BARTOLOMEO CRISTOFORI

La spinetta ovale del 1690
The 1690 Oval Spinet

a cura di / edited by Gabriele Rossi-Rognoni

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The Creation of a New Instrument: the 'Oval Spinet' from a Builder's Perspective

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The making of copies of historical keyboard instruments has had a long tradition in the 20th century, closely related to the growing influence of historical performance practice in the second half of the century. In contrast, copy making as a form of organological research in musical instrument museums is still rarely practised. The following article aims to shed some light on how Cristofori planned and built the 1690 oval spinet, based not only on the measurements and analyses carried out on the original but also on the experience of making this copy. (Fig. 1)

Inventing a New Structure

The unorthodox forms and building techniques that Cristofori adopted throughout his life lead us to suspect that he was not in fact an instrument maker by training. That he received, at least for a period, a stipend from the Medici court,[1] had become a member of Prince Ferdinando's '*virtuosi di Camera*' (a group of composers and musicians),[2] and had never joined the guild that included instrument makers (the *Università di Por San Piero e Fabbricanti*),[3] tend to confirm the supposition that he was a gentleman inventor/builder, possibly a musician, who felt free from the constraints of the professional instrument building traditions.

All his life he was interested in the structure of instruments. From the notes that Maffei writes about Cristofori, we learn that Cristofori believed that in order to sound well, the soundboard should be free from pressure from the bentside.

> Perfection in instruments lies in their measurements and above all in the soundboard being neither too thick nor too thin, and to have removed the elastic property from the bentside and the bridge. Because as long as these are pushing on the soundboard, to resist this the instrument does not sound[4]

It is something of a paradox that whilst Cristofori was praising the sound of the old instruments, he eschewed many of the building techniques that their makers adopted. In fact even in the most traditional looking of his surviving instruments, the ebony harpsichord (Florence, Galleria dell'Accademia, Museo degli strumenti musicali inv. 1988/101), Cristofori makes an entirely original framework.[5] Of course throughout the history of art a profession of veneration for the old masters has accompanied a belief in progress, that is in improving on their techniques.

This problem of the pressure of the bentside on the soundboard may possibly be a key to understanding the genesis of the 1690 oval spinet. For the bentside of a normal harpsichord follows the curve of the bridge and is thus concave in shape, structurally the weakest possible

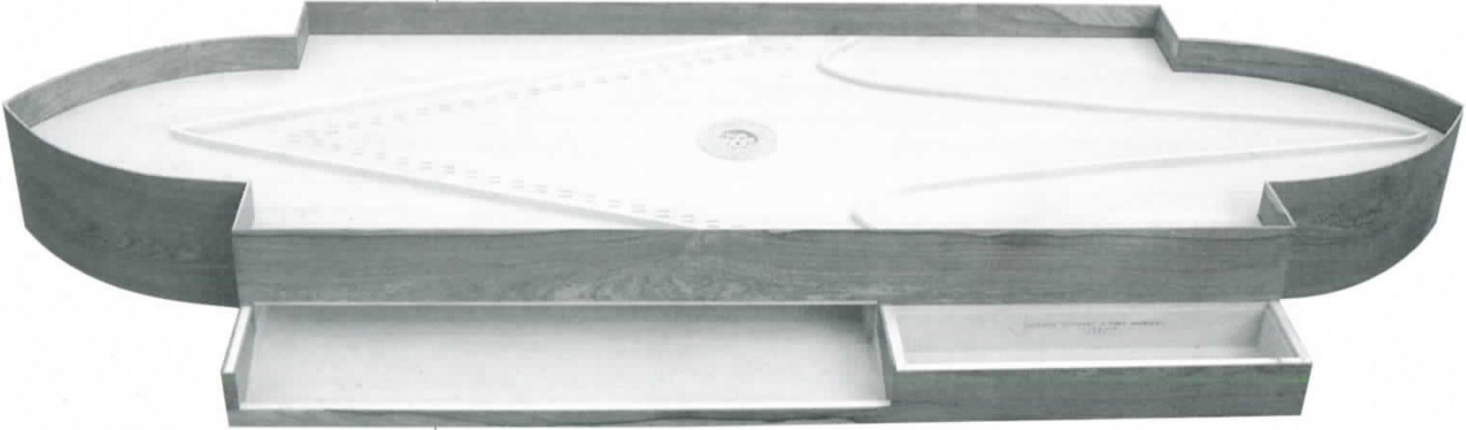


Fig. 1

Tony Chinnery, Kerstin Schwarz, copy of Bartolomeo Cristofori's 1690 oval spinet, 2002.

