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The Pianos of Bartolomeo Cristofori

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THE INVENTORS and dates of invention of a vast number of instruments are unknown to us. One notable exception is the piano. Bartolomeo Cristofori (1655–1731) is generally credited as its inventor, and its date of invention in Florence has been narrowed to the last few years of the seventeenth century. Three pianos made by Cristofori have survived; yet, despite the significance of these instruments, they have never been the subject of a detailed comparative study. In 1977, the Metropolitan Museum of Art's Department of Musical Instruments decided to ready its 1720 Cristofori piano (see fig. 1) for a recording project. The instrument was studied for possible structural weakness, and during the course of this examination the instrument's peculiar case design was discovered. The immediate question arose as to whether all three Cristofori pianos were constructed in the same way. The author received a research grant from the Museum in 1978 to study the other Cristofori pianos in the Museo degli Strumenti Musicali in Rome (1722) and the Musikinstrumenten-Museum der Karl-Marx-Universität in Leipzig (1726). The unusual structural design of the Metropolitan Museum's 1720 piano was found to be mirrored in the two later examples. A full study of the three instruments revealed many similarities as well as subtle differences that testify to the experimental nature of these earliest known pianos.

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An inventory of musical instruments owned by Prince Ferdinando de' Medici dated 1700 lists an "arpicimbalo di Bartolomeo Cristofori, di nuova inventione, che fa il piano e il forte."[1] This suggests that Cristofori devel-

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1. Vinicio Gai, *Gli strumenti musicali della corte Medicea e il Museo del Conservatorio "Luigi Cherubini" di Firenze* (Florence: Licosa, 1969). The inventory begins on p. 6, and the *arpicimbalo* is mentioned and described in detail on p. 11.

FIGURE 1. The 1720 piano by Bartolomeo Cristofori in the Metropolitan Museum of Art, New York. Photograph Courtesy of the Metropolitan Museum.

oped a keyboard instrument with striking mechanism sometime late in the seventeenth century. In 1711, Scipione Maffei announced the invention of this instrument in an article entitled "Nuova invenzione d'un gravecembalo col piano e forte,"[2] which provided a technical description of Cristofori's hammer action and discussed novel structural aspects of his instrument's design that reflected his acoustical theories. Based upon a first-hand examination of several of Cristofori's pianos, the article dealt with the new tonal and expressive qualities imparted by the striking mechanism and their effect upon performance technique, described the type of music suitable

2. Scipione Maffei, "Nuova invenzione d'un gravecembalo col piano e forte," *Giornale de' litterati d'Italia* 5 (Venice, 1711): 144–59. A transcription and English translation appear in Edward Rimbault, *The Pianoforte: Its Origin, Progress, and Construction* (London, 1860), pp. 95–102.

for the instrument, and touched upon the controversy over the instrument's merits and shortcomings vis-à-vis the harpsichord.

While Maffei's article established Cristofori as the inventor of the hammer mechanism among his contemporaries, other instrument makers in Germany and France independently developed striking actions early in the eighteenth century. In 1721, Christoph Gottlieb Schröter submitted models of hammer actions to the court of the Elector of Saxony, where he hoped to receive funds to construct instruments incorporating them. While it is believed that he was not successful at having his instruments built, drawings made from his models indicate that they were workable in design, and in fact his ideas appear to have been the inspiration for the "German" action, which employed a hammer pivoting within a flange mounted on the back of the key lever.[3] Schröter claimed to have invented the hammer action in 1717. He was preceded by at least one other inventor, however, for in 1716 a Frenchman named Jean Marius submitted drawings of hammer actions to the Académie royale des sciences in Paris.[4] These plans suggest poor design, and it is not known whether attempts were ever made to construct instruments employing his striking mechanisms. Thus, on the basis of the date of publication of Maffei's article and the dates of Marius's and Schröter's submission of drawings and models to their prospective royal patrons, Cristofori was deemed the inventor of the piano. This conclusion persisted throughout the eighteenth and nineteenth centuries. Maffei's article was quoted and translated in numerous journals and lexicons,[5] thereby spreading and maintaining the notion of Cristofori as the inventor of the piano. In recent years, references to *cembali* with "piano and forte" have been discovered, such as in the sixteenth-century letter from Hippolito Cricca (called Paliarino) to the Duke of Modena.[6] In all likelihood, this instrument was a two-register harpsichord with movable registers. An ambiguous reference to what may have been a striking mechanism in the fifteenth-century manuscript of Arnault of

