The pianos of Bartolomeo Cristofori and Gottfried Silbermann: different instruments with the same hammer action

Kerstin Schwarz

Bartolomeo Cristofori, working at the Medici court in Florence at the end of the seventeenth century, developed a hammer action for the harpsichord, thus inventing the first piano. The two earliest documents concerning Cristofori's new instrument comprise a description in a 1700 inventory of the musical instrument collection of Grand Prince Ferdinando de' Medici and an article pubished by Scipione Maffei in the *Giornale de'letterati d'Italia* in 1711.[1] Maffei was one of the editors of the *Giornale.*

The description in the inventory of 1700 begins with the words: *Arpicimbalo di Bartolomeo Cristofori, di nuova inventione, che fa il piano e il forte* and the title of Maffei's article begins with the words: *Nuova Invenzione d'un gravecembalo col piano e forte.*[2] Both sources thus mention a newly invented harpsichord that could play soft and loud.

The earliest clear reference to a piano by Gottfried Silbermann is in Johann Heinrich Zedler's *Universal-Lexicon aller Wissenschafften und Künste* in volume V, published in 1733:

> 'Not long ago, this famous *Herr* Silbermann invented another instrument. He calls it *Piano Forte* […].'[3]

Silbermann apparently chose the name that the instrument can still have today, that is, without the word *cembalo* (harpsichord).

The three surviving Cristofori pianos are dated 1720 (Metropolitan Museum of Art in New York, acc. no. 89. 4. 1219), 1722 (*Museo degli Strumenti Musicali* in Rome, inv. no. 918, fig. 1*)* and 1726 *(Museum für Musikinstrumente der Universität Leipzig im Grassi Museum*, Leipzig, inv. no.

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[1] The inventory is preserved in: *Archivio di Stato di Firenze*, *Guardaroba Medicea*, document no. 1117 and cited in: Vinicio Gai, *Gli Strumenti Musicali della Corte Medicea e il Museo del Conservatorio 'Luigi Cherubini' di Firenze*, Florence 1969, 6–21. The longer description, published with no author's name in 1711 is: Anon, 'Nuova

[2] See: Gai, *Gli Strumenti Musicali della Corte Medicea e il Museo del Conservatorio 'Luigi Cherubini' di Firenze*, *op. cit.*, 11 and: Anon, 'Nuova Invenzione d'un gravecembalo col piano e forte aggiunte alcune considerazioni sopra gli strumenti musicali', *op. cit.*, 144.

[3] *Ferner hat auch dieser berühmte Herr Silbermann vor kurtzen wiederum ein neues Instrument erfunden, so er Piano Forte nennet* […]. Johann Heinrich Zedler, *Großes vollständiges Universal-Lexicon aller Wissenschaften und Künste*, 68 vols., Halle and Leipzig 1732–1754, V, 1733, col. 1804.

170). All three belong to Cristofori's later period during which he probably no longer made instruments for the Medici court. Prince Ferdinando de' Medici, who had invited him from Padua to Florence as harpsichord maker and curator in 1688, already died in 1713. Although Cristofori then continued to occupy his official position as curator of the collection, it was probably only a nominal appointment. He held the title for the rest of his life. He died in 1732.

Figure 1. The 1722 Cristofori piano in the *Museo degli Strumenti Musicali*, Rome. Photo courtesy of the Italian *Ministero per i Beni e le Attività Culturali.*

Although details of the hammer action in the Cristofori piano listed in the 1700 inventory are unknown, the article Maffei published in 1711 includes a description and drawing of Cristofori's hammer action as Maffei must have seen it in 1709. The drawing clearly shows an escapement mechanism whereby the hammer escapes from the action train before striking the strings. Also shown is an intermediate lever and a leathered hammer of solid wood. The damper shown operates from under the strings and the hammer action includes a primitive check, that is, a means of catching the hammer after it strikes the strings. The sprung jack, standing on the intermediate lever, pushes the hammer up near the latter's pivot point (fig. 2).

By 1720 Cristofori had developed his hammer action. This developed form is found in all three surviving pianos (fig. 3).

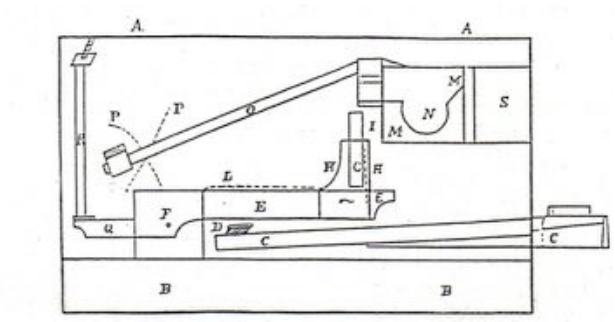

Figure 2. Cristofori's hammer action as depicted in the article published by Maffei in 1711 in the article: 'Nuova Invenzione d'un gravecembalo col piano e forte aggiunte alcune considerazioni sopra gli strumenti musicali'.

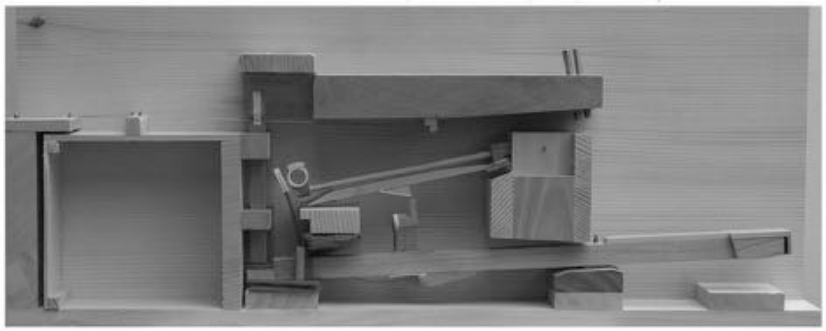

Figure 3. Cristofori's hammer action shown in an action model from the action of the 1726 Cristofori piano in Leipzig. Model and photo: Kerstin Schwarz.