form. A slight flexing of the base under the tension of the strings allows the bentside to pull in, squeezing the soundboard. The fact that in Italian building the soundboard is normally designed with cross ribbing to play a structural role and resist this pressure, seems to contradict Cristofori's thinking as reported by Maffei.

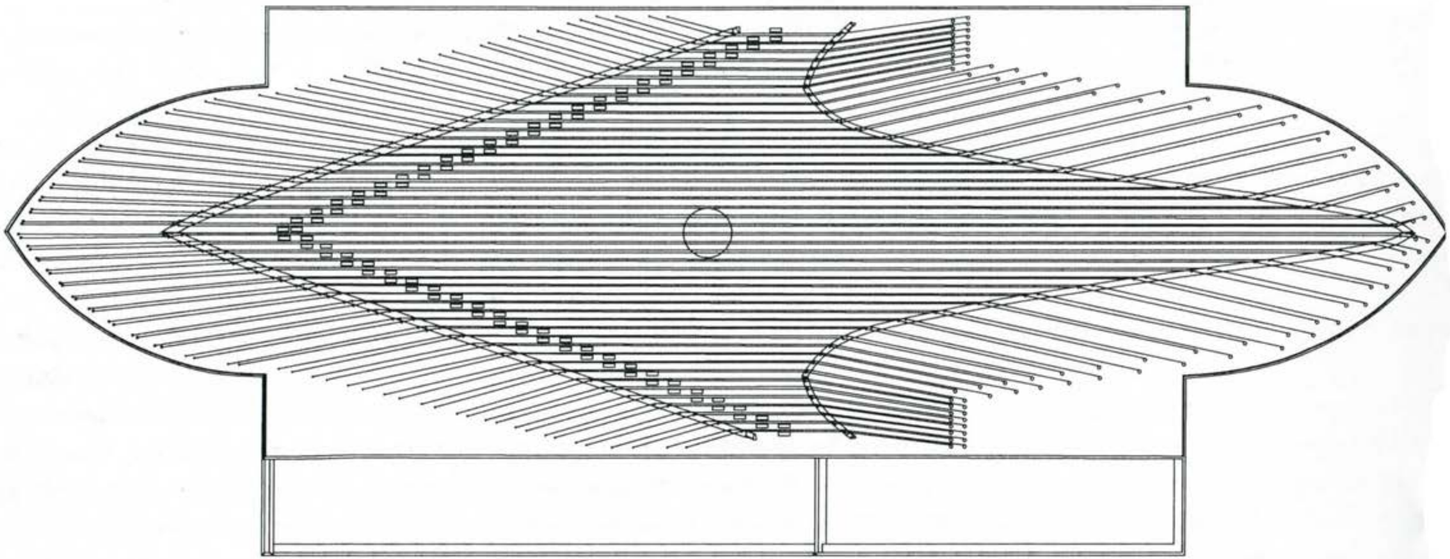
In looking at the design of Cristofori's oval spinet from the structural point of view, it may be useful to consider an analogy taken from architecture, that of an arched opening in a building. Since time immemorial the archway has been adopted as the best way to resist the downward pressure of the wall above it. We can now imagine taking away the rest of the building and substituting its downward pressure on the arch with the mechanically equivalent pull of a series of weighted wires attached around the inside of the archway. As can be seen from Fig. 2, the structure of Cristofori's spinet is basically a double archway. The pressure of the longest strings attached near the points of the arches tends to push the sides outwards rather than pull the bentside inwards as with a harpsichord. Going up the scale, however the inward pull of the strings attached around the bentsides counteracts this outward pressure. Evidence that Cristofori was thinking along these lines comes from his use of double pinning in the nuts (the left hand bridges). In a harpsichord the usual reason for double pinning is to prevent the bridge being pushed over by the sideways pressure of the strings. In the 1690 spinet, however this would not be a problem in the nuts as the V form of the nut assembly makes them rigid enough to prevent this tilting over. Instead the purpose of the double pinning seems to be to distribute the tension more evenly round the curved sides, including the point of the arch as can be seen from Fig. 3.

