napoli*, 'every day we experience the felicitous effect that violinists draw from the forced tightness of the *cantino*', which must certainly have contributed to the fame of those made at Naples.⁷⁰

§5.4. THE CHANTERELLES' 'PERFECT FIFTH'.

The strings discussed above often suffered from inharmonicity, meaning that their overtones were no longer whole multiples of the fundamental, causing some aperiodic vibrations. The cause could be either a diameter that was irregular or ovalized, or the varying linear density of the gut. Practical repercussions were:

- ◆ *Instruments without frets, plucked* (such as harps and the unstopped strings of theorboes and archlutes): a muted tone, unstable due to high inharmonicity, and rapidly dying away⁷¹
- ◆ *Instruments with frets, plucked or bowed*: the frequency of the note is no longer inversely proportional to the length of the string when fingered, with possible deviations of as much as a semitone. The aperiodicity of the vibrations may also make the strings skim over the frets, causing the 'frying' sound complained of by Lorenzo da Pavia at the end of the fifteenth century (§1).

⁶⁵ Letter dated Breslau, 31 July 1829 and addressed to a correspondent of his at Naples: quoted in Mimmo Peruffo, 'Nicolò Paganini and gut strings: the history of a happy find', *Recercare* 12 (2000), pp. 137-147: 138. In the article, Peruffo also provides the results of a test carried out by him on a roll of strings preserved at Genoa among the relics of Paganini, reaching the conclusion that the famous violinist presumably used a 'medium twist' chanterelle (c45° angle), with a diameter of about 0.70 mm. Violin chanterelles made of four strands were also requested by the Leipzig publisher Peters to the string-maker Pietro Ruffini, in 1824 [B, I.4.1].

⁶⁶ Charles Guhr, *L'art de jouer du violon de Paganini* [...] (Paris: Shonenberger, n.d.), p. 3. See also Giancarlo Conestabile, *Vita di Nicolò Paganini* (Perugia: Bartelli, 1851), p. 246-7.

⁶⁷ See also 'Il violino', *Gazzetta musicale di Napoli* 6 (1857), p. 321. Henry Bouasse, *Cordes et membranes* (Paris: Delagrave, 1926), pp. 277-8, states on the other hand that some violinists slackened all their strings a bit in such a way that they were obliged to press the finger near the nut even when playing the former open strings, which they did in order to continue to apply to the latter 'their abominable *vibrato*!'

⁶⁸ Arturo Codignola, *Paganini intimo* (Bergamo: Municipio di Genova, 1935), p. 340 (concert on 3 June 1831, by *Athenaeum*: 'He strings his violin very thinly; nevertheless, there is a roundness [and] silkiness of tone which is at once delightful and astonishing').

⁶⁹ Guhr, *L'art de jouer du violon*, p. 3: 'Outre qu'on tire des sons plus nourris d'un violon monté avec des cordes fortes, les cordes faibles ont encore cet inconvénient, surtout dans les temps humides, que le Mi est très exposé à siffler. Cet accident est souvent arrivé à Paganini, et a toujours eu une facheuse influence sur la hardiesse de son exécution.'

⁷⁰ L., 'L'arpa', *Gazzetta musicale di Napoli* 6 (1857) p. 11: 'Dopo Paganini, tutti i gorni si esperimenta il felice effetto che ritraggono i violinisti dalla forzata tensione del cantino'. In 1885, when the pitch at the Teatro alla Scala was reduced to an *a'* = 432 Hz, the violinists of the orchestra feared that the chanterelle would lose brilliance: 'Il nuovo diapason al Teatro alla Scala di Milano', *Gazzetta musicale di Milano* 40 (1885) pp. 308-309.

⁷¹ Giordano Riccati, 'Suono falso', *Prodomo della Nuova Enciclopedia Italiana* (Siena: Pazzini e Bindi, 1779), pp. 96-128: 96.

Figure 3 illustrates the classical way of testing the ‘trueness’ of a string:

- ◆ If the testers saw only two immobile sinusoids (at the upper and lower ends of the vibration envelope respectively), they judged the string to be ‘good’ (the upper illustration); in fact we now know that although this condition is necessary, it is not sufficient (e.g. a uniformly conical string is ‘false’, even though it passes this test).⁷²
- ◆ If, on the other hand, they saw the silhouettes of other strings within the envelope (the lower illustration), the string was assuredly false.

A string that is deemed good at low tension (as illustrated here) may no longer be good at working tension, since the lack of homogeneity of both gut and twisting could give rise to uneven stretching.⁷³ It was for these reasons that authors such as Jean Rousseau (1687) advised checking by using fifths and octaves after tuning the open strings. The tuning was then completed by moving the frets slightly up or down,⁷⁴ which is why gut-strung instruments have movable frets. ‘Strings for making frets’ are mentioned in a Roman inventory [*Bd*, 1701: *corde da far tasti*].

Not all chanterelles were of the highest quality. In about 1822, in a hank of 30 violin chanterelles, the percentage of ‘good’ ones was no higher than 50% for Neapolitan strings and below 20% for the

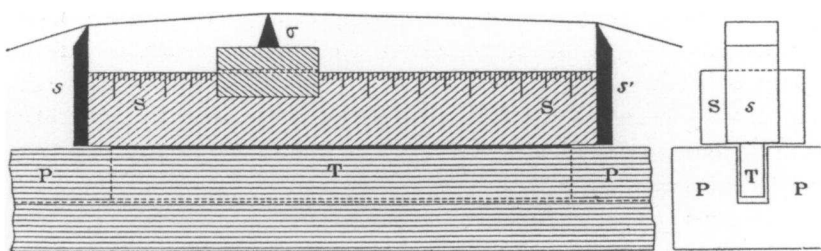


Figure 6. Sonomètre used by manufacturers to check the ‘trueness’ of a gut string (Henry Bouasse, *Cordes et membranes* (Paris: Delagrave, 1926), pp. 150-51). The bridge σ was adjusted so that the two parts s and s' were successively in the ratio of the octave, fifth and twelfth: if the string passed this test, the two points s and s' were marked with ink and the said section could be mounted on the instrument. If it did not pass the test, the cursor STs was made to slide along the stator PP, passing on to a new section of string to be tested.

French ones.⁷⁵ Even in 1926 the physicist Henri Bouasse observed that out of ten top quality strings, violinists ‘with a sharp ear’ might have difficulty in finding even one that was acceptable, and that often even the eleventh was no better than the preceding ones.⁷⁶ To improve the precision of their products, in the late nineteenth century manufacturers began to use special monochords to identify the thicker parts of the string, which they then ‘rectified’ by abrasion. Examples of this approach are the *phonoscope* proposed by Plassiard (1879) and the *sonomètre* in Figure 6, illustrated by Bouasse (1926).⁷⁷ In 1874 the firm of Ruffini was also doing this, following a method invented by J.-B. Vuillaume of Paris.⁷⁸ Nevertheless, the first half of the following century was dominated by machine-polished German chanterelles called ‘da concerto’ or ‘perfect fifth’. The Weichold brand appears, for example, in the 1904 pricelist of

⁷² Bouasse, *Cordes et membranes*, p. 152.

⁷³ Joseph-Antoine Plassiard, *Des cordes harmoniques en général et spécialement de celles des instruments à archet* (Mirecourt: Chassel, 1879), pp. 5, 10, 36. I must honestly warn the reader that I have already examined another work (1874) by this author, who is certainly the most important of the researchers addressing the problem scientifically, in the article quoted above (footnote 62). The article’s mis-spelling of his surname as ‘Plessiard’ has unfortunately been adopted by several later authors. His biographical data can be found in Paris at the Archives Nationales, Ms F.14.2301/1: *Dossiers des ingénieurs des ponts et chaussées*. Born at Lunéville on 7 August 1807; a pupil at the École Polytechnique and École des Ponts et Chaussées (1827-30); a State engineer (Metz, Bastia, Lorient, 1832-1869); retired in 1869, to Lorient, as ‘officier de la Legion d’honneur’ (a decoration bestowed on all *ingénieurs en chef de première classe*). In 1878, at Lorient, he completed the mentioned work, which was then put on sale in Paris at the shop of the string-maker Jérôme Thibouville-Lamy, with whom he evidently collaborated. His research on the subject is already cited in Camille Durutte, *Esthétique musicale - Technie ou lois générales du système harmonique* (Paris: Mallet - Bachelier et al., 1855), p. 16.