A comparison of the 1711 drawing and the hammer actions of the three surviving pianos shows that Cristofori not only made radical changes between 1709 and 1720 but also that he continued to make smaller changes between 1720 and 1726. He changed the types of hammerheads: in 1722 he used small solid wooden hammer heads covered with one layer of deerskin leather and in 1726 paper rolls made of several layers of hand-made paper held together with glue (fig. 4). He also employed different hammer butts (fig. 5) and different shapes for the intermediate lever (fig. 6), as well as different forms of dampers (fig. 7) in the three pianos.

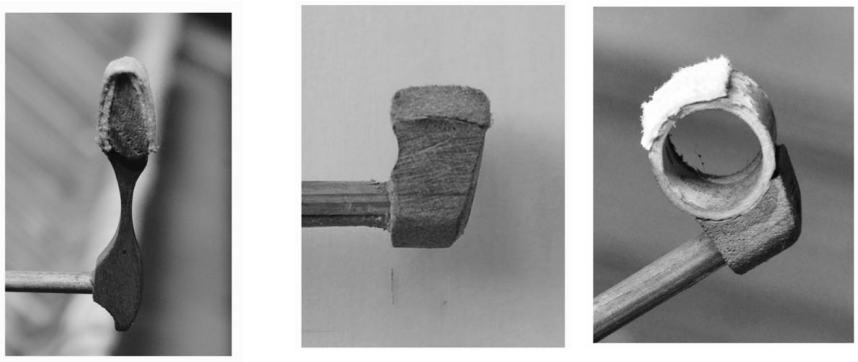

Figure 4. The hammerhead types in the three Cristofori pianos. From left to right: 1720, 1722, 1726. Photos: Kerstin Schwarz.

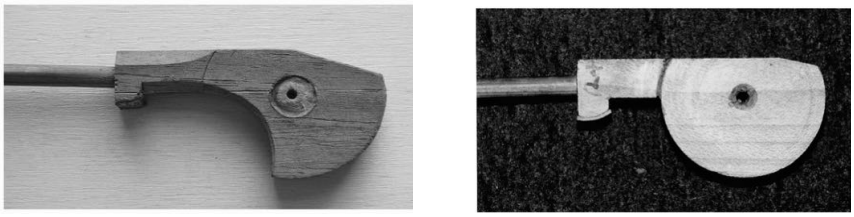

Figure 5. Hammer butt types in two Cristofori pianos. Left 1722, right 1726. Photos: Kerstin Schwarz.

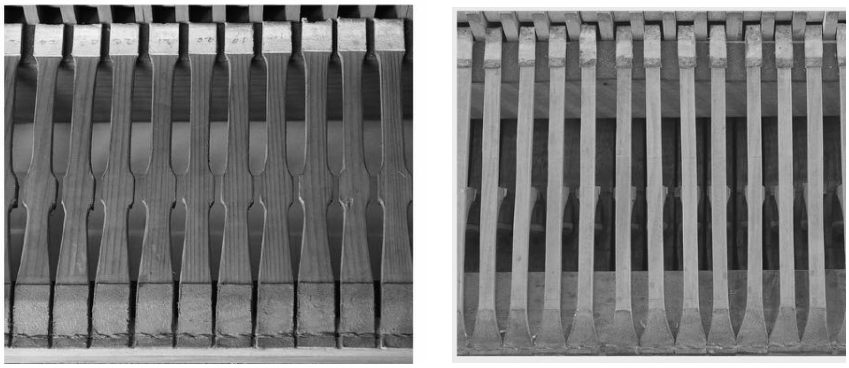

Figure 6. Two types of intermediate levers in Cristofori's pianos. Left 1722, right 1726. Photos: Kerstin Schwarz.

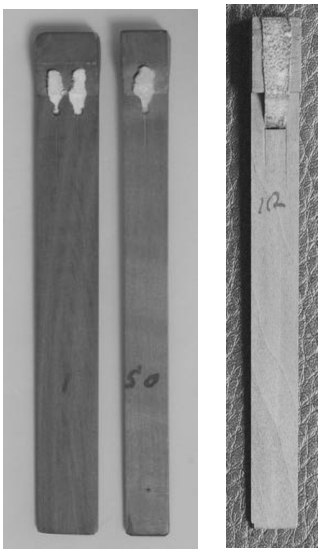

Figure 7. Different types of dampers in two Cristofori pianos. Left 1720, right 1726. Photos: Kerstin Schwarz.

Johann Ulrich König (1688–1744), privy councillor and court poet in Dresden, translated the 1711 description of Cristofori's piano and published it (together with a good copy of the drawing of Cristofori's hammer action) in Mattheson's *Critica Musica* of 1725.[4]

Mattheson, also in the *Critica Musica* of 1725, refers to pianos made in Florence and in Freiberg, no doubt referring to those of Cristofori and Silbermann. In a reference to the latter's invention of the *Cymbal d'amour* (a special type of clavichord), Mattheson remarked:

> '[…] in due course Secretary König wants to make a comparison between the Florentine and the Freibergischen instruments […]'.[5]

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[4] Johann Ulrich König, 'Musicalische Merckwürdigkeiten. Des Marchese, Scipio Maffei, Beschreibung eines neuerfundenen Claviceins, auf welchem das *piano* und *forte* zu haben … ', in: Mattheson, *Critica musica*, *op. cit.*, II, 335–42. König worked from the second publication of the description: Scipione Maffei, *Rime e prose del sig. marchese Scipione Maffei parte raccolte da vari libri, e parte non più stampate. Aggiunto anche un saggio di poesia latina dell'istesso autore*, Venice 1719, 309–16. This information was kindly communicated by Denzil Wraight in March 2018.