Looking at the assembled spinet frame, the pressure of the bass strings transmitted by the curved walls of the spinet is taken by the rectangular part of the frame. On the left, there is a triangular structure formed from the case sides and the diagonal hitch pin rails. These diagonal hitch pin rails are fixed to a 4 mm thick board that extends above the key frame. The

Fig. 3

Ricostruzione CAD della disposizione delle corde sulla spinetta ovale del 1690.

CAD simulation of the string disposition of the 1690 oval spinet.



purpose of this lower soundboard (for want of a better name) would be mysterious if it were not for the passage from Maffei quoted above, for without it the tension of the strings attached to it would be taken by the soundboard alone. However, this lower soundboard is weakened by the clearance holes cut in it for the jacks and Cristofori has strengthened it with a rib. (See Fig. 2)

In the five surviving instruments (two harpsichords and three pianofortes) from the 1720's, Cristofori takes a completely different approach to the structural problem cited by Maffei. In these instruments, the bentside edge of the soundboard is not connected to the outer case wall at all, but is fixed to a separate inner bentside. Thus the soundboard is completely freed from the pressure of the strings, which are anchored to the outer bentside wall.[6]

So perhaps the search for a new structural approach to the creation of a double register instrument, rather than aesthetic considerations, led Cristofori to create this striking design. In the second of his oval spinets, Cristofori conserves the form and structure of the earlier instrument. This would appear to attest to the success of his design. In the 1693 instrument (Leipzig, MusikinstrumentenMuseum der Universität, inv. 53) Cristofori even lightens the case by eliminating the front and rear inner case walls used in the previous model. Evidently he believed that the structure was strong enough without them. The main difference between the two spinets is the somewhat wider case of the 1693 instrument, explained by the addition of two extra notes, as the 1693 has a chromatic 4-octave range. Comparison of the two radiographs also reveals a difference in the anchoring of the strings around the curved sides. In the later instrument, Cristofori extends the straight hitch pin rails until they reach the bentsides. It seems that Cristofori also eliminates the use of double pinning in his second instrument (although the bridges have been changed we know this from the absence of any plugged holes round the edge of the case near the point).[7]