3 Rimbault, *The Pianoforte,* p. 108.

4. Ibid., p. 102.

5. These include: Johann Mattheson, *Critica musica* (Hamburg, 1725), vol. 2, p. 335; Johann Gottfried Walther, *Musicalisches Lexicon* (Leipzig, 1732), p. 192; Lorenz Christoph Mizler, *Musikalische Bibliothek* (Leipzig, 1738); Friedrich Wilhelm Marpurg, *Kritische Briefe über die Tonkunst* (Berlin, 1764); Jacob Adlung, *Musica mechanica organoedi* (Berlin, 1768); Johann Nikolaus Forkel, *Allgemeine Litteratur der Musik* (Leipzig, 1792), p. 262; Abraham Rees, *New Cyclopedia* (London, 1802–20); Rimbault, *The Pianoforte* (London, 1860); Leto Puliti, *Cenni storici della vita del Serenissimo Ferdinando dei Medici* (Florence, 1874); and Cesare Ponsicchi, *Il pianoforte* (Florence, 1876).

6. Francesco Valdrighi, *Musurgiana* (Modena, 1879), p. 26.

Zwolle[7] suggests that there may well have been a hammer mechanism developed much before Cristofori's invention.

We know little about Cristofori's career as an instrument maker. A baptismal certificate reveals that he was born in Padua in 1655.[8] It is believed that on a visit to Padua in 1687 Prince Ferdinando de' Medici became acquainted with Cristofori and asked him to become a court instrument maker in Florence.[9] It is probable that Cristofori assumed his position shortly thereafter, but the first record of his work there was not until August, 1690, when an archival reference concerning reimbursement for materials and services refers to him by name.[10] A number of archival entries concerning Cristofori's career as an instrument maker and curator of instruments at the Medici court are transcribed by Leto Puliti[11] and translated by Raymond Russell.[12] The entries deal primarily with bills submitted by Cristofori for work done by him, and from these records it is evident that much of his time was spent in maintaining, repairing, and restoring court instruments, as well as building new ones. He also appears frequently to have been occupied with the task of moving instruments to and from the theater and various royal residences. At times he required reimbursement for payment made to an assistant and cabinet maker, and he often required funds for having lumber resawn and for supplies such as cypress wood from Candia (Crete), vulture feathers, brass and iron wire, fish glue, pins, leather, and nails.[13]

Following Prince Ferdinando's death in 1713, Cristofori was made curator of musical instruments by the Prince's father, Grand Duke Cosimo III. Inventories made in 1700 and 1716 (the latter signed by Cristofori) reveal that the court possessed a large number of instruments (approximately 150

7. G. le Cerf and E. R. LaBande, *Instruments de musique du XVie siècle: Les traités d'Henri-Arnault de Zwolle et de divers anonymes* (Paris: August Picard, 1932).

8. B. Brunelli Bonetti, "Bartolomeo Cristofori e il mondo musicale padovano," *Bartolomeo Cristofori, inventore del pianoforte,* Publicazione ufficiale del comitato per la celebrazione del III centenario dalla nascita di Bartolomeo Cristofori (Padua: A cura dell'Ente provinciale per il Turismo, 1955), p. 31. Erroneous dates are given in François-Joseph Fétis, "Cristofori," *Biographie universelle des musiciens,* 2d ed. (Paris, 1860); Rimbault, *The Pianoforte,* p. 94; and the *Catalogue of Keyboard Musical Instruments in the Crosby Brown Collection* (New York: Metropolitan Museum of Art, 1903), p. 122.

9. A. J. Hipkins, "Cristofori," *Grove's Dictionary of Music and Musicians,* 5th ed. (New York: St. Martin's Press, 1954).

10. Raymond Russell, *The Harpsichord and Clavichord* (London: Faber and Faber, 1965), p. 126.

11. Puliti, *Cenni storici,* p. 45.

12. Russell, *The Harpsichord and Clavichord,* p. 126.

13. Ibid.

as of 1716)[14] including bowed string instruments by Stainer, the Amatis, and Stradivari. Keyboard instruments by Baffo, Domenica da Pesaro, Girolamo Zenti, and Giuseppe Mondini also appear, as well as seven keyboard instruments by Cristofori.