[5] *Dresden. In den Breslauer Nachrichten Sammlungen, im Sommer-Quartal 1724. Monaths Junii, der V. Classe, im 2. Artic. ist eine Beschreibung des von dem Herrn Silbermann erfundenen und verfertigten Cembals d'Amour, nebst einem Risse, und dem Attestat von hiesigen Musicis, item dem Königlichen Privilegio, so der Herr Geheime Secretaire König gedachtem Herrn Silbermann, samt dem Character eines Hoff- und Land- Orgelbauers, allhier procuriret, zu finden, p. 697 & seq. Allein die Beschreibung will noch nichts sagen, weil nicht gemeldet worden, worinnen eigentlich seine Vorzüge vor andern Instrumenten, und die grosse Kunst des Verfertigers bestehet: welches Ruhmgemeldter Herr Secretaire König, bey müßiger Zeit einmal ausführlich auffsetzen, und eine Parallele zwischen dem Florentinischen und dem Freybergischen machen, will.* Mattheson, *Critica Musica*, *op. cit.*, II, 380.

The reference to Silbermann's *Piano Forte* in Zedler's *Universal-Lexicon* was already mentioned above:

> 'Not long ago, this famous *Herr* Silbermann invented another instrument. He calls it *Piano Forte*. He delivered it last year to His Royal Highness the Crown Prince of Poland, Lithuania etc., also Elector of Saxony. It was received most graciously on account of its exceptionally pleasant sound.' [6]

This crown prince would have been Augustus the Strong's son, who was to be the next Elector, Frederick Augustus II of Saxony and King August III of Poland. The article must therefore have been written before Augustus the Strong died in February 1733, indicating that the article refers to a piano made by Silbermann before then; the words 'last year', perhaps written in late 1732 (ready for publication in 1733), could have referred to the year 1731.

Johann Friedrich Agricola, in one of his additions to Adlung's *Musica Mechanica Organoedi*, posthumously published in 1768, also wrote of pianos made by Silbermann. He mentioned that J. S. Bach first criticized Silbermann's piano and that to obtain Bach's approval, Silbermann had to work on his hammer action for 'many years' before he obtained Bach's approval.[7] Although Agricola's text does not mention the date of the first meeting with J. S. Bach, that meeting could have taken place in the early 1730s. This is not contradicted by the earlier texts cited above: they refer to pianos by Gottfried Silbermann made in the 1720s and 1730s. The orders from the Prussian court came in the 1740s, shortly after Silbermann had obtained Bach's approval.

The surviving records for the acquisition of two *Hammerflügel* from Silbermann for the court of Frederick the Great in Potsdam are dated 1746 and 1747.[8] Of the two *Hammerflügel* that survive in Potsdam one is in

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[6] *Ferner hat auch dieser berühmte Herr Silbermann vor kurtzen wiederum ein neues Instrument erfunden, so er Piano Forte nennet, und in vorigen Jahre Ihro Königl. Hoheit dem Cron-Printzen von Pohlen und Littauen etc. auch Churfürsten in Sachsen übergeben* […]. Zedler, *Großes vollständiges Universal-Lexicon*, *op. cit.*, V, 1733, col. 1804.

[7] [J. S. Bach] *hatte den Klang desselben gerühmet, ja bewundert: Aber dabey getadelt, das es in der Höhe zu schwach lautete, und gar zu schwer zu spielen sey.* […] *Hieran arbeitete er viele Jahre.* […] *Kurz darauf liessen des Königs von Preussen Maj. eines dieser Instrumente, und als dies Dero allerhöchsten Beyfall fand, noch verschiedene mehr, von Hrn. Silbermann verschreiben.* […] *Hr. Silbermann hatte auch den löblichen Ehrgeiz gehabt, eines dieser Instrumente, seiner neuern Arbeit, dem seel. Hrn. Kapellmeister Bach zu zeigen und von ihm untersuchen zu lassen; und dagegen von ihm völlige Gutheissungen erlanget.* Johann Friedrich Agricola, comment to §. 529 in: Jacob Adlung, *Musica Mechanica Organoedi*, 2 vols., Berlin 1768, II, 116ff.

[8] The two Silbermann *Hammerflügel* were paid from King Frederick's privy purse as recorded in the *Geheimen Staatsarchiv der Stiftung Preußischer Kulturbesitz*. See: Christoph Henzel, "*Die Schatulle Friedrich II. von Preußen und die Hofmusik*" (part I), in: *Jahrbuch des Staatlichen Instituts für Musikforschung Preußischer Kulturbesitz* XXXVI, 1999, 36–66, here

Sanssouci, dated 1746, corresponding to the invoice of 1746, and the other, neither signed nor dated, is in the *Neues Palais*.[9] Besides the two invoices, Silbermann *Hammerflügel* are listed in the inventories of the Potsdam palaces of the 1780s and of 1825.[10] Descriptions by historians such as Friedrich Nicolai are also known.[11] Photos of the Silbermann *Hammerflügel* at Potsdam (including the one that was in the *Stadtschloß*) from before the Second World War have also survived.[12]

Figure 8. The *Hammerflügel* by Gottfried Silbermann at the *Stadtschloss*, Potsdam. This print has as its original caption: 'SILBERMANN GRAND PIANO A. D. 1746. *From the original used by* J. S. BACH *in the Town Palace, Potsdam. Published by permission of* H. I. H. THE CROWN PRINCESS OF GERMANY.'