⁷⁴ Hubert Le Blanc (1740), too, advised that ‘two strings of the same thickness, as clear as rock crystal, make the 5th at a considerably different degree forward and back’: Mark Lindley, *Lutes, viols and temperaments* (Cambridge: Cambridge University Press, 1984), pp. 5 (Le Blanc) and 6 (Rousseau).

⁷⁵ ‘Rapport fait par M. Robiquet sur le concours du prix proposé pour le perfectionnement de l’art du boyaudier’, *Bulletin de la Société d’encouragement de l’industrie nationale*, 21 (Paris, 1822), pp. 332-344: 342. See also [*L*, 28].

⁷⁶ Bouasse, *Cordes et membranes*, p. 131.

⁷⁷ Plassiard, *Des cordes harmoniques*, p. 11; Bouasse, *Cordes et membranes*, pp. 150-51.

⁷⁸ Betocchi, *Forze produttive della provincia di Napoli*, vol. 2, p. 292.

Messrs Carlo Schmidl of Trieste: 'Quinta perfetta o Weichold'.⁷⁹ Germany even imported Neapolitan strings and re-exported them perfectly rectified as 'Italian from Naples and Rome'. Jealous of their tradition but incapable of developing themselves, in 1933 the manufacturers in these two cities were still hoping to emulate the Germans.⁸⁰ As we shall now see, however, by that date other materials had already made gut chanterelles obsolete, including the 'perfect fifth'.

§5.5. SILK AND STEEL. For bowed instruments, silk is mentioned in Italy as early as 1640, by Giambattista Doni. In order to differentiate the timbre of two of the pseudo-Greek modes he intended to reintroduce into musical practice, this author proposed to employ gut for the 'more brilliant' of the two and to 'adapt the other with strings of twisted raw silk, which, finished in a certain way that we have discovered, provide an excellent sound'. He adds that in China and Persia 'the thin strings are not made of any other material', so that very probably he got the idea from Pietro Della Valle, who had returned from a long trip to the Orient and was his collaborator in his musical experiments.⁸¹ (In this connexion, Mersenne adds that the Chinese used

such strings even for their 'harpsichords').⁸²

Silk strings were introduced in France about 1803, thanks to a process invented by Baud.⁸³ As a result of its approval by François-Joseph Gossec, it saw a certain popularity during that century, also as a version known as 'acribelle', without ever managing to enter into 'common use'.⁸⁴ Their manufacture in Venice started about 1830, apparently employing original techniques devised by the 'mechanician' Locatelli. Barberi and Beretta's musical dictionary (1869) states that those produced in Italy 'need not envy the French ones and may, by chance, even be better'.⁸⁵

Unwrapped steel chanterelles were only introduced for violins in 1883, at the suggestion of Giuliano Hubar. At a demonstration at the Liège Conservatoire it was noted that their greatest defect was that of over-tiring the right wrist, since greater effort was needed for the bow to make them vibrate.⁸⁶ In Italy, in 1899, their 'sharp and oscillating' timbre was not particularly appreciated.⁸⁷ In 1904 the previously cited pricelist of Messrs Schmidl offered violinists as many as four different kinds of chanterelle: gut, silk, acribelle and steel.⁸⁸ Again in 1937-38 this last-mentioned material was criticised for its not very 'sweet and continuous' sound and

⁷⁹ See footnote 56. This type of string is also mentioned in 1925, by Bachman, *Encyclopedia of the Violin*, p. 153.

⁸⁰ Franco Tufari, 'Corde armoniche', *Artigianato degli strumenti musicali. Atti della riunione di esperti tenutasi in Napoli il 25 e 26 giugno 1932-X* (Florence: Vallecchi, 1933), pp. 61-63.

⁸¹ Giambattista Doni, *Annotazioni sopra il compendio de' generi e de' modi della musica* [...] (Rome: Fei, 1640), p. 349: '[...] mantenendosi le corde di minugia in quel sistema, che vorremo sia più spiritoso, accomodare l'altro con le corde di seta cruda ritorta: le quali acconcie in certa maniera da noi ritrovata, rendono un buonissimo suono; et peraltro s'usano ne' Regni della Cina, et di Persia: dove le corde sottili de gl'istrumenti d'altra materia non si fanno'.

⁸² [Marin Mersenne,] *Questions harmoniques* [...] (Paris: Villery, 1634), p. 146: 'Les Chinois mettent à leurs espinettes et autres instrumens, des cordes de soie crüe retorte, qu'ils preferent aux nostres de boyau ou de metal. (Car le Pere de la Croix et Mendosa soutiennent contre Trigault qu'ils ont de tout temps l'usage des clavecins.)' On the Chinese origin of silk strings, see also John Downing, 'Chinese Catlines', *FoMRHI Quarterly* 78 (Jan. 1995) p. 24 (Comm. 1319). Werner Bachmann, *The Origins of Bowing* (London, OUP: 1964), pp. 78-82 notes that silk and metal strings were known from the Middle Ages.

⁸³ [Baud,] *Observations sur les cordes à instrumens de musique tant de boyau que de soie; suivies d'une lettre du C. Gossec au C. Baud; du Rapport du C. Gossec à l'Institut national, sur les cordes de soie du C. Baud; et de l'extrait du Procès-verbal de l'Institut national, relatif à ce Rapport* (Versailles: Pierres, 1803). On the subject see Cohen, 'A Cache of 18th-century Strings'.

⁸⁴ Adrien de La Fage, 'Ragguaglio della parte musicale dell'Esposizione Musicale di Parigi', *Gazzetta musicale di Milano* 14 (1856) pp. 49-52.

⁸⁵ Pietro Lichtenthal, *Dizionario e bibliografia della musica*, vol. 1 (Milan: Fontana, 1836), pp. 205-206 ('Corde'); Antonio Barberi, Giovanni Battista Beretta, *Dizionario enciclopedico universale dei termini tecnici della musica* [...], vol. 1 (Milan: Pirola, 1869-72), pp. 446-7 ('Corde armoniche'): 'Corde di seta vennero fabbricate con nuovi metodi [as compared to Baud's] dal meccanico Locatelli di Venezia e da altri, e si continua a farne anche adesso, e, a quanto sembra, null'hanno da invidiare a quelle di Francia, se, per avventura, non sono anche migliori'.

⁸⁶ 'Alla rinfusa', *Gazzetta musicale di Milano* 38 (1883) p. 34. The diameter normally used at the end of the century for unwrapped steel was 0.26 mm: Auguste Tolbecque, *L'art du luthier* (Niort: chez l'auteur, 1903), pp. 129-30.

⁸⁷ Leandro Passagni, *Il violino* (Milan: Pigna, [1899]), p. 13 ('aspro e oscillante').

⁸⁸ Mentioned in footnote 56.

metallic timbre, and its use was advised only for home practice purposes.⁸⁹ In 1939 the violinist Remy Principe stated that the gut E was then ‘little used’ because it was too sensitive to climatic variations and perspiration, as well as not being strong enough for the ‘pitch in use’. Steel was preferred, despite its defects of timbre, lower sound volume and slow response to the bow.⁹⁰ A further defect of the gut E was that, owing to abrasion by bow and fingers, it became ‘false’ after about 60 hours’ playing.⁹¹ It was the steel E, however, owing to its much higher Youngs modulus, that prompted the introduction of the fine-tuner screw on chanterelles.