It has not yet been possible to determine the number of instruments constructed by Cristofori. The roman numeral "I" appears on the underside of a rail supporting the action of the 1720 piano, and the mark "XX" appears on an action-rail support of the 1726 piano. Whether these are serial numbers is unclear. Certainly the piano of 1720 was not the first constructed by Cristofori. The mark "I" may mean that the hammer action in the 1720 piano was the first incorporating the later design that is evident in the three surviving instruments, but which differs markedly from the earlier action pictured in Maffei's article. It is interesting that there appears to be little concordance between the inventories of 1700 and 1716 with respect to the instruments ascribed to Cristofori. Most of the instruments attributed to him appear to have been ordinary harpsichords. The inventory of 1700 reveals three cembali, all of two registers (two of which had keyboard ranges of *GG–c‴*, the other with a range of *C–c‴*, as well as three additional harpsichords in spinet form (one designated "spinettone da orchestra"), two of which had ranges of *C–c‴*, the spinettone having a range of *GG–c‴*. The inventory of 1700 also lists an instrument designated "arpicembalo di nuova inventione, che fa il piano e il forte," with a keyboard range of *C–c‴*.[15] The inventory of 1716 mentions no instrument with a hammer mechanism, but lists four cembali with one register, another cembalo, a "spinettone da teatro," and an upright cembalo, all by Cristofori.[16] Presumably, those instruments that do not appear on the inventory of 1716 were sold or otherwise dispersed. Aside from the instruments built for the Medicis, it is possible that Cristofori also constructed instruments privately. Cristofori died in Florence on January 27, 1731.

The early action design pictured and described in Maffei's 1711 article (see fig. 2) differed considerably from the later configuration found in the three surviving pianos dating from the 1720s. The drawing in Maffei's article shows a heavy intermediate lever moved by the back of the key lever beneath it. The spring-loaded escapement jack is supported by the intermediate lever and activates a pivoted hammer possessing a flat striking surface. The hammers are caught on their rebound by a network of silk threads. The dampers, which rest on the back section of the centrally piv-

14. Puliti, *Cenni storici,* pp. 101–107.
15. Gai, *Gli strumenti musicali,* p. 6.
16. Puliti, *Cenni storici,* pp. 101–107.

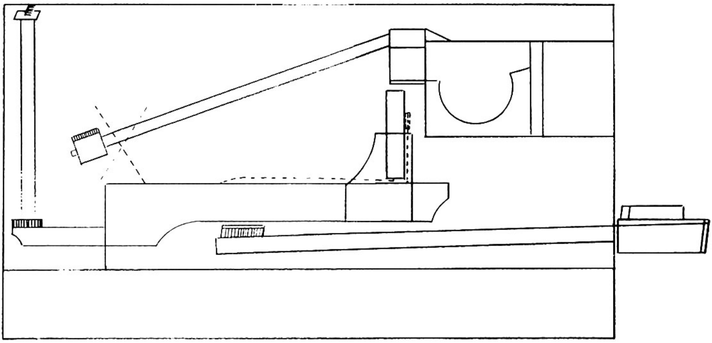


FIGURE 2. Drawing of the Cristofori piano action of 1711, after an illustration in Scipione Maffei, "Nuova invenzione d'un gravecembalo col piano e forte," *Giornale de' litterati d'Italia* 5 (Venice, 1711).

oted intermediate lever, are located beneath the strings and are lowered away from them as the key is depressed.[17] This configuration, widely circulated by virtue of Maffei's article and König's German translation published in 1725,[18] apparently never served as a model for other instrument makers, as hammer actions of this type are not found in surviving pianos of any other maker. In the actions of the three known pianos of Cristofori, the movable, spring-loaded jack is supported by the key lever (see below, figs. 8–10), as opposed to the massive intermediate lever pictured in Maffei. The jack pushes a light, leather-hinged intermediate lever situated between the jack and the hammer. An adjustable padded stop permits the position of the jack to be regulated so that it disengages from the intermediate lever just before the hammer strikes, but not before the motion of the key lever has ended. Displacement resulting from the contrary rotational movement of the jack-bearing key lever and the intermediate lever, together with the free movement of the jack provided by its spring, constitute Cristofori's escapement mechanism. In the earlier action, pictured in 1711, the spring-loaded jack pressed directly against the hammer butt and was able to slip aside before the motion of the key lever caused the hammer to become wedged against the strings. The pivoted, massive intermediate lever pictured in 1711 caused the hammer to rise and the damper to fall simultaneously. The light, terminally hinged intermediate levers in the three