62–5. See too: Constantin Restle, 'Gottfried Silbermann und die Hammerflügel für den Preußischen Hof in Potsdam', in *Jahrbuch des Staatlichen Instituts für Musikforschung Preußischer Kulturbesitz* XXXIIX, 2001, 189–203, here 191f.

[9] *Neues Palais*: *Stiftung Preußische Schlösser und Gärten*, Potsdam, inv. no. V 12; *Sanssouci*: *Stiftung Preußische Schlösser und Gärten*, Potsdam, inv. no. V 13.

[10] *SPSG, Historische Inventare Nr. 400*: Neues Palais 1811, *Hist. Akten nr. 216*: *Acta Inventarii von den in den Königlichen Schloß zu Potsdam befindlichen Meublen, Betten sowie fürstl. als für Domestiquen und andere dem Kastellen Knopff zur Inspektion anvertrauten Effecten*. 1780, *Akte 220* : *Acta betreffend die Inventaria des Königlichen Schloßes zu Potsdam*. 1780-1825, DIZ-Film 84, 22.2.10 *SPSG historische Inventare Nr. 399 Neues Palais*, 1799. Silke Kiesant, curator of clocks and musical instruments for the *Schlösser und Gärten*, Potsdam, kindly provided photocopies of these documents.

[11] See: Friedrich Nicolai, *Beschreibung der Königlichen Residenzstädte Berlin und Potsdam und aller daselbst befindlichen Merkwürdigkeiten und der umliegenden Gegend*, vol. III, Berlin 1786, 1141, 1145 and 1239.

[12] Communicated by Silke Kiesant.

Charles Burney (in 1775) and Alfred Hipkins (in 1896) respectively refer to the Silbermann *Hammerflügel* they saw during their visits to Potsdam.[13] These sources and records indicate that there were three Silbermann *Hammerflügel* at Potsdam, one each in the *Stadtschloß*, *Sanssouci* and the *Neues Palais*. The *Hammerflügel* in the *Stadtschloß* burnt in a fire in April 1945 after an Allied bombing raid at the end of the Second World War. Whether the *Hammerflügel* now in the *Neues Palais* or the one formerly in the *Stadtschloß* corresponded to the invoice of 1747 is not known. The matter is complicated by the fact that the *Neues Palais* was not completed until 14 years after Silbermann died.

A third surviving Silbermann *Hammerflügel*, dated 1749 (fig. 9), is in the *Germanisches Nationalmuseum*, Nuremberg (inv. no. MI 86).

Figure 9. *Hammerflügel* of 1749 by Gottfried Silbermann, *Germanisches Nationalmuseum*, inv. no. MI 86. The case is of walnut; the stand a copy of the one in *Sans Souci.* Photo: Günther Kühnel, *Germanisches Nationalmuseum*, Nuremberg.

[13] See: Charles Burney, *The present state of music in Germany, the Netherlands and the United Provinces*, vol. II, London 1775, 145; Alfred J. Hipkins, 'Silbermann', in: Henry Cope Colles (ed.), *Grove's dictionary of music and musicians*, 3rd ed., 6 vols., New York 1947, IV, 755.

The hammer actions in the three surviving *Hammerflügel* by Silbermann are almost exact copies of the hammer action found in the 1726 piano by Cristofori.[14] Although Silbermann was said to have taken years to try to improve his own hammer action after J. S. Bach's criticism, the action of which Bach approved had nothing to do with that process: Silbermann's hammer action is so closely copied from the hammer action in Cristofori's 1726 piano that Silbermann must have dismantled, carefully studied and measured the action of a Cristofori instrument of about 1726.[15]

The hammer actions of the three Silbermann *Hammerflügel* made with great prescision; they are identical with each other and may be described as standardised. Figures 10 to 12 shows details:

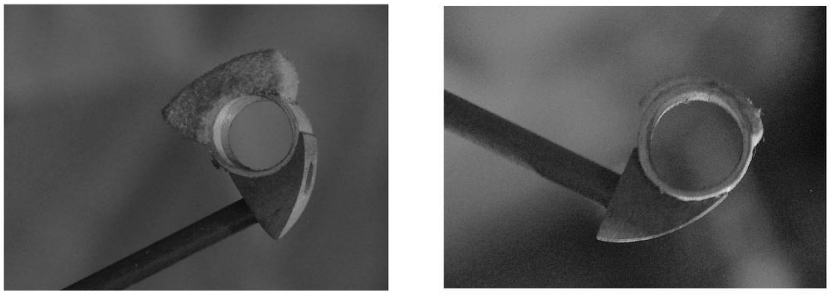

Figure 10. Hammerheads in Silbermann's 1746 piano: left, a bass hammerhead; right, a treble hammerhead. Photos: Kerstin Schwarz.

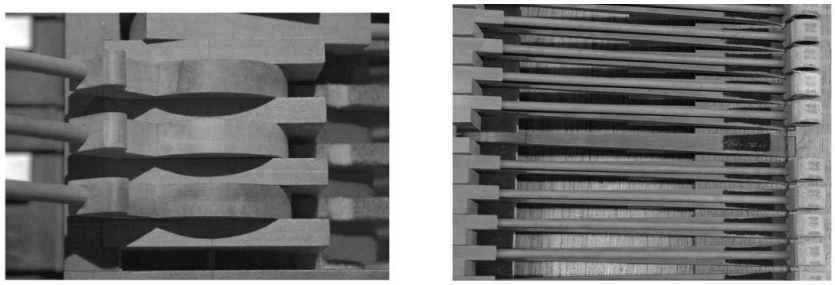

Figure 11. Some hammer butts (left) and intermediate levers in Silbermann's 1746 piano. Photos: Kerstin Schwarz.

