

Early Keyboard Instrument Symposium

Meeting organised by the Edinburgh University
Collection of Historic Musical Instruments
St. Cecilia's Hall, Edinburgh
24-26 October 2008

Saturday, October 25 at 14.40

A Construction Principle in Venetian Harpsichords; what do we measure? - Denzil Wraight

Although I have entitled my talk "A" construction principle, in fact I want to talk about two dimensions in the design and construction of Italian harpsichords, with special reference to instruments made in Venice: the width of the instrument and its length.

There has of course been a great deal of work done over the years by many authors to try and determine how the old makers laid out their instruments and I do not intend to try and review all this work in the limited time available today. I would however like to mention one article published by Stephen Birkett and William Jurgenson entitled "Why didn't historical makers need drawings?" since it contains a lucid and critical review of the different types of methods the organological community has used over the years to analyse the construction of instruments¹. They introduced a terminology which is appropriate for my purposes today. The question is: were instruments designed from the "outside in", or from the "inside out"? That is, did the Italian makers start with case dimensions, perhaps using modular design or geometric construction, and then fit the keyboard and strings to it, or did they start with the keyboard and strings, then build the case around them?

Of course history is rarely so simple that it can be encompassed and constrained by rigid principles. On this occasion of the 40th anniversary of the Russell Collection I would like to pay a small tribute to John Barnes who was for many years in charge of the instruments here. A thought of his has long accompanied me in my own searches that we should be careful not "to impose on history a more orderly progress than actually took place"². Nevertheless, it will be my clear contention today that many Venetian harpsichords were designed from the "inside out". Furthermore, I think it is correct to say that the exact width of the instrument was of secondary importance and that the length of the case spine was probably not even measured. If I am correct in my interpretation that the spine length was derived from other factors, then it follows that we would be mistaken if we tried to describe such a harpsichord from the "outside in". This means that a search for the case length in terms of inches, modular dimensions, or proportions would, for some instruments, be travelling along the wrong route.

The problem is, in analysing old instruments, that one can usually find measurements or proportions which fit some dimensions, even after a case has had its original size

¹ Birkett, S., and Jurgenson, W., 'Why Didn't Historical Makers Need Drawings? Part II - Modular Dimensions and the Builder's *Werkzoll*', *GSI* 55 (2002), 183-239.

² Barnes, J., 1973, 'The stringing of Italian harpsichords', *Der Klangliche Aspekt beim Restaurieren von Saitenklavieren*, ed. Schwarz, V. (Graz, 1973), 35-39; p. 36.

changed! However, rather than analyse the highways and byways of organological thinking on these matters I shall lead you more directly to the observations I have to offer. These have grown from the examination of Italian harpsichords so the data has been empirical, but it has required a long process of data collection, reflection, and the trying out of several types of explanation. The final impulse in the direction my thoughts have taken, did not come until I was "forced", one might say, to think as an organ maker and not simply as a harpsichord maker. This came about through the project to make a small chamber organ based on the instrument by Lorenzo da Pavia of 1494 which was produced in Venice. There has long been a division of trades between organ and harpsichord making, but in the 16th century in Italy there was apparently not such a clear-cut demarcation. In Venice this may have had to do with the guild system where the *corporazione* were less restrictive than the German *Zünfte*. We know that two members of the Trasuntino workshop, Alessandro and Vito, worked on organs. Domenico da Pesaro, whose surviving oeuvre is the largest of any 16th-century string keyboard instrument maker, also produced at least one chamber organ with paper pipes.

However, I need to start the description at a different place in order to guide you through the steps I have taken. When I started examining Italian instruments I became aware of the use of positioning pins at the bridges of harpsichords and virginals. These are usually now only visible as plugged pin holes beside the bridges, and from studying unaltered instruments it became clear that such positioning aids in the layout were used at the *f* notes of an instrument, not at the *c* strings which we nowadays usually measure. This feature was found with such regularity and even on instruments with a compass of C/E-c³, so that I can state that this "f-orientation" was the dominant feature of Italian, 16th-century instrument making. At a later date we find that the larger C/E-f³ compasses were no longer used, but instead C/E-c³ and it is normal in 18th-century instruments to find positioning pins at the *c* notes.

