**Early Keyboard Instrument Symposium**

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**Collection of Historic Musical Instruments**

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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*', GSJ 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.

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changed! However, rather than analyse the highways and byways of organlogical

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

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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

Domenco 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,

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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 illustrated 3. 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 than 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.

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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 f1. Since f1 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 c² measurements. Indeed, in the

1531 and 1538 Trasuntino harpsichords f1 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 f² 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 f², we find that he used 72" for the same

dimension. So in either case we find the theoretical relationship preserved of f² x 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

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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 lowerpitched

variety. If the f² is 9 1/4 Venetian inches then the string is 268 mm in our

modern measurement and the c² string is nominally 357mm long, in order to translate

this into values with which many will be more familar. 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 a1, 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-c4 or if you prefer CC/EE-c³. The scale is long and

apparently 10 1/2 Venetian inches at f² 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.

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I have just cited two harpsichords where knowledge of the f² 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 f² 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 f1 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 f1 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-f³, 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 Gordion 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.

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Whether this harpsichord was created using the symbolic F string length I could not

say for sure at this stage: the original f² 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 f² of 215 mm. This is of the correct order of magnitude to match my

reconstructed f² 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 aharpsichord 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.