[14] Stewart Pollens already noted that Silbermann must have specifically copied Cristofori's hammer action as found in the 1726 Cristofori piano. See: Stewart Pollens, *The early pianoforte*, Cambridge 1995, 115 and 157.

[15] There is evidence that Gottfried Silbermann had access to a Cristofori piano of around 1726 through the young Saxon aristocrat Christian Heinrich von Watzdorf. Von Watzdorf owned a *forte piano*, possibly acquired in Florence in about 1726. He lived in Crostau, a small Saxon village about 60 km east of Dresden. Gottfried Silbermann built an organ, commissioned by von Watzdorf, for the church in Crostau. See the article by Michael Latcham below.

Figure 12. A damper from Silbermann's 1746 piano. Photo: Kerstin Schwarz.

The measurements of Silbermann's hammer actions follow those of the hammer action of the 1726 Cristofori with the exception of the escapement jacks. These are 5mm longer in Silbermann's actions than in the 1726 action by Cristofori. Furthermore, some of the parts are made of different woods. Silbermann chose lime for the key levers, following his tradition, with ebony for the naturals and bone on stained fruit wood for the accidentals; Cristofori followed his respective tradition with chestnut for the key levers, box for the naturals and ebony on stained fruit wood for the accidentals. For the intermediate levers and hammer shanks Silbermann used pear while Cristofori used spruce or cypress. The following figures (figs. 13 and 14) compare models of the hammer actions of Cristofori and Silbermann.

Silbermann, in copying Cristofori's hammer action, precisely copied the paper roll that makes up each hammerhead, the balance point of the key lever and the point of escapement of the jack. Silbermann's choice of pear for the intermediate lever, the hammer shank and the hammer rests makes his action somewhat heavier than Cristofori's action, but the greatest difference for the player is caused by the greater hammer travel in Silbermann's pianos. In the 1726 Cristofori piano the hammer has to travel 2.5cm to reach the strings whereas in Silbermann's *Hammerflügel* the hammer must travel 4cm to reach the strings, almost twice as far. For this reason, Silbermann's *Hammerflügel* have a slower and heavier hammer action in which the repetition is not as good as in Cristofori's pianos. The moment at which the hammer escapes the action train occurs later in Silbermann's pianos because the jacks must remain in contact with the hammer for longer. Nonetheless, because of the different case construction, and above all because of the difference in soundboard design, Silbermann's *Hammerflügel* are capable of a louder sound than are the pianos of Cristofori.

Gottfried Silbermann copied the 'inverted' wrestplank used by Cristofori with the strings attached to the tuning pins under the wrestplank while tuning takes place above as usual. Otherwise, the two makers followed entirely different principles in constructing the cases of their pianos. Cristofori used the same inner construction, very light and flexible, in his pianos as in his surviving harpsichords of 1722 and 1726.[16] The baseboards,

[16] For a comparison of Cristofori's hapsichords and pianos, see: Kerstin Schwarz, 'Bartolomeo Cristofori. Hammerflügel und Cembali im Vergleich', *Scripta artium* 2, 2000/02, 23–67. For a description and line drawing of the inner construction, see the article by Stewart Pollens above.

belly rails and inner braces are of 11mm thick poplar (the belly rail in the 1726 piano is of spruce), in itself a light wood. They have Cristofori's special bentside construction in which there is an inner bentside for the soundboard and a separate outer bentside to take the tension of the strings.

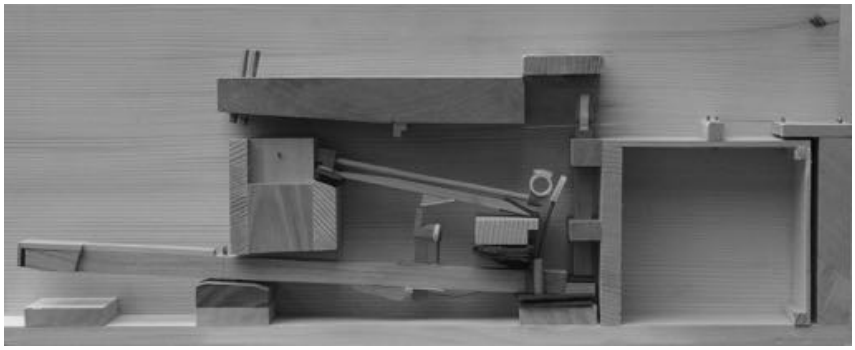

Figure 13. A model of the hammer action of Cristofori's 1726 piano. Model and photo: Kerstin Schwarz.

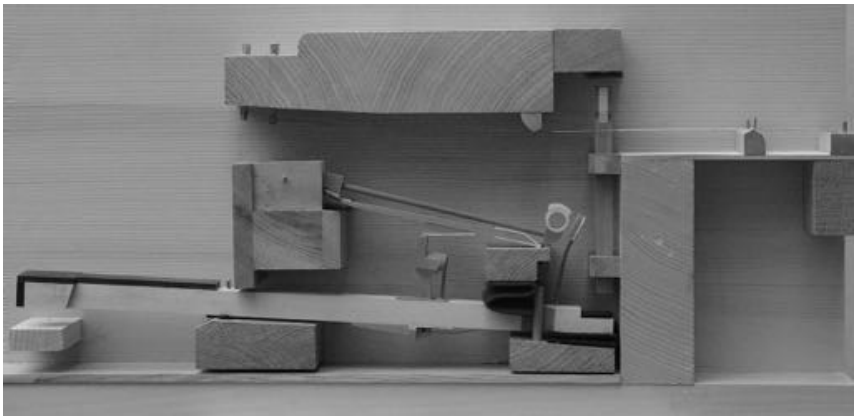

Figure 14. A model of the hammer action used by Gottfried Silbermann in his pianos of the 1740s. Model and photo: Kerstin Schwarz.