17. Maffei, "Nuova invenzione," in Rimbault, *The Pianoforte*, p. 99.
18. Mattheson, *Critica musica*, vol. 2, p. 335.

surviving instruments serve only to lift the hammers. In these actions, the point of contact between the jack and the intermediate lever is approximately half-way along the length of the lever, thus reducing the "mechanical advantage" of the system (i.e., the hammer moves through a greater distance, but with less force, than the key lever). It is interesting that the motion of the jack in Cristofori's hammer actions is somewhat reminiscent of the motion of the tongue in the harpsichord jack. Both are propelled vertically and remain firm during their upward motion, but become flexible and move sideways during their downward movement through the use of a spring. It is conceivable that Cristofori was influenced by the preexisting harpsichord mechanism when designing his hammer action. The dampers of the surviving pianos are racked and constructed like tongue and quill-less harpsichord jacks, and they damp above the strings. The dampers are graduated in width. The wider, and thus heavier dampers are located in the bass, while the narrower ones damp the treble strings. The damper jacks rest upon the back of the key levers and bear leather damper pads. The network of silk threads that cushioned the rebounding hammers in the earlier piano mechanism described by Maffei was replaced by a fully developed back-check in the later instruments that have survived to this day. The back-check, attached to the back of the key lever, consists of a stout piece of wire padded at the top end with leather. As the key lever rotates, the back-check intercepts the rebounding hammer and catches it, thereby controlling its descent, reducing noise, and preventing it from bouncing up and restriking the strings. Cristofori's back-check was used in both the "English" and the "German" actions that developed later in the eighteenth century, and it can be found virtually unmodified in today's piano actions.

Certain features of Cristofori's piano action, such as the spring-loaded jack and the back-check, have stood the test of time and have been retained either intact or in principle in the modern piano. Other features, such as his intermediate lever, are of questionable value. Two forms of the "English" action that evolved from Cristofori's design, the "single action" found in simpler square pianos and the action used in many English grand pianos, employed no intermediae lever. This configuration, particularly as found in the English grand pianos that used a spring-loaded jack, was entirely successful and provided good repetition speed and control over gradations of loudness. The intermediate lever in Cristofori's later instruments was a holdover from his earlier design, but its sole function in the actions of the surviving instruments was to alter the system's leverage. This could have been done more directly, as in the "English" action, by having the jack strike the hammer closer to its pivot point.

The overall effectiveness of Cristofori's design cannot be denied, however. The delicate adjustments needed to make the escapement work can be easily done, and despite the fact that the components of the action are complex and somewhat crudely fashioned even by eighteenth-century standards, Cristofori's hammer action possesses roughly the same playing characteristics as the harpsichord. It is often the case that mechanical inventions are initially overly complex and require rethinking to isolate the essential elements and thus simplify the overall design. What makes Cristofori's invention so astounding is the fact that there is nothing inherent in the hammer that makes it more capable of producing gradations in loudness than the plectrum used in the harpsichord. Both the hammered dulcimer and the psaltery, the respective predecessors of the piano and the harpsichord, were capable of dynamic gradation. When the keyboard was adapted to the psaltery, the lateral distance at which the plectra were held in relation to the strings became invariable, and thus the performer lost the ability to modify the plucking strength. Cristofori intuited that pivoted hammers could be propelled with different force by altering the force on the keys. In a system in which momentum was transferred from the key lever to the hammer, any change in the force placed upon the key would be reflected in the force of the hammer's blow and consequently in the volume of sound produced. Previously, alterations in force placed upon harpsichord keys produced no effect, as the elasticity of the plectrum and its fixed lateral position in relation to the string were the only factors determining the volume of sound. In developing a hammer action, it was not only necessary for there to be a transfer of momentum from the key lever to the hammer, but the hammer also had to be free to fall away from the strings upon impact and pass by the raised jack. In other words, the hammer had to move reciprocally in response to the simple upward motion of the jack. Cristofori's mechanical solution was so well thought out that it became the basis for today's piano action.