The Stringband

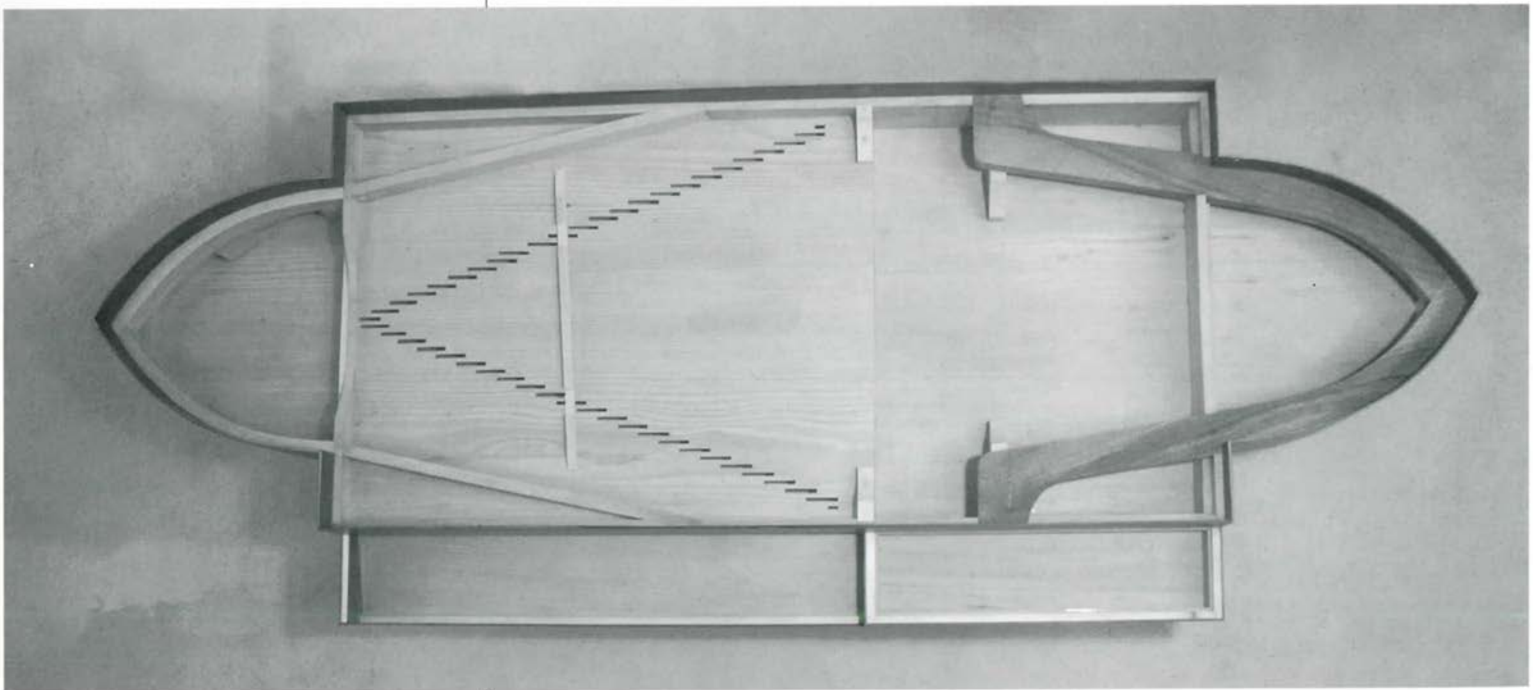
In laying out the plan of the stringband, Cristofori must have started by determining the position of the jacks. The angle of the two parts of the register making the V shape is determined by two factors: the spacing of the strings (measured across the string band), and the width of the keyboard, which determines the spacing of the key levers. For the latter, Cristofori uses the same octave span, 165 mm, that we find in his other keyboard instruments. The position of the bridges and the nuts in the plan is determined by two things, the length of the strings, and the plucking points. It is unfortunate that for a comparison of his scaling, we have to turn to instruments built more than 30 years later, as neither the 1693 oval spinet nor the ebony harpsichord have their original bridges and nuts.[8] However, what is clear from examining the following tables is that throughout this 30 year period, Cristofori seems to have maintained a remarkably constant scaling, at least for the top $2\,^1/_2$ octaves of the range. Apart from anything else, this would appear to indicate that the pitch of the instruments and the quality of the strings used would have remained fairly constant. (See Tables 1 and 2)

Perhaps even more remarkable than the string lengths, is the similarity in the plucking points.[9] Cristofori's harpsichords have nuts which are very nearly straight, as are the nuts in the 1690 spinet, apart from a small curve at the bass end. Of course, in the spinet, the key levers are perpendicular to the strings rather than parallel to them as in a harpsichord. The

Fig. 2

Tony Chinnery, Kerstin Schwarz, copia della spinetta ovale di Bartolomeo Cristofori del 1690, 2002. Foto dello strumento prima del posizionamento della tavola armonica.

Tony Chinnery, Kerstin Schwarz, copy of Bartolomeo Cristofori's 1690 oval spinet, 2002. Photo of the instrument before the positioning of the soundboard.