Silbermann built his *Hammerflügel* in the Saxon tradition of harpsichord making: they have cases of solid oak or walnut. Nonetheless, although Saxon harpsichords are built with an angled tail, Silbermann's three *Hammerflügel* have a bentside that continues in a curve at the tail to meet the spine. No harpsichords by Silbermann survive, but in comparison with Saxon harpsichords of the time, the inner construction of his pianos, of spruce, uses thicker wood: the bottom and the inner braces are 2.5cm thick; the belly rail is 4cm thick. These larger dimensions suggest that Silbermann strung his *Hammerflügel* with thicker strings than his harpsichords, giving a higher overall tension on the case, which would add

to the capacity of his pianos to make a louder sound than Cristofori's pianos. No string gauge markings survive on the three *Hammerflügel* by Silbermann to support or contradict this idea.

Cristofori's pianos have no means of disengaging the dampers all at once and nor are there timbre stops as such. In the 1720 piano the action and keyboard do not shift. In the 1722 piano they shift to the left such that each of the hammers strikes one string instead of two. The shifting is only possible after having taken out the movable block on the left side of the keyboard (fig. 15). This indicates that this device was more likely intended as a help for the tuner than as a *una corda* device for the player. In the 1726 piano the shifting of the keyboard can be done easily and quickly without moving a block (fig. 15). Here the keyboard shift thus appears to have been intended as an *una corda* device for the player.

Figure 15. On the left, the bass keyboard endblock removed in the 1722 Cristofori piano and the keyboard shifted left for *una corda*. On the right the bass keyboard endblock of the 1726 piano in its permanent place with a small space between the block and the cheek to allow the keyboard to be shifted left for *una corda*. Photos: Kerstin Schwarz.

Cristofori's *una corda* was copied by Silbermann, in his case certainly as a device for the player. Furtheremore, Silbermann added two stops to his three *Hammerflügel*. One of these stops engages or disengages all the dampers by means of two stop levers, positioned left and right in the keywell. These can be used separately, thus more or less dividing the stop bass and treble. The second stop lowers ivory plates onto the strings to give a vibrant effect. This stop, operated by levers behind the nameboard above the wrestplank, can be either engaged or disengaged in its entirety.

The greater distance the hammers have to travel in the *Hammerflügel* of Silbermann has to do with their higher cases. As with the keyboard and action of Cristofori's instruments, the keyboard and hammer action in each of Silbermann's *Hammerflügel* together slide in on the baseboard of the instrument. As Silbermann's cases are 3cm higher than Cristofori's, the hammers have to travel further to reach the strings above. This greater distance also has consequences for the sound: the greater energy that can be acquired travelling the greater distance allows for more volume.

The soundboard constructions and layouts of the instruments of the two makers differ in every way. Cristofori's cypress soundboards are relatively thick, measuring between 3mm and 4mm in thickness, whereas those of Silbermann, made of spruce are very thin, measuring between 2mm and 3mm in thickness. The ribbing of the soundboards also vary significantly in their designs.

Cristofori's pianos of 1722 and 1726 have a four-octave range, C to c'''. The Cristofori piano of 1720 originally had a range of four and a half octaves, FF, GG, AA to c''' (without either $FF^{\#}$ or $GG^{\#}$). The Silbermann *Hammerflügel* of 1746 has the range FF to d''', the other two Silbermann *Hammerflügel* have the range FF to e'''.

Cristofori's pianos have sets of strings that have sounding lengths suited to brass stringing throughout. The strings have sounding lengths close to those of his harpsichords (table 1). In the 1711 article the description of the special double bentside construction is brought into relation with Cristofori's use of thicker strings for his pianos than usual, that is, in his harpsichords.[17] However, Maffei's notes made in 1709 during his interview with Cristofori seem to allude to the special double bentside construction in connection to the sound of the instruments.[18] A relation between the construction and the improvement of the sound is also noted in an anonymous and undated contemporary music lexicon.[19] Nonetheless,

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[17] Anon, 'Nuova Invenzione d'un gravecembalo col piano e forte aggiunte alcune considerazioni sopra gli strumenti musicali', *op. cit.*, 153.

[18] *La perfezione degli stromenti sta nelle misure, e sopra tutto in non essere il fondo nè troppo grosso nè troppo sottile; e nell'aver primo tolto la virtù elastica al loro incurvato, ed al ponte* (The perfection of instruments is found in their dimensions and above all in not having soundboards too thick or too thin and in having first removed the elasticity in their curvature and the bridge). Quoted in: Ochi 'Bartolomeo Cristofori, Scipione Maffei e la prima descrizione del gravecembalo col piano e forte', *op. cit.* See too: Pollens, *The early pianoforte*, *op. cit.*, 235 (transcription), 233 (the translation given here).

[19] *Christofori Bartolomeo da Padova* [...] *inventore de gravecembali a martelli, i quali producono diversa qualità di voce si per il colpo de'martelli nelle corde, sì ancora per l'interna diversa struttura del corpo dello strumento, ma questa non è visibile nell'esterno* [...] (*Christofori Bartolomeo* of Padua [...] inventor of large harpsichords with hammers which produce different qualities of voice both by striking the strings with hammers and also by the different internal construction of the instrument, but which is not visible from the outside […]. Anonymous music lexicon, formerly the property of *Padre* Martini, *Civico Museo Bibliografico Musicale*, Bologna, ms. H 62.