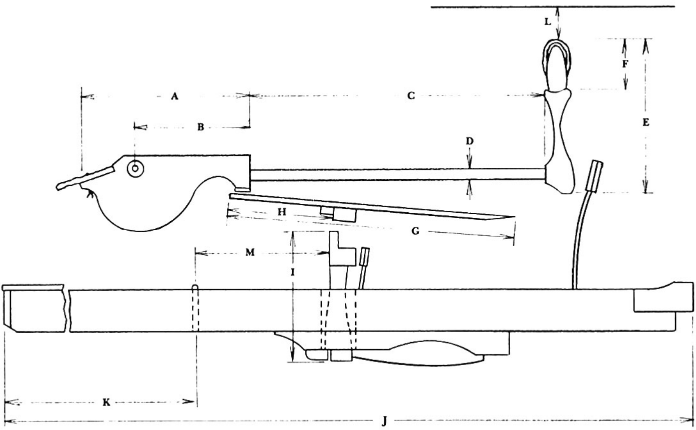
What led Cristofori to experiment with the hammer action is a matter of conjecture. Certainly, the existence of the clavichord suggested that a keyboard instrument could produce dynamic gradation. The 1716 Medici inventory of instruments mentions a *Geigenwerk*, and thus Cristofori was aware of another keyboard instrument capable of dynamic gradation. It has been suggested that the great popularity of the hammered dulcimer in the late seventeenth century may have alerted him to the possibility of developing a keyboard instrument with hammers; if this was the case, one can speculate that Cristofori's initial fascination may have been with attempting to produce a keyboard instrument with the tonal characteristics of the dulcimer, and that the ability to produce gradations in loudness followed unexpectedly.

While there is a major difference in design between the hammer actions of the three surviving Cristofori pianos and the action pictured in Maffei's drawing, there are some subtle differences among the surviving actions themselves. Table 1 summarizes the basic measurements of the hammer-action parts. From a glance at the tabulated figures, it is clear that Cristofori did not establish a set of measurements for constructing the parts of his piano actions. Key-lever lengths, the height and position of the jack along the key lever, the dimensions of the intermediate lever, and hammer measurements vary among the three instruments. There appear to be no consistent changes in the leverage system between 1720 and 1726, and thus certain proportions are roughly maintained. For example, the distance between the front of the key and the balance pin is approximately equal to the distance between the balance pin and the jack; the jack strikes the intermediate lever at the midpoint of the lever; and the intermediate lever makes contact with the hammer at a point located one-fifth of the length of the hammer, measured from the pivot point.

Most interesting is the variation in the construction of the hammers of the three instruments (see figs. 3–5). The piano of 1720 has hammer heads consisting of two sections: a carved lower section glued perpendicularly to the hammer shank, and an ovoid section of wood with a leather covering fitting into a depression in the lower piece. The upper sections appear to be replacements, the originals probably being cylindrical tubes of parchment, such as are found in the hammers of the piano of 1726. The difference in overall height between the hammer heads of the piano of 1720 and those of the pianos of 1722 and 1726 is due to the placement of the wrestplank. The inverted wrestplank of the two later pianos permitted the use of shorter hammer heads, as the strings were pined beneath the plank and were therefore closer to the hammers in their resting position. In order to keep the hammer travel short in the piano of 1720 (which had its strings hitched above the wrestplank) the hammer heads had to be taller. The wrestplank of the 1720 piano is also tapered toward the gap in order for the shanks to clear it. Maffei mentions the inverted wrestplank in his article,[19] and the hammer heads shown in his drawing of the action are corre-

19. Maffei, "Nuova invenzione," in Rimbault, *The Pianoforte,* p. 100.

TABLE 1
Comparative Dimensions of the Hammer Mechanisms of the Three Cristofori Pianos



		1720 Piano	*1722 Piano*	*1726 Piano*
A		52 mm.	48 mm.	48.5 mm.
B		34 mm.	33 mm.	32.5 mm.
C	Bottom hammer	123.5 mm.	116 mm.	121 mm.
C	Top hammer	112.5 mm.	115 mm.	117.5 mm.
D		4 mm.	4 mm.	4 mm.
E	Bottom hammer	49.5 mm.	12 mm.	24.5 mm.
E	Top hammer	46.5 mm.	13.5 mm.	19.5 mm
F	Bottom hammer	19 mm.		18.5 mm.
F	Top hammer	16 mm.		12 mm.
G		113 mm.	130 mm.	135.5 mm.
H		54 mm.	68 mm.	69.5 mm.
I		62 mm.	59 mm.	56.5 mm.
J	Bottom hammer	443 mm.	332 mm.	344.5 mm.
J	Top hammer	407 mm.	320 mm.	336 mm.
K	Bottom hammer	165 mm.	124 mm.	123.5 mm.
K	Top hammer	159 mm.	123 mm.	125 mm.
L	(Approx. range)	31–35 mm.	35–36 mm.	22–23 mm.
M	Bottom hammer	148 mm.	110 mm.	116 mm.
M	Top hammer	135 mm.	110 mm.	111 mm.