In some Venetian harpsichords we find lines scribed on the baseboard underneath the wrestplank and sometimes extending back through the instrument to the bentside and tail. The 1538 Alessandro Trasuntino harpsichord in Brussels has a full "drawing", one might call it, on the baseboard. The unsigned harpsichord, originally made with split sharps and now in Schloß Köpenick, Berlin, also has a full drawing. The 1579 Baffo harpsichord in Paris also has lines extending deep into the instrument, which are partly visible through holes in the baseboard. These scribed lines are also at the *f* notes and represent more or less accurately the position of the *f*-strings. Since such "drawings" are not always present in harpsichords; one might surmise that they were only used when a new or difficult design was constructed, a design for which patterns or jigs were not available. Virginals rarely had such construction lines: those made in 1548 and 1575 by Domenico da Pesaro are the best examples.

When we consider the spacing of these *f* lines on the baseboard, the question arises how they were positioned and what was the order of construction of case, keyboard and jackslides. The 1579 Baffo harpsichord, I mentioned just now, provides an answer. Beside the string lines there are indentations on the baseboard of what is in all likelihood the mark of a jack which has been placed in the jackslide and then hit with a hammer to leave these marks. When one considers how such jackslides were made it is obvious what order of construction would have been used. The jackslide consists of small blocks glued between two thin strips of wood. The blocks would be

positioned to leave the necessary amount of play for each actual jack. Our method today is to work with standard sizes, and with modern machinery jacks can be produced with a high accuracy. Nevertheless, we can readily appreciate that the cumulative error of only 0,1mm would yield a total error of 5mm across the width of a 50-note keyboard. The Venetian harpsichords we are considering here typically had a 50-note C/E-f³ compass. In practice you will find that the octave width of these string lines varies slightly. If you were to make the keyboard before the jackslide, alignment problems of the jacks with the keylevers would probably result. Thus, starting with the jackslide and aiming for the nominal width of the keyboard enables the jackslide to be trimmed in construction to come within tolerance and the keylevers to be cut to fit *exactly* the slot positions.

So what would the nominal keyboard width have been in a Venetian harpsichord? It turns out that the width of the keyboard at the natural covers is usually the number of notes divided by two, and expressed in Venetian inches. Thus, a C/E-f³ compass, which has 50 notes is often 25 Venetian inches wide, a fact which has not escaped the attention of some other researchers. In a smaller instrument with a C/E-c³ compass, for example the 1548 virginal by Domenico da Pesaro now in Brussels, the keyboard width is nominally 22 1/2 " and the number of notes is 45. As it happens, the *Stichmaß*, the modern measurement we have created for a 3-octave span, is *exactly* the same for both of these compasses, that is, 506 mm (assuming a Venetian inch of 28,95mm), but one can see from another harpsichord by Domenico da Pesaro that the approximately 19" he has used for a compass with 38 notes results in a *Stichmaß* of 491 mm. This is not an isolated example and three keyboard instruments made by Cristofori and Ferrini in Florence show the use of inch measurements across the width of the keyboard which yield *Stichmaß* measurements of 499, 493, and 491 mm. Expressed in other terms, the octave width varied; only the total width was determined.

The issues become fairly complicated here. Birkett and Jurgenson have postulated a rule of thumb that the keyboard width is the number of notes *plus* one, divided by two and expressed as a *modular* inch. That is, the inch unit is not necessarily related to a local measurement, but is used for the instrument. Some Italian harpsichords follow this rule, for example two of the Cristofori or Ferrini harpsichords, but others, including the Venetians I have mentioned, do not. We need not pursue this matter further at this point since the issues are partly practical ones of keyboard or stringband layout, and there may also be unfathomable elements: one virginal by Domenico da Pesaro has a particularly small *Stichmaß* of 485 mm, which makes each octave about 7mm smaller than the "standard" 50-note size I mentioned of 506mm. I recall in this connection Isabella d'Este's instruction to Lorenzo da Pavia that he take account of her small hand size when making a virginal for her.

We need only consider one other detail before we can complete the construction of the width of the instrument. Either side of the keyboard there will have to be some keyboard blocks, because in all but very early Italian harpsichords, the keyboard lies *between* the wrestplank blocks. Thus, a space either side of the keyboard is needed, and this is nominally the same width in the bass and treble, usually about 1 Venetian inch. We find that in many Venetian harpsichords the width of the baseboard, that is, *before* the case sides are added, matches a whole number of Venetian inches. In the larger C/E-f³ compass harpsichord, the baseboard may be 27" wide, that is 25" for the keyboard plus 2" for the blocks. Yet in one harpsichord by Domenico da Pesaro,

made in 1554 and now in Paris, the baseboard width is a credible 24 1/2 Venetian inches and this seems to have resulted from the 45 note compass yielding a 22 1/2" keyboard, to which two blocks of 1" were added. I think most of us would find it a little strange to *start* the width planning with a non-whole number of inches. It seems therefore that we should envisage the maker thinking from the "inside out" and in *actual practice* going through the following steps: jacks, jackslide, keyboard, baseboard width.