§6. PITCH AND STRINGING

The tables given above in §5 show that, even for the same type of string, there was a fairly wide range of diameters. Stringing was sometimes denominated *di grosso* (Table 5), or *faible* or *un peu plus forte* (Table 10), depending not only on the performer’s preference, but also on the pitch adopted. For example, in order to lower the pitch of a fretted viol, to suit singers, Silvestro Ganassi (1542) advised pushing the bridge closer to the tailpiece and ‘using strings as far as possible thicker than usual’; if the pitch had to be raised, the bridge should be moved in the opposite direction. This, he implies, provides proper resistance under the bow. He recommends that this operation must suit the tension of the ‘thin strings’, i.e. those under greatest stress. He concludes that when in doubt it is best to keep the pitch slightly low, in order (as he tells us was recommended by Nicolas Gombert

(c1495-c1560)) not to tire the voices and at the same time ensure that the strings emit a ‘sweeter harmony’ and avoid breaking.⁹²

In his introduction to *Florilegium secundum* (1698), Georg Muffat states that the French pitch was one or even one-and-a-half tones lower than German pitch. He adds that he too would prefer it low like the French, in such a case ‘using somewhat thicker strings’.⁹³ His statements are confirmed by various pieces of evidence we shall now examine. In 1756 Leopold Mozart advised, as Ganassi had, that thinner strings are well-suited to violins tuned to a high pitch, and *vice versa*.⁹⁴ Leopold mentions this fact again indirectly in a letter written from London in November 1764, in which he says that violins in London and Paris were strung more heavily than in Austria, and that the pitch was ‘very low’ in the French capital.⁹⁵ Anton Felix Schindler, the conductor who was one of Beethoven’s closest friends while he was working in Vienna, informs us in about 1816 that this had considerable effects on the acoustic performance of stringed instruments. He states that German musicians visiting Paris were struck by the fullness of the sound of French orchestras and attributes this quality to the low pitch they used, which meant that much thicker strings could be employed.⁹⁶ This explains why, as La Lande states in 1769, the Neapolitan *cordari* sent ‘thinner strings’ to Germany than to France and England.⁹⁷ Reliable information about the stringing of the violin family during Beethoven’s time is provided by the German violinist and conductor Franz Joseph Fröhlich, confirming the smaller diameters mentioned above (see Table 8).⁹⁸

⁸⁹ Giuseppe Strocchi, *Liuteria, storia e arte* [...] (Lugo: Cortesi, 1937), p. 217 (he also criticises the sonority of silk chanterelles, used – he says – especially by those with sweaty hands); Corrado Rovini, *Il violino* [...] (Pisa: Nistri-Lischi, 1938), p. 162.

⁹⁰ Giulio Pasquali, Remy Principe, *Il violino* [...] (Milan: Curci, 1939), p. 42.

⁹¹ Bouasse, *Cordes et membranes*, p. 151.

⁹² Silvestro Ganassi, *Regola Rubertina* (Venezia: presso l’autore, 1542), pp. 13-14.

⁹³ Bruce Haynes, *A History of Performing Pitch. The Story of ‘A’* (Lanham, Maryland, and Oxford: The Scarecrow Press, 2002), pp. 148, 206. Haynes corrects a mistaken interpretation of the text, made by Arthur Mendel (1978), who had in turn led other commentators of the same passage to the opposite conclusions.

⁹⁴ Leopold Mozart, *Gründliche Violinschule* [...] (Augsburg: Lotter und Sohn, 1787), p. 8 (the first edition of 1756 contains these remarks). He adds (pp. 8, 102) that thicker stringing is also advisable if the violin is a large model, and in order to strengthen one’s fingers. This must have been known to Paganini as he often practiced on a large violin strung with strings ‘almost as big as those of a violoncello’: Conestabile, *Vita di Nicolò Paganini*, p. 55.

⁹⁵ *Mozart Briefe* [...] ed. Wilhelm A. Bauer and Otto E. Deutsch, vol. 1 (Kassel: Bärenreiter, 1962), p. 177.

⁹⁶ Arthur Mendel, ‘Pitch in Western Music since 1500. A Re-examination’, *Acta musicologica* 50 (1978) pp. 1-93: 84.

⁹⁷ La Lande, *Voyage*, p. 413.

⁹⁸ Franz Joseph Fröhlich, *Vollständige theoretisch-praktische Musikschule* [...] (Bonn: Simrock, [1810-11]), part 4, pp. 7-8 (‘Allgemeine Bemerkungen für die Geigeninstrumente’). Fröhlich’s violin G is in perfect agreement with the prescriptions given in 1791 by Galeazzi, *Elementi teorico-pratici di musica*, vol. 1, p. 75 (*seconda non molto grossa*). For the C of the viola, Galeazzi prescribes to use a violin D as a core; this would suggest the equivalence: viola D = (thin) violin D.

Instrument	1st string	2nd string	3rd string	4th string
VIOLIN	D _E n° 17 = 0.52 mm n° 16 = 0.63 mm	D _A = more than ⅓ larger than D _E n° 15 = 0.73 mm n° 14 = 0.85 mm	D _D = still more than ⅓ larger than D _A n° 12 = 1.07 mm n° 11 = 1.21 mm	G string: wound on a thin D _A
VIOLA	D _A = no info	D _D ≈ little more than ⅓ larger than D _A	G string: wound on a D _A	C string: wound on a thin D _D
CELLO	D _A = a thin D _D of the violin	D _D = ⅓ larger than D _A	G string: wound on a D _A	C string: wound on a D _D , but with a thicker wire than viola C
DOUBLE- BASS	D _G n° 2 ≈ 3 mm	D _D little larger than n° 1 ≈ 4 mm	D _A n° = bottom gauge hole ≈ 5-6 mm	E string: wound on a D _D

Table 8. *Stringing of the violin family in the early nineteenth-century Germany (Fröhlich, 1810-11). D = diameter, n° = gauge number of Fig. 7, mm = millimetre conversion taken in scale on the same gauge (Fig. 7(top), below). For the D string of the double-bass Fröhlich recommends thin wire for the covering, to assist the bow to grip the string.*

Robust stringing was also required for the vast and acoustically highly absorbent Italian opera houses. For the *Teatro Regio* at Turin, the contract for the 1768-69 season prescribed for the orchestra: 'as far as violins and violas are concerned, we require they must be strung with *grossi*, as they use to say, that is mounted with thick strings'.⁹⁹ Gaetano Pugnani's preference for this kind of stringing (§5.3) may thus be connected to the fact that he was the first violin in this orchestra.¹⁰⁰

§7. VIOLIN FAMILY: SCALING OF DIAMETERS

§7.1. TENSION vs FEELING. In §4.1 we recalled that a string with a given length, subject to tension T , has a vibration frequency f proportional to the square root of the ratio of T and its mass M , i.e.: $f \propto (T/M)^{1/2}$. Historical documents tell us that the scaling of violin string diameters was calculated according to the following schemes, only the first of which is mentioned before the mid-eighteenth century:

1. *Equal tension*. T is kept constant, so that, going towards the bass, M has to be increased. The diameter of each successively lower string increases by 50% (i.e. by the ratio of a fifth 3:2).
2. *Progressive scaling of tension*. Going towards the bass, T is progressively decreased a little, so that M has to increase less than in the previous

case. This leads to more uniform diameters and less total tension. This scheme was first reported by Giordano Riccati in 1767.¹⁰¹ Whereas Riccati indicates a constant scaling ratio of tensions (0.67), in 1806 the abbé Sibire mentions (on the basis of notes made by the luthier Lupot) variable ratios between one string and the next. Lupot scaled tension arithmetically rather than geometrically, leading to a proportionally smaller size for the treble string.¹⁰²

Both these schemes were later justified in various ways, often using questionable arguments of a physical-mathematical kind: equal feeling when plucking the strings, equal resistance to the bow in passing from one string to another, uniformity of tone quality across the strings, load symmetry on the soundboard, etc.