	Spinetta ovale, 1690 Oval spinet, 1690		Clavicembalo, 1722 Harpsichord, 1722		Clavicembalo, 1726 Harpsichord, 1726
	Registro lungo Longer register	Registro corto Shorter register	Registro lungo Longer register	Registro corto Shorter register	Registro 8' 8' register
Do¹/C	1561	1541	1982	1970	1857
Fa¹/F	1540	1518	1621	1619	1621
Do²/c	1095	1064	1132	1084	1130
Fa²/f	851	820	850	814	857
Do³/c'	564	540	569	545	571
Fa³/f'	426	407	427	408	428
Do⁴/c''	287	271	285	273	287
Fa⁴/f''	217	203	214	206	215
Do⁵/c'''	143	132	143	133	144

	Spinetta ovale, 1690 Oval spinet, 1690		Clavicembalo, 1722 Harpsichord, 1722		Clavicembalo, 1726 Harpsichord, 1726
	Registro lungo Long register	Registro corto Short register	Registro lungo Long register	Registro corto Short register	Registro 8' 8' register
Do¹/C	143 9.1%	126 8.2%	165 8.3%	147 7.4%	168 9%
Do²/c	141 13%	121 12%	145 13%	127 12%	146 13%
Do³/c'	123 22%	102 19%	120 21%	102 19%	123 22%
Do⁴/c''	96 33%	76 28%	93 32%	76 28%	94 33%
Do⁵/c'''	70 49%	52 39%	65 45%	48 36%	68 47%

pair of jacks for each note are facing each other, plucking inwards towards the string pairs and the difference in both string lenghts and plucking points between the two registers would have been minimal had Cristofori not made use of two expedients to bring them so close to those of his harpsichords. Firstly he staggers the nut pins instead of putting them in a straight line. Secondly he utilizes the fact that the plectra are not mounted centrally in the jacks, as on one side of the tongue more space is required for the damper slot. Looking from above at each pair of jacks mounted in the instrument it will be seen that the plectra for the shorter strings are always those closer to the nut. In order to achieve this, Cristofori had to make the jacks for the shorter keys with their dampers mounted on the opposite side of the plectra with respect to those for the longer keys.

What seems to emerge from these considerations is that Cristofori had decided early in his building career on the ideal string lengths and the plucking points for his harpsichords, and that he took great care to apply these measurements to an instrument with such a different plan as this spinet.

The Case

Having laid out his stringband, Cristofori now had to design the case around it. One puzzling feature will be noticed on considering Fig. 3. For although there is almost too much space around the bass end of the nuts, the bass end of the right hand bridges come very close to the edge of the case, leaving no free space for the soundboard there. Of course, the problem could have been resolved by lengthening the plucking points, which would have had the effect of

moving the stringband to the left. It is clear, however, that Cristofori did not want to compromise on this point. Why could Cristofori not just have lengthened the rectangular part of the case to the right of the keyboard? A possible answer comes from aesthetic considerations. The front protruding part of the instrument is divided into two parts, one of which houses the keyboard (AB in the diagram on p. 82) and the other a toolbox (BC). If we calculate the width of the keywell (including the walls to the left and right of the keywell), as a proportion of the total length of the rectangular part of the instrument, (the proportion AB:AC in the diagram) we obtain a number that is quite close to the Golden Section.[10] This possibly determined the length AC of the straight part of the case, and therefore the proportions of the rectangle (ACGH in the diagram) which turn out to be quite close to 2:1. In the same way the proportions AC:JE and DF:CG, which determine the height and the width of the two lateral corners turn out to be not far from the Golden Section.
The curved walls of the spinet are circular arcs, so that the radius of the arc DE, for instance, has its centre point close to F. This is necessary for the joins between the curved sides and the small straight sides to be orthogonal.