We can turn now to the other dimension of the harpsichord: its length. Of course, when I described the procedure of laying out the width of the instrument, I had implied that the position of the jackslide was known. How this was normally derived I cannot say with certainty since the "drawings" we find on the baseboards vary. The front edge of the wrestplank, that is the player's side, appears to have been an important datum line and the bellyrail position is also usually marked. Once these positions have been established, the line of the jackslide is decided. Obviously practical experience enters into the design, that is knowing how long the keylevers need to be and what slope of the jackslide is acceptable or desirable. In all Venetian harpsichords I can recall, the jackslide is not at 90° to the spine, but slopes forward towards the player.

It appears to me that the string lengths were measured in Venetian inches, using the normal commercial measurement where the foot is about 347,4mm, yielding an inch of 28,95mm, but for many years I considered the possibility that there might have been a special "organ makers' " foot which was used by instrument makers. Gastone Vio published a document which showed a drawing from 1707 including the measurement of "piedi organici" of 265mm, as was inferred by comparison with the Venetian foot also illustrated³. This possibility was especially interesting because this is the measurement (within a few mm) used at f² in a number of the 50-note Venetian harpsichords I am talking about today, such as the 1531 Alessandro Trasuntino harpsichord in the Royal College of Music. Thus, such an instrument could be described as an "eight foot" instrument. Whether this was a widely-used reference standard, or a method of measurement existing alongside the Venetian inch has not been determined.

Regarding the empirical data on string lengths, I have been able to measure a large number of lengths between the nut and bridge pins and also find the positions on the soundboard when bridges have been moved so that the data is based on many instruments. Certain string lengths occur with such regularity that we can be sure we are not observing an isolated phenomenon.

As for the string layout, it may well have been that the nut position was laid out as a measurement from the front edge of the wrestplank and that the string band was developed from this. In the 1538 Alessandro Trasuntino harpsichord there is not even a nut line; the strings have been measured backwards from the front edge of the soundboard and end at a curved bridge line. Obviously this was used to develop the case outline, which is usually parallel to the bridge line.

Since I only know of two baseboard drawings which are accessible, the information is limited; the second harpsichord is that I referred to earlier which is in the collection at

³ Vio, G., 'Documenti di storia organaria veneziana', L'Organo 14 (1976), 33-131; disegno per l'organo di S. Margherita.

Schloß Köpenick and was originally made for the court at Ferrara, possibly by the Trasuntino workshop. The 1531 and 1538 Trasuntino harpsichords, although similar in size, are not identical and this complicates the interpretation.

However, what has gradually been distilled from several sources is the following scheme, which I present as a drawing on the handout (reproduced at the end of this file). It represents the string band seen in the case of the instrument. What is evident is that the string scale usually doubles at the octave down to f^1 . Since f^1 is also the string in the middle of the instrument it may have had the significance for the Venetian maker which we now tend to accord to c^2 measurements. Indeed, in the 1531 and 1538 Trasuntino harpsichords f^1 at the bridge, or the apparent bridge line, is 24" from the front edge of the case, and this may have been intended. Thereafter, travelling down towards the bass we encounter the well-known problem that the harpsichord maker after starting with a scale of 9 1/4" at f^2 cannot double the strings at the octaves f and F otherwise he would end up with a string length of 74 Venetian inches, or about 2140mm at F . Since the case lengths used did not permit a bottom C of more than about 1800mm, roughly a whole Venetian foot shorter, it is clear that that the Pythagorean scaling, as we now call it, of doubling at each octave has to be abandoned at some point. The Venetian organ maker of course would be *obliged* to make his open-flued F pipe 74" long since air does not permit otherwise. In the harpsichord we just use thicker strings.

What we find though in this type of Venetian design is that the *theoretical* length of the F string is incorporated into the dimensions of the baseboard, even though the actual string length is shorter. Alessandro Trasuntino has made the case length of the 1531 harpsichord, as measured along the F string line, 74" from the tail to the front edge of the case. In the 1538 harpsichord, which appears to have had slightly shorter strings, probably about 9" at f^2 , we find that he used 72" for the same dimension. So in either case we find the theoretical relationship preserved of $f^2 \times 8 = F$.

I have been able to find six Venetian harpsichords which *clearly* show the expected theoretical F string length as a dimension in the case. There are 10 others which would qualify if one is prepared to admit errors of a cm or so.