Cristofori's harpsichords of 1722 and later, with thinner strings, also have the double bentside construction, suggesting that at least from 1722 onwards Cristofori may have seen the connection between sound and construction as applicable to all his instruments.

Silbermann's *Hammerflügel* have strings with sounding string lengths in the bass suited to brass stringing, but from the high bass up, they have longer strings than found in Cristofori's pianos. Silbermann's treble strings have sounding lengths appropriate to iron (see the table below).[20]

The stronger inner constructions of Silbermann's *Hammerflügel* suggest that he not only used longer strings but also thicker ones for his *Hammerflügel* than for his harpsichords. The old strings preserved on the Silbermann *Hammerflügel* in Nuremberg suggest the same. It seems likely that the total string tension on a Silbermann piano would have been about twice that on a piano by Cristofori. Nonetheless, the lack of string gauge numbers on either the pianos of Cristofori or the *Hammerflügel* of Silbermann leaves this suggestion as no more than well-informed speculation.

Cristofori's brass stringing and the sounding string lengths he chose are suited to a pitch of a'=415Hz, a pitch also used in Dresden as so-called chamber pitch. Three of Silbermann's organs, built for the court church, for the *Sophiakirche* in Dresden and for the church in the small Saxon parish of Frauenstein, were made to sound at this pitch. Nonetheless, most of Gottfried Silbermann's organs were tuned at so-called choir pitch, that is, at about a'"=460Hz.

Saxon harpsichords of the mid-eighteenth century have sounding string lengths suited from the high bass upwards to iron stringing. No harpsichords signed by Gottfried Silbermann have survived. In the table above, the string lengths of two the 1726 harpsichord and the 1726 piano, both by Cristofori are given. In the same table the string lengths of two of Silbermann's *Hammerflügel* are compared with those of a harpsichord sometimes ascribed to Silbermann and with those of a harpsichord by Johann Heinrich Gräbner the Younger of Dresden[21] Both the latter harpsichords have string lengths characterised by a sounding length for the note c" of around 330mm. Similar string lengths, characterised by such a sounding length for the note c", are also found in two Saxon harpsichords in *Schloß* Pillnitz, Dresden.[22]

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[20] Although Cristofori used the word *acciaio* and not *ferro* and although contemporary German texts use the word *Stahl*, not *Eisen* in connection with music wire, the modern usage of the word iron is adopted here. Unless otherwise stated, the measurements given here were made by the author.

[21] A close inspection of the harpsichord attributed to Silbermann in Berlin reveals little that is reminiscent of the construction of Silbermann's *Hammerflügel* except perhaps in the layout of the keyboard. For these harpsichords, see the following note below.

[22] These comprise a Saxon harpsichord sometimes attributed to Gottfried Silbermann, *circa* 1740, (inv. no. 37413, sometimes also attrbuted to his nephew

Table comparing of sounding string lengths (longer 8-foot strings, mm)[23]

	Piano Cristofori 1726	Cembalo Cristofori 1726[24]	Piano Silbermann 1746[25]	Piano Silbermann 1749[26]	Cembalo Saxon undated[27]	Cembalo Gräbner d.J. 1774[28]
	C–c'''	C–c'''	FF–d'''	FF–e'''	FF–f'''	FF–f'''
FF	-	-	1840	1845	1960	1868
C	1960	1857	1592	1595	1650	1595
c	1125	1130	1068	1072	1130	1098
c'	568	571	608	613	646	637
b'				331		
c''	281	287	309	312	331	336
c'''	145	144	150	146	171	172

Two of the surving Silbermann *Hammerflügel*, those in Nuremberg and in the *Neues Palais*, Potsdam, have the possibility of transposing the keyboard by a semitone. In each of these instruments, the keyboard, and with it the whole hammer action, slides horizontally left or right such that the hammers strike the strings a semitone lower or higher. The tuning pins are arranged in the wrestplank in a pattern analogous to that of a keyboard. With the keyboard in the higher position, the tuning pin pattern corresponds to that of the keyboard. It thus seems that the higher position was 'normal' for the keyboard. In other words, the keyboard could be shifted down a semitone from the normal rather than up. At first, the sounding string lengths of the 1749 Silbermann piano in the *Neues Palais*, when compared with those of the Saxon harpsichord, would suggest otherwise – that the low position, giving a sounding length for the note c'' of 331mm (b' in the table), the same as the sounding length for the note c'' in the Saxon harpsichord. This then suggests that the pitch of the 1749 *Hammerflügel* with the keyboard in low position would have been the same as the pitch of the Saxon harpsichord, presumably chamber pitch with

Johann Georg) and another by J. H. Gräbner the Younger, 1739, inv. no. 37414. For reasons of space these are not included here.

[23] The 1726 Cristofori harpsichord has only one set of 8-foot strings.

[24] *Museum für Musikinstrumente der Universität Leipzig im Grassi Museum*, Leipzig, inv. no. 85. Measurements by Kerstin Schwarz.

[25] *Sanssouci*, Potsdam. Measurements from: Herbert Heyde, *Musikinstrumentenbau,* Leipzig 1986, 162.

[26] *Germanisches Nationalmuseum*, Nuremberg. Measurements (with the keyboard in high position): Georg Ott und Kerstin Schwarz.

[27] *Musikinstrumenten-Museum*, Berlin, cat. no. 3. Measurements: Horst Rase, *Kielinstrumente*, Berlin 1991, 108.