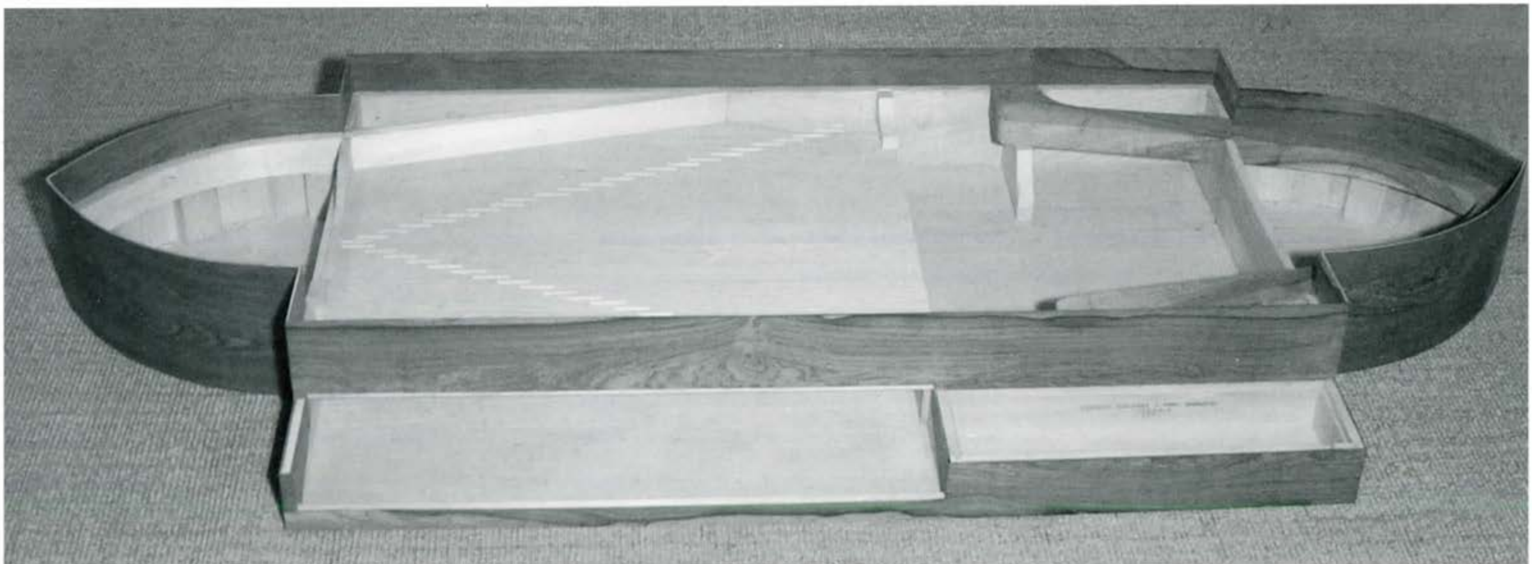
The Frame

A feature which Cristofori inherits from the Italian tradition is that of building up his instruments from the baseboard (this in contrast with the North European tradition exemplified by the instruments of the Ruckers family, where the baseboard is fixed onto a pre-existing case). Furthermore, the oval spinets have the typically Italian characteristic of thin case walls re-enforced with mouldings at the top and bottom, something that Cristofori seems to have abandoned in his later work, judging from the surviving instruments. However in the 1690 oval spinet, this is qualified by the fact that the long straight sides have inner re-enforcing walls. In this building tradition, a self-supporting framework is first assembled on the baseboard and the sides are then glued to that. (Fig. 4)
The sequence of operations involved in building the case of the copy of the 1690 spinet was probably that adopted by Cristofori. In preparing the plans for the frame of the copy, some direct measurements of the original instrument were possible through cracks in the baseboard and soundboard, and holes in the bentsides, otherwise measurements taken from the full size radiograph by the Opificio delle Pietre Dure were used. Very helpful also was the possibility of examining the interior of the 1693 spinet through two holes that had been cut in the baseboard by a previous restorer. Having marked and cut out the baseboard, on the rectangular part a sort of double box was made by joining together three transverse frame members with the front and back inner case walls. These inner case walls function also as soundboard liners. There is a cutout in the front board for the keyboard, and a small cutout in the backboard for the rear right hand corner of the key frame. After gluing on the lower soundboard, vertical support blocks were glued on to the base at the corners of the bentsides and at their midpoints. The wrestplank, formed from two pieces of Walnut sawn to shape and jointed together was glued onto these support blocks and into cutouts in the front and backboards. It is not clear how Cristofori formed the bentside liners, either by heat bending, sawing to shape or laminating thin strips of wood. There are no kerf cuts visible in the radiograph, and sawing to shape would have resulted in a weaker structure, so in the copy these liners were laminated from 3 strips.