In eight instruments this dimension is not from the tail to the front edge of the baseboard, but to the front edge of the *wrestplank*. This tends to make the instrument slightly longer. It might seem strange to use such a datum line, but if you would recall the drawing of Arnaut de Zwolle's *clavisimbalum*, the length of the case extends only to the front edge of the *wrestplank* so the player's part of the keyboard is nominally outside the case outline. You will find a collage of this on the handout, where the keyboard has been cut off the drawing and placed inside the instrument. There is also a passage in Vicentino's description of making the archicembalo, where he speaks of the keyboard as being *fuori dello strumento*, outside the instrument, so it was apparently common to think of the instrument proper as ending at the nameboard.

Now the implication of what I have described here for the case measurement should be clear: if only the distance of the tail to the front of the instrument was measured, then the *actual* spine length was a result of the tail angle used, and was probably not even measured. It is also possible that the length of the F string used at the

soundboard level was itself not measured, but resulted from a suitable position of the bridge relative to the case side.

How the old makers thought about these issues is hard for us to reconstruct, but it appears that the theoretical length of a string was sufficiently significant for them that it should be included in the instrument, even if only in a symbolic fashion.

What strengthens me in the belief I have *not* imposed more order on history than actually existed, is that this construction principle can be used to test the design of other sizes of harpsichord. I have presented instruments which were of the lower-pitched variety. If the f^2 is $9 \frac{1}{4}$ Venetian inches then the string is 268 mm in our modern measurement and the c^2 string is nominally 357mm long, in order to translate this into values with which many will be more familiar. The Venetian maker might have understood the instrument as having a 74" F, or if he used the *piedi organici* it would have been an 8 foot instrument. Strung in iron wire, such scales would probably have stood around 400-415 Hz at a_1 , although my talk today does not take us into this area of pitch.

Now for the two predictions from the hypothesis: One exceptionally long harpsichord is the 1579 Baffo I mentioned earlier. Although this endured three different keyboard compasses during its history, all the original keylevers have survived and the original compass can be seen as C/E- c^4 or if you prefer CC/EE- c^3 . The scale is long and apparently $10 \frac{1}{2}$ Venetian inches at f^2 which would yield an F length of 84" or 2432mm; we find a length of 2435mm from the tail to the front edge of the baseboard along the line of the F string, which is surprisingly close.

A shorter instrument which has the predicted theoretical F string length between the tail and front edge of the wrestplank is the 1554 Domenico da Pesaro harpsichord in Paris. Thus, it seems to me that we are dealing with a construction principle which was widely used in Venice. Half of the instruments I have had time to study measured from the tail to the wrestplank and the others used the front edge of the baseboard as the measurement point. It is apparent that the longer-scaled instruments used the front edge of the *baseboard* as the datum line, which tends to shorten the overall size, whereas the higher-pitched ones used the front of the *wrestplank*. Thus, the the case sizes are not in exact proportion to their pitches; the higher-pitched ones are a little longer.

Although I have found that this theoretical F string length was laid symbolically along the line of the F string, it would not surprise me if it were to be found that some makers used the length of the spine for the symbolic F string. Ideas become familiar through use and the original intention can be lost sight of. Thus, when searching for a symbolic F string length I would not limit my search to the position of the F string.

To what extent this construction principle was used outside the lagoon city, on *terra firma* as the Venetians say, is something I have not yet been able to examine in detail. It does appear though as if we can understand Cristofori's long harpsichord designs as approximating to this rule. Although Cristofori is best known as having worked in Florence, he came from Padova in the Venetian Republic, which is a mere 8 hours paddle up the Brenta canal from Venice. The instrument making traditions there are barely distinguishable from Venetian ones, when one thinks of the work of Francesco Ongaro.

I have just cited two harpsichords where knowledge of the f^2 length enabled us to predict, and then confirm, the theoretical F string length as one of the baseboard dimensions. Of course this can also work the other way around. Since we can now be reasonably sure that the principle was used, it is possible to check the length from tail to baseboard front, or to the wrestplank edge, and see whether it can yield information about the original f^2 string length. There are many instruments where the original string lengths cannot be clearly seen as marks on the soundboards or wrestplanks after alterations. One of these is the Ferrara harpsichord now in Schloß Köpenick I have mentioned. The exact scale at f^1 is unclear, since parts of the baseboard were cut out during earlier repairs, but it is about 17 Venetian inches. However, a length of exactly 68" can be found for the F line on the baseboard drawing, if we assume a C/E compass. From this we can infer an f^1 length of 17", which is exactly 1/4 of 68". This information also helped in an unexpected way to resolve another issue where the exact placement of the F was unclear: I had originally interpreted the baseboard lines as yielding a compass starting on the unusual C.D.E, that is chromatic from C, but without C# and Eflat. John Henry van der Meer had suggested a compass starting on C short octave, but the F-line analysis agrees with his interpretation.