In 1855-74, Joseph-Antoine Plassiard worked out a solution on a physical-mathematical basis half way between Riccati's and the equal tension theory. He concluded that the optimal ratio of diameters between two adjacent strings is 1.355 (which corresponds to a 0.82 ratio of tensions). This is very close to the ratio adopted in Germany at Beethoven's time (see Table 8 above). Plassiard also carried out experimental investigations of diameter scaling and the decrease in density that strings undergo when stretched on the instrument. His results

⁹⁹ Marie-Thérèse Bouquet, *Il teatro di corte dalle origini al 1788* (Turin: Cassa di Risparmio, 1976; collana *Storia del Teatro Regio di Torino*, Alberto Basso coordinatore, vol. 1), p. 177: 'quanto a violini e viole, se esigge che sieno montati di grossi, come si suole dire, cioè armati di corde grosse'.

¹⁰⁰ Alberto Basso, *Il teatro della città dal 1788 al 1936* (Turin: Cassa di Risparmio, 1976; collana *Storia del Teatro Regio di Torino*, Alberto Basso coordinatore, vol. 2), pp. 26-28.

¹⁰¹ Barbieri, 'Giordano Riccati', p. 26; Segerman, 'Strings through the ages', p. 55.

¹⁰² Plassiard, 'Des cordes harmoniques', p. 34 (tensions scaling down in the ratio 19:17:15:13).

are summarised in Table 9. This shows that his theoretical ratio of tensions between two adjacent strings rises from 0.80 (e.g. = 7.00:8.75 before the string is tightened) to 0.82 (= 6.75:8.25 tightened), which is slightly closer to equal tension conditions (ratio 1.00).¹⁰³

	E	A	D	G
Calculated tension of the string not mounted, new (kg)	8.75	7.00	5.62	4.50
Actual tension after mounting (kg)	8.25	6.75	5.50	4.50
Drop of tension (%)	-6.0	-3.5	-2.0	—

Table 9. *Tension difference in violin strings (J.-B. Vuillaume) between the theoretical value calculated prior to mounting and the value needed in the actual tuning, owing to the fall in linear density due to the stretching of the string: Plassiard's data, 1879.*

Plassiard's data show that, when not mounted, the density of violin gut strings was 1600 kg/m³ for the chanterelle, 1500 kg/m³ for the second, and 1300 kg/m³ for the third.¹⁰⁴ Other French authors at the time assumed the density of all three was the

same.¹⁰⁵ Although Plassiard's measured densities for the chanterelle and the second are difficult to believe and may even be erroneous, this should warn us to be prudent in calculating gut string diameters when the documentation does not provide the value. The introduction of progressive scaling of tension did not cause the complete abandonment of equal tension stringing, which continued to have its supporters (e.g. Durutte), as can be deduced from Table 10.¹⁰⁶

§7.2. THE DILEMMA OF THE VIOLIN 3RD STRING. According to Brossard (c1711) and Laborde (1780), French violinists used open-wound D strings for most of the eighteenth century.¹⁰⁷ In 1806 Baud tells us that at his time it had become plain gut again. Owing to its considerable diameter, it caused 'the inconvenience of being muted itself and of making also the neighbouring strings muted'. He therefore proposed an overspun D on a silk core.¹⁰⁸ The negative effect on neighbouring strings was evidently due to the need to reinforce the bass-bar. A similar effect on the open C of the violoncello will be seen in §7.3.

Baud's proposal, based on the concept of homogeneous timbre, was taken up by the luthier Lapaix, as well as by string specialists such as

Source	E	A	D	G
Delezenne, 1853 (D, mm), <i>mince</i>	0.61	0.82	1.02	wound on 0.91 gut
Idem, <i>épais</i>	0.70	0.96	1.39	wound on 0.99 gut
Durutte, 1855 (D, mm), <i>faible</i>	0.60	0.90	1.35	0.15 brass on 0.90 gut
Idem, <i>un peu plus forte</i>	0.65	0.975	1.462	0.16 brass on 0.975 gut
Simoutre, 1900 (T, kg) [D, mm]	8-9 [0.62-0.68]	6-7 [0.81-0.90]	6-6.5 [1.21-1.30]	6
Tolbecque, 1903 (D, mm)	0.60	0.80	1.15	0.14 silver (or copper) on 0.85 gut

Table 10. *Violin stringing: D = diameter, T = tension. In Simoutre, the [D] have been calculated assuming a' = 435 Hz, gut density = 1300-1400 kg/m³, vibrating length = 0.33 m, in the worst configuration both of the density and T.*

¹⁰³ Plassiard, 'Des cordes harmoniques', p. 18.

¹⁰⁴ Plassiard, 'Des cordes harmoniques', p. 14.

¹⁰⁵ Durutte, *Esthétique musicale*, p. 17 (assumes 1385 kg/m³); Charles-Édouard-Joseph Delezenne, *Expériences et observations sur les cordes des instruments à archet*, offprint from *Mémoires de la Société des sciences, de l'agriculture et des arts de Lille*, vol. 31 (1863) pp. 91-114 (Lille: Danel, 1853), p. 15 (assumes, as an average, 1265 kg/m³).

¹⁰⁶ Delezenne, *Expériences*, p. 20; Durutte, *Esthétique musicale*, p. 17; N.-E. Simoutre, *Aux amateurs du violon - Historique, construction, réparation et conservation de cet instrument*, 3rd edn. (Paris: chez l'auteur, 1900), p. 56 (Simoutre was a luthier); Tolbecque, *L'art du luthier*, pp. 129-30 (in his preface he states that besides being a luthier, he has played in orchestras for 40 years).

¹⁰⁷ Barbieri, 'Giordano Riccati', p. 34. A 'wound' D is also mentioned by [Louis de] Jaucourt, 'Violon', *Encyclopédie* [...], vol. 17 (Neufchâtel: Faulche, 1765), pp. 317-321: 319 (G and D 'sont filées d'argent ou de cuivre').

¹⁰⁸ [Baud,] *Observations*, pp. 23-4: 'le re n'étant plus, comme autrefois, à demi filé, et ayant déjà, par la grosseur qu'il a fallu lui donner pour résister à l'archet, l'inconvénient d'être sourd pour son compte et d'assourdir encore les cordes voisines [...]'.

Source	A	D	G	C
Raoul, c1797 (n° of strands)	7-8	12-13	wound on an A	wound on a D
Romberg (D, mm: from Figure 7)	1.46	2.00	wire on 1.26 gut	wire on 1.72 gut
Lapaix, 1853; from Plassiard, 1879, <i>faible</i> (T, kg) [D, mm]	12.59 [1.13-1.17]	9.64 [1.49-1.54]	8.55	12.39
Idem, <i>forte</i>	17.46 [1.33-1.38]	13.05 [1.73-1.80]	10.02	13.24
Durutte, 1855 (D, mm)	1.10	1.65	60.17 brass on 1.10 gut	0.26 brass on 1.65 gut
Tolbecque, 1903 (D, mm)	1.20	1.40	0.15 copper on an A	0.37 copper on a D

Table 11. Violoncello stringing: D = diameters, T = tensions. In Lapaix, the [D] have been calculated assuming $a' = 435$ Hz, gut density = 1300-1400 kg/m³ (for each of the two extreme values), vibrating length = 0.68 m.