FIGURE 3. A hammer from the 1720 Cristofori piano in the Metropolitan Museum of Art. Photograph by the author.

FIGURE 4. A hammer from the 1722 Cristofori piano in the Museo degli Strumenti Musicali, Rome. Photograph by the author.

FIGURE 5. A hammer from the 1726 Cristofori piano in the Musikinstrumenten-Museum der Karl-Marx-Universität, Leipzig. Photograph by the author.

spondingly short. The hammer heads of the 1722 piano must closely resemble those shown in Maffei's article. They have flat striking surfaces covered with a thick, woolly leather, similar in texture to the leather covering the cylindrical heads of the 1726 instrument. The hammer heads of the 1726 piano (see fig. 6) were made by rolling a strip of parchment into a cylinder. The walls of the cylinders are about eight layers thick and are stiffened by the glue used to bind the strip of parchment together. When first constructed, the cylindrical heads were undoubtedly firm, yet elastic and light in weight. The hammer butts of the three surviving instruments contain a pierced leather bearing through which a metal rod passed. Two rods, inserted into the left and right hammer-rail supports, each served as a common pivot for half of the hammers. The butts of the hammers of the pianos of 1720 and 1726 are roughly semicircular, whereas the butts of the 1722 hammers have been carved back. It is not known whether the present shape is original or whether the butts were reshaped to lighten them. Lead weights inserted behind the pivot point further reduce the effective weight of the 1722 hammers.

The intermediate levers and jacks are similar, although not identical in detail and design. In the piano of 1720, the intermediate levers are wider than those of the later pianos. They are carved away above the jack stop, however, to permit a tool to be inserted so that the position of the jack could be adjusted. In the pianos of 1722 and 1726, the intermediate levers are narrower, so that the regulating tool could be inserted between the lev-

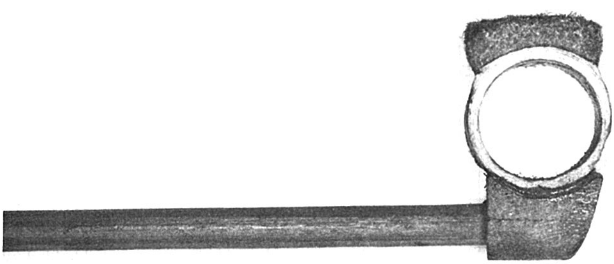


FIGURE 6. A hammer head from the 1726 Cristofori piano. Photograph by the author.

ers without the need for carved access spaces. The jacks differ in the method by which the spring is inserted into its resting slot. In the piano of 1720 the access to the slot is through a groove cut in the side of the jack, whereas the jack of 1726 uses a flat-bottomed hole drilled partially through the side. The 1722 jack is drilled through completely, and thus the spring can be inserted in its slot from either side of the jack.

The key levers of the pianos of 1722 and 1726 are cut in the traditional manner, while those of the 1720 piano are most unusual in that the heads of the natural keys have been grafted onto the remaining section of the key levers (see fig. 7). This graft is concealed by the boxwood plating, which is of one piece. The reason for this unusual construction is unexplained. It may reflect a shortening of the key levers, but the many modifications made to this instrument do not suggest that there was a need to make such an alteration. The elaborately cut wooden block that supports the jack spring and that forms the lower section of the jack mortise in the piano of 1720 is not present in the two later pianos (see figs. 8–10). In these instruments, the spring is attached directly to the key lever, and a smaller wedge-shaped block acts as the bearing surface for the jack. Basically, many of the minor structural differences between the piano of 1720 and the later examples suggest that construction was being simplified. Many structural elements in the 1720 piano action are unnecessarily labored in detail. In general, the two later examples show greater similarity to one another than to the earliest of the surviving pianos. This suggests either that Cristofori had

FIGURE 7. Front section of a key lever from the 1720 Cristofori piano. Photograph by the author.

settled upon a basic design for his pianos sometime between 1720 and 1722 or that the piano of 1720 was an experiment and the later pianos are in fact similar to earlier ones that have not survived. We know from Maffei's article that Cristofori had constructed several pianos with inverted wrestplanks prior to 1711. Thus, the 1720 piano was a departure from his established design. Whether this piano was the first or only one to have a wrestplank in the uninverted position is a matter of speculation. The 1720 piano action also differs significantly from that described in Maffei's article. The most obvious explanation for this discrepancy is that Cristofori modified his action between 1711 and 1720. Another possibility is that Maffei's work is in error, and that his description and drawing are phantasies. He states in the article that the mechanism is difficult to understand and describe, and that he was writing from memory with the assistance of some notes and a rough model of the hammer action.[20] In all likelihood Maffei's description is an accurate one. It is highly specific in reference to structures—such as the silk network that catches the hammers on their rebound and "jawbone shaped pieces" (flanges) supporting the jack—that do not exist in the three surviving pianos. Therefore, the differences between the description found in Maffei's article and the three surviving Cristofori pianos are probably due to alterations in design made between 1711 and 1720.