[28] *Museum für Musikinstrumente der Universität Leipzig im Grassi Museum*, Leipzig, inv. no. 91. Measurements: Hubert Henkel, *Kielinstrumente*, Leipzig 1979, 99.

a'=415Hz. If this were right, the 1749 *Hammerflügel* would have had the possibility of transposing up a semitone from a'=415Hz to a'=440Hz.

The 1746 *Hammerflügel* by Silbermann was used at *Sanssouci* by Carl Philipp Emanuel Bach to accompany Frederick the Great in his frequent concerts, playing the flute. The king was not only an able flautist but also interested in the construction of his flutes. He ensured that they were of the best wood and by no means accepted every flute made for him by his flute tutor, Johann Joachim Quantz. Thomas Lerch has been able to establish the pitches of surviving flutes by Quantz.[29] These pitches range from a'=390Hz to a'=408 Hz. This strongly suggests that Silbermann's *Hammerflügel* at *Sanssouci*, with no transposition possibility, was intended to be tuned at about a'=390Hz or a little higher. The sounding lengths of the strings, with a length for c" at 309mm, are comparable to those of the 1749 *Hammerflügel* in the *Neues Palais* with the keyboard in its low position, then with a sounding length for c" at 313mm. In other words, the Silbermann piano of 1749, with the keyboard in high position, played at a pitch of about a'=415Hz and had the possibility of transposing down to about a'=390Hz, necessary to accommodate the king's flutes. That the high position was the normal one is supported by the tuning pin pattern.

Gottfried Silbermann built *Pantalons* – giant dulcimers – to order for the famous Pantaleon Hebenstreit. Hebenstreit invented his enormous dulcimer in about 1705. Like other instrument makers, Silbermann was probably impressed by the magical effects of Hebenstreit's performances. Hebenstreit played his instrument with hammers; the strings were not damped and presumably only damped by Hebenstreit using his hands and forearms when he wanted, as on a modern cimbalom. Hebenstreit may thus not only have inspired Silbermann to find a means of imitating the effects of playing strings with hammers (but then from a keyboard), but also to find a means of damping the strings when required. Hebenstreit's hammers were of bare wood, producing a bright sound that he alternated with a more mellow sound by binding the hammers with cotton and other materials. Silbermann's early pianos, those he made before discovering Cristofori's action, may have had bare wooden hammers with the strings not normally damped. After discovering Cristofori's hammer action (with no means of disengaging all the dampers at once but with leathered hammers), perhaps Silbermann invented the two stops found in his surviving *Hammerflügel.* While Silbermann's hammer action is copied from Cristofori, perhaps the two hand-operated levers for lowering or raising the dampers all at once (or otherwise more or less divided for the bass and treble) was inspired by Hebenstreit's use of his hands or forearms to damp the strings. Silbermann's ivory plates, lowered onto the strings by using

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[29] See: Thomas Lerch, 'Einige Querflötenmodelle des 18. Jahrhunderts', in: Monika Lustig (ed.), *Flöten, Oboen und Fagotte des 17. und 18. Jahrhunderts. Bericht über den 1. Teil des 12. Symposiums zu Fragen des Musikinstrumentenbaus Michaelstein, 8/9 November 1991,* Michaelstein 1994, 8–20.

two other hand-operated levers, bass and treble, was perhaps to give an imitation of the sound Hebenstreit produced with his bare wooden hammers. By lowering the ivory plates to within about a millimetre above the strings, the strings vibrate against the plates when played, producing a clear silvery sound. Together with the use of the strings undamped, the listener is transported into the world of sound created by Hebenstreit.

One further detail may be mentioned that is important for the sound of Silbermann's *Hammerflügel*. The strings are not arranged at the bridge and the nut in close pairs, one pair for each note. The distances between the strings are the same for all of them. It may be that Silbermann chose this solution because the greater distance through which the hammers must travel brings with it a greater risk that the hammers do not rise in vertical lines. This, combined with the provision of an *una corda* brings in turn the risk that the hammers do not hit a solitary string. By spacing the strings equally, this is diminished. Nonetheless, the equal spacing of the strings creates another risk when playing *due corde*: the strings are struck at the edges of the hammers and thus not always with a definite blow, also disadvantageous to the sound. The mechanism must be built with great precision to function well.

Summary

Bartolomeo Cristofori's pianos, with their light, flexible cases, relatively thin stringing and their minimal hammer travel, gave a particularly beautiful and intimate sound. Although today they must sound closer to the harpsichord than do the instruments of Silbermann, the contemporary text published by Maffei in 1711 described them as new instruments: they required a new way of playing; this was a sensitive instrument, capable not only of gradated dynamics but also of the expression that a cello would possess, at least, added the 1711 article, if the player understood how to use his touch in a new way.

Gottfried Silbermann's *Hammerflügel* with their solid cases, probably with far thicker strings than those used by Cristofori, an entirely different soundboard and bridge and above all with the far greater hammer travel, can create a louder sound than is available from the pianos of Cristofori: the dynamic range is greater. The sound of Silbermann's piano has more fundamental and approaches perhaps more closely to modern expectations of how a piano should sound. The influence of Hebenstreit probably led to the inclusion of the two stops, one to engage and disengage all the dampers at once, the other to create a different timbre. These stops gave the player more possibilities.

Cristofori's extraordinary hammer action, at least as he conceived it, functions at its best in his own instruments. Inserted into the higher cases of Silbermann's *Hammerflügel*, entailing a greater hammer travel, pushed Cristofori's hammer action to its limits. Makers in the late eighteenth century,

first in England and then in France, adapted Cristofori's hammer action rather than slavishly copying it. This adaptation enabled Cristofori's hammer action to develop into the hammer action found in the modern piano.