Delezenne (1853) and Plassiard (1855-79). It encountered resistance, however, not only among violinists (in the same year of 1853 Delezenne confesses that few of them had allowed themselves to be convinced), but also from La Fage, an authoritative musicologist.¹⁰⁹ Indeed, during the same period, Durutte (1855) and the *Manuel du luthier* (1869) mention only plain gut thirds.¹¹⁰ Again in 1879 Plassiard affirmed that the overspun D had been esteemed by various *artistes*: 'some regret the absence of the melancholy sounds produced by the big plain string, while others were seduced by the richness of the sound and the ease with which musical sounds were produced'.¹¹¹ We can see it was the anomaly in the timbre itself that fascinated performers at the time, in spite of the homogeneity aimed at through using the scaling rules seen in §7.1. This is confirmed again in 1927 when Greilsamer informs us that

the use of strings wound with aluminium had not become widespread, 'probably because it takes away the characteristic timbre of the D-string'.¹¹² Similar problems were probably the cause, in the previous century, of the long delay in adopting the overspun G. The situation was no different in Italy, since the data for 1834 [C], 1904 (Trieste catalogue cited in footnote 56), 1905 (Gandolfi), and that provided by Tiby as late as 1933 agree in reporting the exclusive use of a plain gut D.¹¹³ Only in 1939 does the violinist Remy Principe state that the latter string was often replaced by a 'chanterelle overspun with aluminium, which has greater sonority and clarity'.¹¹⁴

§7.3. VIOLONCELLO. The inventories given in §1 provide little information about violoncello stringing. The reason for this is supplied indirectly by the cellist Jean-Louis Duport, according to

¹⁰⁹ Delezenne, *Espériences*, p. 26; Plassiard, *Cordes harmoniques*, p. 19; La Fage, 'Ragguaglio', p. 51.

¹¹⁰ Durutte, *Esthétique musicale*, p. 17; J.-C. Maugin, W. Maigne, *Nouveau manuel complet du luthier* [...] (Paris: Roret, 1869), p. 222 (in which the third string is stated as having 'a mass three times' the chanterelle, i.e. a diameter that was 1.74 times bigger).

¹¹¹ Plassiard, *Cordes harmoniques*, p. 19: 'les uns regrettaient l'absence des sons mélancoliques de la grosse corde nue; les autres étaient séduits par la richesse des sons et la facile production des sons harmoniques'.

¹¹² Lucien Greilsamer, 'La facture des instruments à archet', *Encyclopédie de la musique et dictionnaire du Conservatoire*, ed. Albert Lavignac, part II (Paris: Delagrave, 1927), pp. 1708-1752: 1738: 'Depuis un certain nombre d'années, on a fabriqué des troisièmes cordes de violon munies d'un trait en aluminium. [...] Son usage est très séduisant, mais il ne s'est pas généralisé, probablement parce qu'il enlève à la corde de ré le timbre qui la caractérise'. He then goes on to condemn steel chanterelles.

¹¹³ Riccardo Gandolfi, *Appunti intorno agli strumenti ad arco* (Florence: Galletti e Cocci, 1905), p. 11; Ottavio Tiby, *Acustica musicale e organologia degli strumenti musicali* (Palermo: Industrie riunite edit. siciliane, 1933), pp. 167-8. This is confirmed by the catalogue of the *cordaro* Roberto Salerni (Salle, 1931): for the three top strings of the violin, only plain gut is mentioned [B, Table II]. Of Salerni, a violin A string of this type is still in existence, with a fairly robust diameter (0.91 mm, medium twist), i.e. similar to the A = 0.89 mm given by Giordano Riccati in 1767 [B, II.6] and some of those listed in Table 10 above.

¹¹⁴ Pasquali, Principe, *Il violino*, p. 42: 'Al re di budello si sostituisce spesso un cantino foderato di alluminio che ha

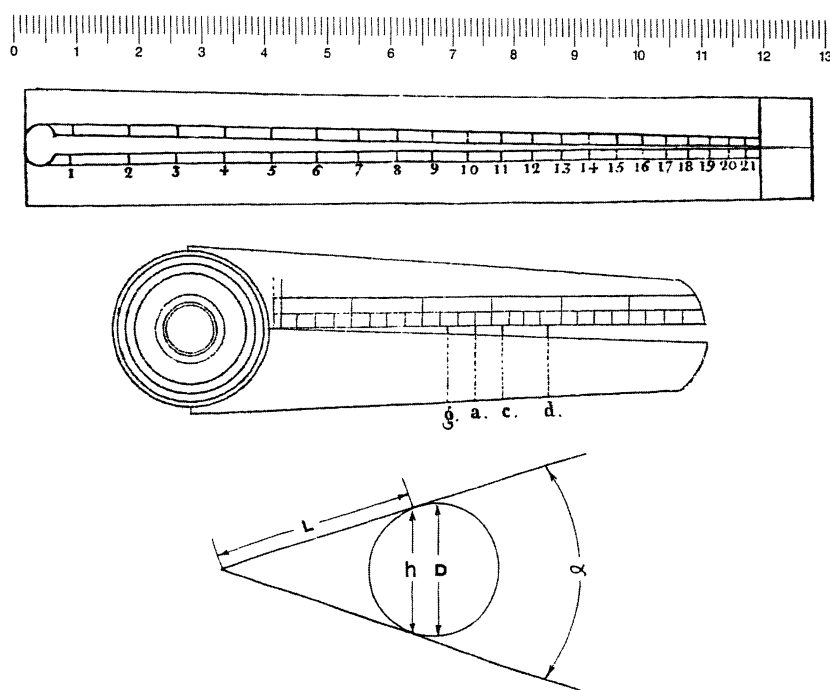


Figure 7. String-gauges (scale shows cm). (top) Franz Joseph Fröhlich, *Vollständige theoretisch-praktische Musikschule* [...] (Bonn: Simrock, [1810-11]), part 4, p. 7. (middle) Bernhard Heinrich Romberg, *A complete theoretical and practical school for the violoncello* (London: Boosey & C, [c1840]), Fig. W (also in *Idem*, *Méthode de violoncelle* [...] (Paris: Lemoine, [c1840])). Using the symbols given in the diagram (bottom) it can be demonstrated that the string diameter D is given by: $D = h / \cos 0.5\alpha = 2L \tan 0.5\alpha$. Since the angle α of the real string-gauges is very small (less than 2° : in the figure it has been greatly increased), it can be assumed that $D \propto h$, with a tolerance of less than 0.1%. As Fröhlich warns, D reduces a little when the string is under tension.

whom the violin chanterelle 'often breaks', whereas 'our own four strings on the contrary are very strong and rarely break: once tightened, they move little'.¹¹⁵ In 1767 another cellist, Jean-Marie Raoul, gives the number of strands employed for the A and D, while for the two lower strings he merely says that they were wound on an A and a D respectively (Table 11). Since the quality of the

gut varied according to the type of string (§2), the diameters cannot be deduced from this data.¹¹⁶ The Neapolitan pricelist dated 1834 agrees with Raoul, also letting us know that a violin third was used as the cello first (Table 6 above). This was also the practice in Germany in Beethoven's time, as shown in Table 8. The diameters that can be calculated from this table are rather small. Only a few decades later, we can deduce from Romberg's string-gauge that the famous cellist used decidedly robust stringing (Figure 7 and Table 11).¹¹⁷

In 1879 Plassiard observes that, according to 'the performers' opinion' and unlike the violin and the viola, a violoncello's fourth string (C) 'has to be tighter' than the third (G). This anomaly is confirmed by the stringing provided by the luthier Lapaix for Delezenne in 1853 (Table 11). He adds that 'the considerable strengthening of the bar made necessary by the great tension of the C must attenuate the sound of the G', just as we have seen for the third string of the violin (§7.2).¹¹⁸ After Romberg, however, much thinner strings were used (Table 11).

§7.4. DOUBLE BASS. Data about double-bass stringing is even rarer than for its smaller relatives. Before the nineteenth century we know only that at Naples, in 1765-66, the lowest string comprised

¹¹⁴ (continued) *maggior sonorità e chiarezza*. For the string-makers of Salle, perhaps over-attached to their tradition of plain gut, the competition of the "Euterpe" and "Pirastro" strings had begun to be unavoidable. As far as Salerni is concerned, it appears that in 1957 he had still not solved the problem of overspinning some of the strings of the violin and viola [Bd, 1934, 1957]. In about 1950 a major move in this direction had been made by the violinist and acoustician Gioacchino Pasqualini [Bd, 1950a, 1950b, 1951] and the distinguished luthier Piero Sgarabotto [Bd, 1950c].