Cristofori's innovative genius extended beyond the hammer action itself to almost every aspect of the piano's design. It is clear that he did not view the piano as simply a harpsichord case with a hammer mechanism, but rather as an entirely new instrument. Many of his innovations were adopted by later builders, and his use of heavier stringing and case structure established the direction assumed in pianomaking that led to the development of the piano as we know it today. Mentioned in Maffei's article and present in the pianos of 1722 and 1726 is the inverted wrestplank. In this configuration, the tuning pins pass through the wrestplank, and the string coils are located beneath the block. The nuts of these two pianos are located on the lower surface of the wrestplank and are unusual in that they are not pinned. Instead of passing around pins, the strings press against a metal rod inlaid in the nut and then pass through a narrow saw kerf that establishes the lateral position of the strings. The advantage of this arrangement is that the wrestplank can be kept thick (about 30 mm., as opposed to about 15 mm. in thickness for the piano of 1720 with noninverted wrestplank) while accommodating the hammer action. In addition, by hav-

20. Ibid., p. 97.

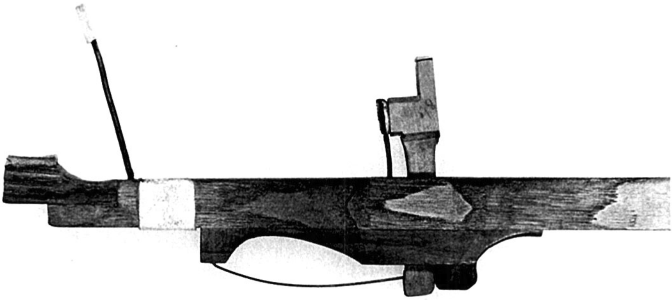


FIGURE 8. A key lever from the 1720 Cristofori piano. Photograph by the author.

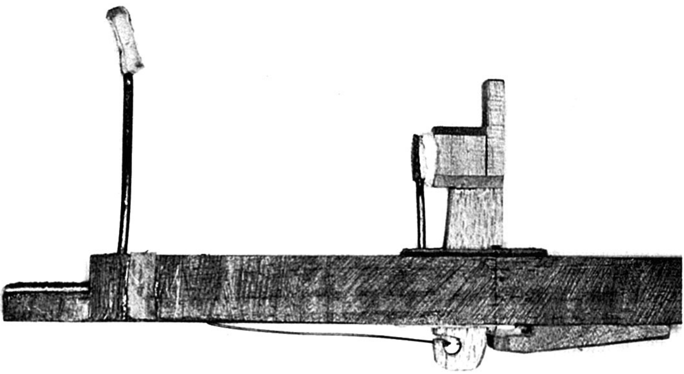


FIGURE 9. A key lever from the 1722 Cristofori piano. Photograph by the author.

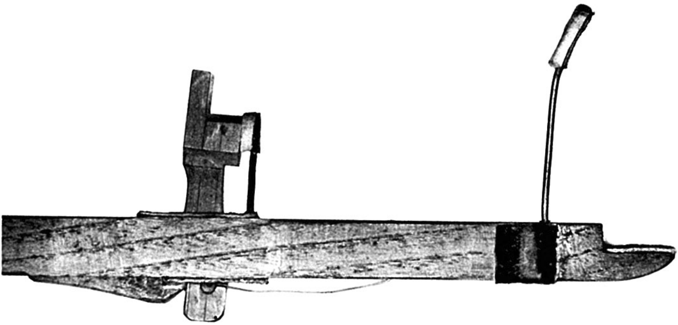


FIGURE 10. A key lever from the 1726 Cristofori piano. Photograph by the author.

ing the nut located above the strings, the strings are pushed more firmly against it during the impact of the hammers. Lifting of the strings away from the nut during hard playing is highly detrimental to the tone, and this problem, dealt with in the nineteenth century by the agraffe and capo d'astro bar, was effectively solved by Cristofori's inverted wrestplank. Another benefit afforded by the inverted wrestplank was the provision for an una corda stop, activated by gripping the knobs located on the keyboard end blocks and shifting the action sideways. The struts that transfer stress from the wrestplank to the belly rail are located above the hammers, and thus do not interfere with the una corda shift (see fig. 11). In the piano of 1720, the struts pass between the hammers and fit so closely that there is no provision for shifting the keyboard.