Fig. 4

Tony Chinnery, Kerstin Schwarz, copia della spinetta ovale di Bartolomeo Cristofori del 1690, 2002. Foto dello strumento prima del posizionamento della tavola armonica.

Tony Chinnery, Kerstin Schwarz, copy of Bartolomeo Cristofori's 1690 oval spinet, 2002. Photo of the instrument before the positioning of the soundboard.



Apart from the wrestblock, all this framework is made of fir, a species growing all down the Apennine chain.

The Case Sides

The front and back straight sides are made in Rosewood planks of thickness varying from 3 mm to 3.5 mm. The curved sides of the spinet have a laminated construction similar to modern plywood. This, even though the curvature does not seem excessive for heat bending. First a layer of vertically grained Poplar 1 mm to 1.5 mm thick was glued around the frame. Being vertically grained meant it was very easy to bend of course. The joins between these and the small straight sides were re-enforced with strips of linen. Then an outer layer of horizontally grained Rosewood of the same thickness was glued around this form, and similarly a strip of Rosewood on the inside that extends from the liners/wrestplank to the top of the case. The small straight sides are also of laminated construction on the keyboard side (AK and CD in the diagram on p. 82), but of solid Rosewood at the backside (IH and FG).
It is more than probable that the Rosewood case sides would have been made by the cabinetmaker listed in the bill presented by Cristofori to the Medici Court.[11] In using this laminating technique, perhaps he was following a tradition of veneering a Poplar support with precious wood. In this case, however the support is reduced to the same thickness as the outer veneer. This practise of building up the sides from multiple layers was one Cristofori continued to adopt throughout his life. It is certainly not a traditional harpsichord-making practice, probably a normal harpsichord maker would have considered this practice to be detrimental to the sound of the instrument.

The Soundboard

The soundboard is made of two wide planks of Cypress. Cristofori used both Cypress from Tuscany as well as Cypress from Crete as we know from the bills he presented to the Medici between 1690 and 1698.[12] However for the 1690 spinet bill he neglects to specify the origin of the soundboard wood.
It was possible to gain access through a long crack in the soundboard to measure the thickness of the right hand half of the soundboard with a magnetic device, but the lower soundboard prevented measurement of the section of the soundboard above the keyframe, apart from a series of measurements taken through the crack down the centre of the soundboard. It was not possible to gain access to the part of the soundboard to the left of the nuts. The measurements give a somewhat greater thickness than might be expected, varying from 3.9 mm to 4.9 mm, except around the treble end of the bridges, where it is thinned down to 3.5 mm.
Most of the measurements are close to 4mm, with strangely, a thickening under the bridges just to the right of the curves along the line of the c′ key lever.
Most Italian builders used Walnut for their spinet bridges, both for ease of bending and for its relative hardness, but Cristofori had a strange predilection for Cypress bridges, which gave rise to problems in bending the curves in making the copy.

The Registers

The registers of the 1690 spinet were built up from blocks glued together stepwise in the traditional Italian manner. Each block has two grooves cut in it, that in the assembled register form the jack slots. Having assembled the registers, the protruding corners of the blocks were then cut off and re-enforcing strips glued onto the sides. (Fig. 5) Unlike a normal spinet, where small inaccuracies can be compensated in assembling the register, in this two-register instrument considerable care was required in preparing these blocks. For the thickness of the blocks determines the string spacing, and the distance between the grooves corresponds to the spacing of the key levers. For this spinet, however, it was necessary to reduce to a minimum the play in the foot of the jacks. For instance the jacks of the shorter keys have to fit into a cutout of 7 mm in the key lever when in the off position. This leaves little more than 1 mm of free space on either side of the jack foot. To reduce this play Cristofori evidently decided to increase the depth of his registers slicing the assembled blocks horizontally into two parts before gluing on the side walls.