¹¹⁵ Jean-Louis Duport, *Essai sur le doigté du violoncelle* (Paris: Imbault, [c1813]), p. 132: 'la chanterelle du violon est très-déliée et casse souvent. Nos quatre cordes sont au contraire très-fortes et cassent rarement; une fois qu'elles ont prises leur tension, elles se dérangent peu'.

¹¹⁶ Jean-Marie Raoul, *Méthode de violoncelle* [...] (Paris: chez Pleyel, [c1797]), p. 3.

¹¹⁷ Bernhard Heinrich Romberg, *A complete theoretical and practical school for the violoncello* (London: Boosey & C, [c1840]); *Idem*, *Méthode de violoncelle* [...] (Paris: Lemoine, [c1840]), Planche, Fig. W.

¹¹⁸ Plassiard, *Cordes harmoniques*, p. 30: 'Le fort barrage qui nécessite la grande tension de l'Ut doit affaiblir le son du Sol'.

	TUNED BY FIFTHS			
Source	A	D	G	C
Delezenne, 1853	3.8	3.9	4.1	no C string
Whiters (Plassiard, 1879), mm	3.15	4.20	5.65	no C string
Other English (Plassiard, 1879)	2.80	3.95	4.56	no C string
Tolbecque, 1903	2.90	3.70	0.43 silver plated copper (or <i>maillechort</i>) on 3.55 gut	no C string
	TUNED BY FOURTHS			
Source	G	D	A	E
Tolbecque, 1903	2.95	3.70	0.43 silver plated copper (or <i>maillechort</i>) on 3.55 gut	double wound: 0.31 iron plus 0.46 silver plated copper (or <i>maillechort</i>) on 4.50 gut
Tiby, 1933	2.50	3.33	wound	wound

Table 12. Double bass stringing: diameters, mm (all the above double basses tuned by fifths have only three strings). One may doubt the reliability of Delezenne's figures as they are surprisingly similar to each other.

120 guts.¹¹⁹ For subsequent periods, see Table 12. For a double bass tuned by fifths (G-D-A), the diameter of the A provided by Delezenne in 1853 (3.8 mm) gives a fairly robust string.¹²⁰ In contrast, weaker stringing was adopted by two English luthiers at the end of the century. They employed plain gut only (even for the G) and a scaling of tensions close to what Plassiard considers ideal (Table 12).¹²¹

In Italy, tuning by fourths was customary: (E)-A-D-G, initially limited to the three high strings, as at Naples in 1834 [C]. Giuseppe Baldantoni (1784-1873) is deemed the first to introduce overspun strings on the Italian double bass.¹²² As with the violoncello, string diameters decreased progressively during the twentieth century (Table 12).

§8. PLUCKED STRING INSTRUMENTS

The following documents supplement or modify

what is already common knowledge from the literature on the subject.

§8.1. LUTES. At least as early as 1599, the strings of the medium and high registers were of 'reinforced' type (Table 3), and were rather apt to break. In 1727 the German Ernst Gottlieb Baron wrote that 'the chanterelle caused the most vexation' when the lute's pitch was high but that, after being lowered by one tone, 'there are instances where a Roman string [i.e. the chanterelle] lasted four weeks'.¹²³ For the basses, the *cordoni* called 'sevenths' (*settima*), mentioned in Table 1 for the harp (1638-40), could have a connection also with the seventh course of the lute.¹²⁴ In 1686, and this is our most ancient witness concerning the use of silk for the lutes, Lana Terzi reports that some preferred silk strings for the bottom register.¹²⁵ Covered strings are mentioned in 1731 when a traveller from Bologna, visiting

¹¹⁹ La Lande, *Voyage*, p. 410. According to Athanasius Kircher, *Musurgia universalis*, vol. 1 (Roma: Corbelletti, 1650), p. 440, in Rome the five strings of the *violone* were manufactured with 200, 180, 100, 50, 30 guts respectively.

¹²⁰ Delezenne, *Espériences*, p. 20.

¹²¹ Delezenne, *Espériences*, p. 20; Plassiard, *Cordes harmoniques*, p. 33; Tolbecque, *L'art du luthier*, pp. 129-30; Tiby, *Acustica musicale e organologia*, p. 168.

¹²² Riccardo Gabrielli, 'I liutai marchigiani', *Note d'archivio per la storia musicale*, 11 (1934) pp. 58-65: 61. At least as early as 1681 a double bass 'with silver strings' is mentioned among the instruments of cardinal Benedetto Pamphilj in Rome: Lina Montalto, 'Fra virtuosi e musicisti nella corte del card. Benedetto Pamphilj', *Rivista italiana del dramma* 5, (1941), pp. 83-97; 96 ('il contrabasso di Teodosio dalle corde d'argento').

¹²³ Douglas Alton Smith, *A History of the Lute from Antiquity to the Renaissance* (no place: The Lute Society of America, 2002), p. 86.

¹²⁴ On the actual use of this 'seventh course' see Stephen Bonta, 'Catline Strings Revisited', *Journal of the American Musical Instrument Society* 14, (1988) pp. 38-60: 56.

¹²⁵ Lana Terzi, *Magisterium naturae*, vol. 2, p. 433: after saying that strings 'ovinae maxime in usu sunt' adds that 'fides sericas crassiores in testudinibus aliqui maxime approbant'. Up to now, the sole reference to silk in that

Augsburg, tells us that he saw an unusual keyboard instrument ‘with overspun strings like the lute’.¹²⁶ He does not state whether this was one of the new lutes, reported after 1719 in Germany, whose range had been extended by a 13th course in the bass.¹²⁷ In 1757 overspun strings on guitars were accused of blurring the bass (owing to their more brilliant and prolonged sound) and of wearing the frets.¹²⁸ Finally, in §1 we saw that in 1630–41, great quantities of strings were dispatched from Rome to Lyons, including some for the ‘lutes used in France’, expressly manufactured ‘like the sample’ given by French Merchants to the *cordari* of the Roman area [*Bd*, 1640a, 1641c]. A possible interpretation is that the latter were intended for the 11-course lute, which was developing in that country from the 1620s, while the Italians continued to use the old tuning.¹²⁹

§8.2. GUITARS. The earliest information concerns the commercial activities of the Roman string-maker Tiburzio Tuzi. We learn from his will (1646) that he ordered cases containing prefabricated soundboards for the Spanish guitar from the Venetian luthier Giorgio Sellas, which he then re-sold to the Roman *chitarrari* such as Magno Nolle and Bartolomeo Frezza [*B*, §I.4.2]. Tuzi was undoubtedly an ideal middleman, as he traded with both foreign and Roman luthiers whereas for most of the latter, contacts outside Rome appear to have been rare. Tuzi, who may not have been the only such trader, thus fostered a type of connection between the luthiers of the two cities, and the impact on types of string instruments deserves investigation.

During the *Seicento* no specific detail emerges: we have only generic mentions of ‘white’ and ‘red’ gut strings, including *di grosso*, for guitars [*Bd*, 1677a]. In the following century, however, the fashion for stringing guitars with metal wire caused serious economic problems for Roman string-makers, to the extent that they reported this crisis to the Papal administration. Their petition was supported by evidence given under oath in 1747 by three of the City’s *chitarrari*. According to this ‘many years ago, the custom was introduced in Rome of using guitars with steel strings, and little by little has grown to such an extent that we currently no longer manufacture guitars with gut strings’.¹³⁰ Other sources confirm that the wire-strung guitars had managed to replace the lute for *basso continuo*, even providing competition, according to Roger North, for the harpsichord.¹³¹ The fashion must have extended to the *colascione*, since one ‘with steel strings’ is recorded in Rome in 1817.¹³² Guitarists later reverted to gut strings. A Neapolitan pricelist of 1834 shows that the diameters employed for guitars did not follow those for the violin, as some believe, but were thinner. Indeed, the price list explicitly states that the first string had only two strands, while for the second and third, a violin first and second were employed respectively (Table 13). The three lowest were then wound on silk, whereas, as we have seen, for bow instruments the same pricelist prescribes a gut core (Table 6). This latter distinction is confirmed both by the *Gazzetta musicale di Napoli* (1854), and Barberi and Beretta’s *Dizionario* (1869).¹³³ The reason for this

¹²⁵ (*continued*) century was the one made by Playford, who in 1664 makes his well-known reference to bass strings overspun on gut or silk: Segerman, ‘Response to Comm 1744 - “Strings of Silk and other Textiles”’.