The interesting thing is that 40 years on from the founding of the Russell Collection there are still problems *here* which have eluded solution. One of the Italian harpsichords (no. 2 in the catalogue of the collection) was largely deciphered by John Barnes, who was able to show that the original compass was C/E- f^3 , 50 notes, and included, in addition, 7 split sharps, that is 57 notes in all. The keyboard was later modified to remove the additional accidentals.

Although the mouldings and arcades are finely made, I have never come across any others which match so I was never able to attribute the instrument to a known maker. Grant O'Brien noticed the similarity of the replacement nut to Cristofori's work and suggested that he, or his assistant Ferrini, had undertaken the alteration to remove the split sharps on the keyboard and change the scaling. I have been able to identify the bridge moulding on the 1666 Zenti in New York as most closely matching no. 2's nut. Since the Zenti modification was undertaken by Ferrini in 1755, this work on no. 2 may have been performed in his workshop around this period.

Although on stylistic grounds I have always thought of this harpsichord as Florentine or Roman, Grant O'Brien has recently attributed its origin to Naples on account of his analysis of the units of measurement used. It seems to me that with the information on construction I have found in Venice, one can see some aspects of this instrument in a different light.

The space between the wrestplank blocks in the Russell Collection's harpsichord is 707 mm and a keyframe of 28 1/2 Roman inches (24,75mm) would fit between them. Now 2x 28 1/2 is 57 and the original compass was made for 57 notes. If we see the keyboard width as about 32 Neapolitan inches (21,99 or 21,844mm) or 25 1/2 Florentine inches (27,54mm), we have none of this explanatory value how unit size and construction are linked. However, I do not expect to have cut the Gordian knot with one blow, but the fact that some Venetian and Florentine keyboards can be explained in terms of the local units creates an interesting case for my interpretation.

Whether this harpsichord was created using the symbolic F string length I could not say for sure at this stage: the original f^2 length can only be reconstructed within a latitude of a few mm. The length of the baseboard at the F string is 1720 mm and implies an f^2 of 215 mm. This is of the correct order of magnitude to match my reconstructed f^2 of 212mm, but 1720mm is not a round number of Roman inches, in fact it is 69 1/2". The spine length at the baseboard is 75 Roman inches and perhaps this is an explanation of the origin on the design.

I think it will take much more analysis of harpsichords of this size from different areas in Italy before we are able to be more confident about the probable construction principle for the case length. What I think can be reasonably concluded from my analysis of the keyboard width, is that the origin is not *indisputably* Neapolitan.

What I have presented to you today was a long running enquiry which did not start by arguing how the old makers *must* have thought and then applying this analysis to instruments. Instead I was led to consider certain factors as a result of the empirical data I collected. Combined with this has been the practice of making instruments, which applies a stiff discipline one does not have when considering matters theoretically at a desk. This has shown me how the Venetian makers appear to have thought from the "inside out" and constructed the jacks, jackslides and keyboards (in this order) to ensure the correct fit. This leads to variations in dimensions, but the action works.

It shows us, I believe, that the problem is always to find your way back into an old and discarded way of thinking in order to understand the motivating ideas. Of course Palladio used modules on his drawings and Arnaut de Zwolle constructed his instruments with them, yet the humble inch appears to have informed the construction of the Venetian keyboard width and with it the instrument. I cannot exclude the possibility that a master craftsman might have done all that I have described in building a harpsichord and yet did not lose sight of the overall proportions of an instrument. Indeed, it seems to me that Lorenzo da Pavia, an organ builder and harpsichord maker of remarkable skill, constructed his chamber organ in 1494 with Venetian inches yet maintained specific case proportions on the *outside* of the construction, something which does not happen with the Venetian harpsichords I have studied where the construction is built up from the inside. The "soul" of the Venetian harpsichord is the keyboard for the width of the case, and the strings for the length of the baseboard; the outer case is the mere shell which contains these essential elements.

The problem of knowing *where* to look for case dimensions in order to analyse them is highlighted by the practice of including a theoretical but impractical F string length in a symbolic fashion on the baseboard. Thus, I believe that my analysis will add an interesting impetus to our ongoing search to understand the past.

Handout: A Construction Principle in Venetian Harpsichords, Deniz Wraight