The registers are not exactly perpendicular to the soundboard. This is because Cristofori decided to give the jacks a forward tilt, 3° for those of the front register, and $1\frac{1}{2}$° for the back register. The reason for this is that the key levers describe an arc when the key is depressed. The angle of the arc is greater for the shorter keys of the front register given the same vertical movement of the jack. Having planed off the registers at the right angle, the two registers were then joined into a rigid V assembly, with a re-enforcing block in the corner, before gluing onto the underside of the soundboard and cutting the clearance slots in the soundboard for the jacks.

The Rose

We know from Maffei's notes that Cristofori believed an instrument should have an opening to the soundbox,[13] and due to the presence of the lower soundboard in these oval spinets, this would be completely sealed if it were not for the rose. The rose is made of a very thin veneer of Cypress glued to backing paper to prevent splitting whilst cutting. It is in two parts, one glued on to the upper surface of the soundboard and the other below. Each part is made of three layers of Cypress glued together.

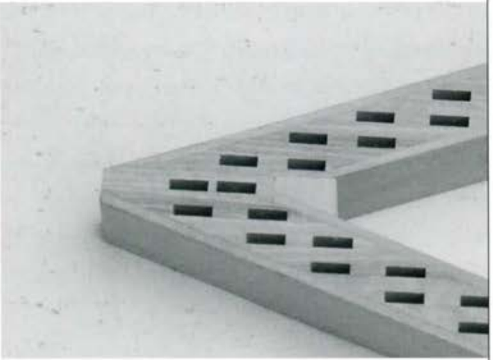
The Action

Cristofori's favoured wood for the key levers seems to have been Chestnut, as used in the ebony harpsichord and in his later instruments. However for the oval spinets he uses Poplar, possibly because he thought that Chestnut would be too heavy, given the length of the longer keys. The key levers are much thicker than normal, 19 mm; this again is evidently to compensate for their length. The key guides consist in tongues of Cypress, which fit into slots cut into the tails of the levers, instead of the usual keyracks. These tongues act also as rests for the jacks of a register when it is in the 'off' position. There are extra thicknesses glued to the levers under the jacks to bring them to the same level as the guide tongues. The jacks rest on a 1 mm layer of leather, glued to both the key levers and the guide tongues, to facilitate the sliding of the keyboard for register change. Due to the precision required for the register mechanism to work correctly, it is quite clear that Cristofori must have marked out the position of the key

Fig. 5

Tony Chinnery, Kerstin Schwarz, copia della spinetta ovale di Bartolomeo Cristofori del 1690, 2002. Lista guida dei salterelli.

Tony Chinnery, Kerstin Schwarz, copy of Bartolomeo Cristofori's 1690 oval spinet, 2002. Registers.



levers with the key plank *in situ*. The key plank is fixed to its frame and placed inside the spinet in the correct position for both registers to be on. In making the spinet copy, a precisely fitting dummy jack was pushed through each register hole and made to mark the key plank (its bottom edges had been sharpened). This determines the spacing of the key levers, the lengths of the longer keys and the positions of the cutouts. In contrast with the delicate work of the outer case in precious wood, that of the key levers seems almost rough. It certainly gives the impression of having been executed very quickly. Is this perhaps the work of the assistant mentioned in Cristofori's bill?

Conclusion

The 1690 spinet is the first example we posses of the inventive power of the man who was later to have given birth to the pianoforte. We hope that this article illustrates how the construction of the copy of this instrument has achieved a double result. The main object was to bring Cristofori's creation back to musical life. But in addition, the process of building the copy has led us to relive the steps that Cristofori must have taken in planning and executing the construction of this remarkable instrument.