¹²⁶ Oscar Mischiati, ‘Notizie di storia organaria e cembalaria nelle carte di Giambattista Martini’, *L’organo* 32 (1998-1999) pp. 89-222: 200 (‘[...] e si invitò il seguente giorno ad udire altri strumenti [da tasto] bizari, quali erano di corde di budella come li violini e chiteroni. Altri con corde ramate come il leutto, varij sordini con corde di ottone et altri di budella [...]’). This appears to be the only surviving document referring to this matter.

¹²⁷ Ian Harwood, Diana Poulton, David van Edwards, ‘Lute 3-4’, *The New Grove Dictionary of Music and Musicians*, vol. 15 (London: Macmillan, 2001), pp. 331-343: 342.

¹²⁸ [Anonymous author], ‘Guitarre’, *Encyclopédie* [...], vol. 7 (Paris: Briasson et al., 1757), pp. 1011-1012: 1011. The guitar described here has five double strings (A-D-G-B-E), with those of the A and D tuned to the octave, the only overspun being the lower string of the A (but he adds that Robert de Visé, who did not use overspun, tuned both A strings to the higher octave).

¹²⁹ On the 11-course lute, see Harwood, Poulton, van Edwards, ‘Lute 3-4’, p. 340.

¹³⁰ Barbieri, ‘Cembalaro’, p. 172.

¹³¹ Robert Strizich, ‘L’accompagnamento del basso continuo sulla chitarra barocca - Parte prima’, *Il Fronimo* 9-n° 34 (1981) pp. 15-26: 23-4.

¹³² Rome, Archivio Capitolino, *Archivio Generale Urbano*, sez. 32, vol. 85 (notary Giacomo Scifoni), 26 March 1817: the inventoried goods of a peasant also include ‘Un leuto, ossia calascione con corde di acciaio poco buono, scudi 0.60’. Gut strings for the ‘calascione’ are however recorded in [*Bd*, 1701, 1785b].

¹³³ ‘Strumenti da suono’, *Gazzetta musicale di Napoli* 3 (1854), p. 115 (gut core for the G of the violin, ‘untwisted silk’ core for the lowest three strings of the guitar and for ‘many’ of the harp); Barberi, Beretta, *Dizionario enciclopedico*,

E:	2 strands, 1 <i>tirata</i> (= 1 st mandolin)
B:	3 or 4 strands (both = 1 st violin)
G:	4 or 5 strands (both = 2 nd violin)
D:	Silver on silk, 1 <i>tirata</i>
A:	Silver on silk, 1 <i>tirata</i>
E:	Silver on silk, 1 <i>tirata</i>

Table 13. *Guitar stringing: from the pricelist, Naples 1834 [C].*

differentiation is unknown, especially considering that present-day string-makers deem that a silk core gives a better performance than gut.¹³⁴

§8.3. MANDOLIN. When Jérôme de La Lande visited Neapolitan string-makers in 1769, he reported that their first string was of gut, with two strands.¹³⁵ This is confirmed in the Neapolitan pricelist of 1834, which prescribes the same chanterelle for guitar and mandolin (Table 13). In 1889, Branzoli gives the stringing for the Neapolitan mandolin adopted in the eighteenth century, adding that 'it is tuned even nowadays in various areas of Italy' in this way (Table 14).¹³⁶ His instructions are supported by those published by Giovanni Fouchetti, with some slight variations, in about 1771.¹³⁷ In 1904, the catalogue of Messrs Schmidl of Trieste prescribes four double steel strings for the Neapolitan mandolin (see footnote 56).

§8.4. HARP. Some of the two- and three-course Italian harps of the late sixteenth and early seventeenth centuries could go as low as G' in the bass.¹³⁸ Strings from Florence were particularly in demand for the lowest register. In 1587 the Court of Ferrara made a payment for 'four hanks of thick strings ordered

MI [<i>e''</i>]	two violin chanterelles
LA [<i>a'</i>]	two steel wires
RE [<i>d'</i>]	two metal strings, each made of two brass wires twisted together (called <i>bordone</i>)
SOL [<i>g, g'</i>]	copper wound on a silk core for the <i>g</i> , thin plain gut for the <i>g'</i>

Table 14. *Neapolitan mandolin stringing, eighteenth and nineteenth centuries: according to Branzoli, 1889.*

expressly from Florence for use on His Highness's harps'.¹³⁹ Florentine strings for the *claviarpa* were purchased by the luthier of the Madrid Court in 1658.¹⁴⁰ Furthermore, several Roman inventories (1638-77) record *cordoni* (probably roped strings) made on purpose for the harp (Table 1 above), stating that the said low strings were 'called sevenths'. No reason is given for this latter denomination, nor is it clear whether it had some connexion with the special strings needed for the 7th course of the lute, which was added to the bass from the 1580s. They are in any case sometimes indicated in Table 1 without specifying for which instrument they were intended. For the middle and upper registers, the inventories cited make no particular reference to the harp. However, Bartolomeo Giovenardi, a Roman harpist employed at the Spanish court, mentions 'reinforced strings' for his instrument in his *Tratado de la musica* (1634).¹⁴¹ Although he does not say so, they must have been the same ones already in use for lute and violin (§§5.2, 8.1; Table 3), as in Spain. In the nineteenth century, the oft-cited Neapolitan pricelist of 1834 mentions plain gut strings for the harp ranging from a single strand (and thus even thinner than the ones for guitar and mandolin) up to a maximum of 18 strands [C].

¹³³ (*continued*) vol. 1, pp. 317, 447 (brass on 'untwisted silk' core for the E, A, D of the guitar; G of the violin wound on gut core). In [C], however, the sixth can also be wound on gut.

¹³⁴ Peruffo, 'Le corde per chitarra [...] - Parte seconda', p. 60.

¹³⁵ La Lande, *Voyage*, p. 410.

¹³⁶ Giuseppe Branzoli, *Ricerche sullo studio del liuto* (Roma: Loescher, 1889), p. 54.

¹³⁷ On these latter, see Ephraim Segerman, 'Highly strung' ('Strings through the ages', part II), *The Strad* (March 1988), pp. 195-201: 198.

¹³⁸ Cheryl Ann Fulton, 'Harp, V-5', *The New Grove Dictionary of Music and Musicians*, vol. 10 (London: Macmillan, 2001), pp. 902-908: 904.

¹³⁹ Elio Durante, Anna Martellotti, *Un decennio di spese musicali alla corte di Ferrara (1587-1597)* ([Fasano:] Schena editore, 1982), pp. 25-6, on 25 June 1587: 'quattro gavettoni di corda grossa fatta far a posta in Fiorenza per servitio delle arpe di S.A.'

¹⁴⁰ Madrid, *Biblioteca nacional*, Ms. 14047/184: 'cinco docenas de cuerdas de florenzia que escogió para la claviarpa'. On strings produced in Spain, we know only that the first *ordenanzas* for the string-makers' guild of Madrid appeared in 1679: Cristina Bordas, 'The Double Harp in Spain from the 16th to the 18th Centuries', *Early Music* 15 (May 1987) pp. 148-163: 157.

¹⁴¹ Fulton, 'Harp, V-5', p. 904.

§9. APPENDIX 1.

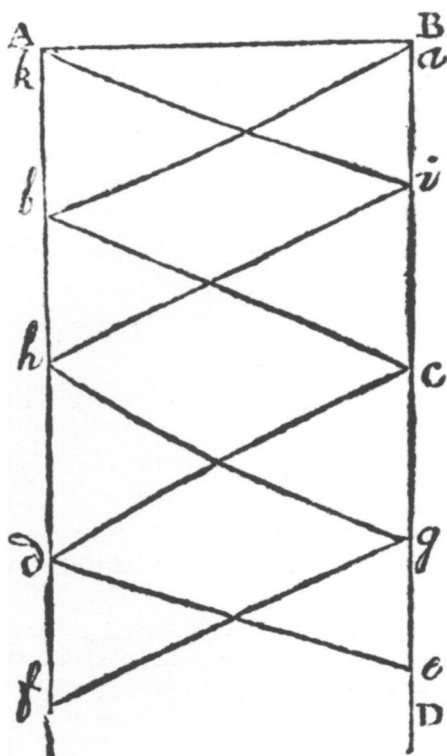
Transcription of the description, by the English tourist Philip Skippon, of string making in Padua, cited as [Sk] in 'Abbreviations used'.

[Padua, end of December 1663]
Making of viol-strings

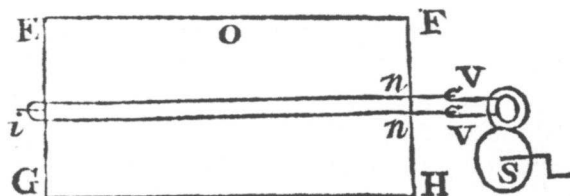
In this city we saw the making of viol-strings, after this manner: First they take the small guts of lambs, weathers, kids, wolves (but use no cats guts), and after they have separated them, and cleansed them from the mesentery, excrements, etc. they put them into the river for half a day, and then keep them for eight or ten days in water mingled in a great tub with a good quantity of *Griepoli*, i.e. tartar, and a small quantity of roach allum.

Note, That this water at the beginning is not so strongly impregnated as at the latter end.

Before they use the water, they scrape off all the fat, etc. with a piece of cane hollowed like an apple scoop; then they take several dishes of the water, and steep the guts in them, and draw them every day twice out of the water, and twice out of dishes without water; thus they are order'd for eight or ten days together; for the oftener they are drawn so, the fairer the strings are made. The workmen have smooth thimbles of brass, through which the guts are drawn. When they are wrought enough, they wind the gut upon the frame *ABCD*, on the pegs *abcdefghik*



The guts are twisted after this manner on a frame *EFGH* fasten'd at *o* to the wall,



The middle of a gut is put about the peg *i*, and the ends of it are fasten'd to the two hooks *vv*, where the gut is twisted by the wheel *S*, till the gut is shortened to the length of the frame; and then the ends *vv* are tied to the pegs *nn*, two sticks being put between the two parts of the twisted gut or string, to keep them from touching one another: Many strings are thus twisted and fastened to the frame, which is put into a pit about the length and depth of a grave, having on one side of it within, a hole where brimstone is burnt, and the pit being shut close with a wooden cover, the smoak of the brimstone smothers within, and makes the strings look white: After an hour or two the frame is taken out, and the strings are exposed to dry; and as the sason of the year is, so they are sooner or later dried; then the strings are oiled by drawing them thorow a piece of hat that is oiled: After they have expos'd them to dry, they take a small rope, made of horse-hair, and steeped in the same liquor where the guts were, and rub it on six or seven strings at a time, and then oil them, and at last tie them up in little bundles for sale.

The smallest strings are made but of one gut, and the younger the animal the finer the string; the greater are made of ten, twelve, and so on to an hundred twisted together.

Note, That the strings are double on each side of the frame.

§10. APPENDIX 2.

The Gut string catalogue pricelist (Naples, 1834) cited as [C] in 'Abbreviations used.

*Fabbrica di corde armoniche di Antonio Putti
sita nelle rampe del Salvatore N. 31, 32, e 33.*

Cantini a due fili per prime di chitarra, per ogni pacchetto	0.60 Ducati
detti a tre fili per seconde	0.90
detti a quattro fili per violino	1.60
Seconde a quattro fili	1.20
Corde colorate, e di argento per vari strumenti, e di diversi prezzi.	

*Fabbrica di corde armoniche dei fratelli Avallone q.m Domenico
sita nel largo Zecca de' Panni al Pendino N. 30*

OGNI PACCHETTO È COMPOSTO DI CORDE 30 TUTTE SENZA GIUNTA	
Cantini a 1 filo per arpa ogni pacchetto	0.30 Ducati
a 2 fili per chitarra, arpa, e mandolino	0.60
a 3 fili per violino di 3 tirate e per 2° di chitarra	0.90
a 4 fili per violino di 3 tirate e per 2° di chitarra	1.20
a 4 fili per violino di 4 tirate e per 2° di chitarra	1.60
a 2 fili per chitarra a 1 tirata	0.30
a 3 fili per violino a 1 tirata	0.30
Seconde a 4 fili per violino, e terze di chitarra a 1 tirata	0.60
a 4 fili per violino di 3 tirate, e terze di chitarra	1.20
a 5 fili per violino, terze di chitarra, e per arpa	1.50
Terze a 7 fili per violino, [prime di] violoncello, ed arpa	2.10
a 8 fili per violino, prime di violoncello, ed arpa	2.40
Bassi a 10 fili per arpa	3.00
a 12 fili per arpa, e seconde di violoncello	3.60
a 14 fili per arpa	4.20
a 16 fili per arpa	4.80
a 18 fili per arpa	5.40
Quarte di chitarra in seta filate di argento per una tirata	0.90
Quinte di chitarra in seta filate di argento per una tirata	1.20
Seste di chitarra in seta, o in budello filato di argento per una tirata	1.50
Quarte di violino in budello filate in argento per una tirata	0.90
Terze di violoncello in budello filate di argento ogni corda	0.15 [sic]
Quarte di violoncello in budello filate di argento	0.24 [sic]
Prime di contrabbasso	0.50
Seconde di contrabbasso	0.70
Terze di contrabbasso	1.20
Corde da battere cotone, lana, ed altro di palmi 24 di prima sorte	0.60
Corde da battere cotone, lana, ed altro di palmi 24 di seconda sorte	0.50
Assortimento di arpa con corde raddoppiate e rollò di latta	6.00

*Fabbrica di corde armoniche di Giuseppe de Guida
sita nel vicolo Cordari alla Fontana dei Serpi al Pendino N. 4*

CORDE BIANCHE OGNI PACCHETTO DI NUM. 30	
Cantini a 1 filo	0.30 Ducati
detti a 2 fili per chitarra, o mandolino	0.60
detti a 3 fili per violino di 3 tirate	0.90
detti a 3 fili di 4 tirate	1.20
detti a 4 fili di 3 tirate	1.20
detti a 4 fili di 4 tirate	1.60
detti a 4 fili di 4 tirate di 84 pollici inglesi	1.80
Seconde a 4 fili per violino	1.20
dette a 5 fili	1.50
Terze a 5 fili, e prime da violoncello	1.80
dette a 7 fili	2.10
dette a 8 fili	2.40
Corde a 10 fili	3.00
dette a 12 fili per seconde di violoncello	3.60
Qualunque altra specie di corde, che si desiderano a più fili, e più lunghe saranno pagate a seconda de' suddetti prezzi.	
Corde colorate di qualunque sorte a' prezzi medesimi.	
Per le corde di contrabbasso, e per battere bambagia, e lana si valuteranno le qualità de' fili agli stessi prezzi.	
Assortimenti di arpa composti in ottave con corde di 8 palmi lunghe, ossia 84 pollici inglesi nella 1, 2, e 3, e raddoppiate nella 4, e 5 ottava; ogni assortimento...	6.00
Ogni sorte di corde filate di argento sopra seta, e sopra corde si pagheranno a prezzi discreti.	