In an effort to isolate the stress-bearing parts of the case from the resonating structures, Cristofori devised a highly complex arrangement that essentially provided an independent thin-walled case supporting the soundboard built within the heavy-walled case supporting the strings (see fig. 12). Outwardly, the case sides of the Cristofori pianos appear to be about 12 mm. thick. On closer examination, one sees that the bentside is laminated above the hitchpin rail, and the laminations (each 6 mm. thick) are concealed by a veneer cap. The hitchpin rail is shelf-like and extends over the soundboard without touching it. The hitchpin rail is supported in

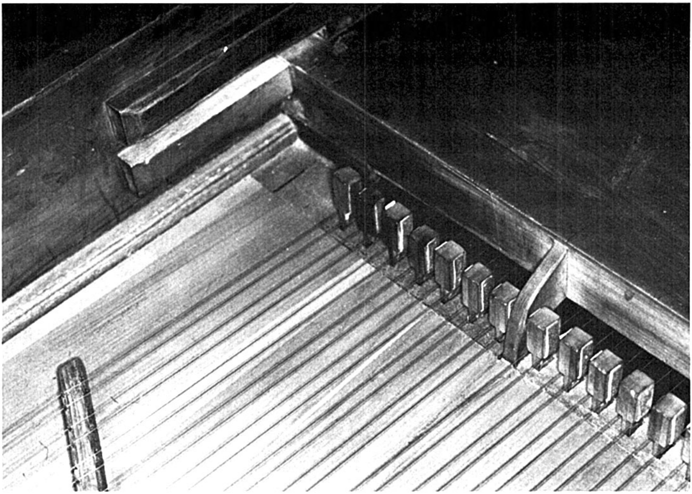


FIGURE 11. Wrestplank and strut in the 1726 Cristofori piano. Photograph by the author.

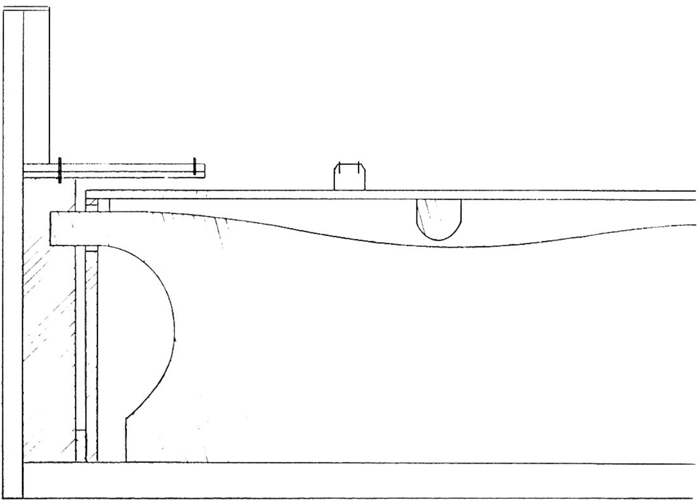


FIGURE 12. Schematic drawing of cross section of the 1720 Cristofori piano case.

this position by a 19 mm. wide poplar liner that extends to the case bottom. This heavy liner is sawn transversely to permit it to follow the curve of the outer bentside. The inner 6 mm. thick lamination of the bentside abuts the hitchpin rail, thereby preventing it from lifting away from the lower liner. In the 1722 piano, the hitchpin rail at the tail is sandwiched between two sections, upper and lower, which make up the tail. The case of the 1722 piano is unpainted, and the edge of the hitchpin rail can be seen from the outside of the case, laminated between the upper and lower section of the tail.

Glued to the lower part of the heavy poplar liner is a 4 mm. thick spacer to which an inner bentside of fir, also 4 mm. thick, is glued. This inner bentside supports the soundboard and does not touch the outer case. Even the diagonal braces that run from the spine to the outer bentside pass through oversized holes in the thin-walled bentside, and consequently do not touch it. The soundboard and its thin, supporting bentside are therefore isolated from the massive case and braces. By devising this complex case, Cristofori was essentially preserving the traditional resonant structure of the Italian harpsichord while permitting the use of heavier strings supported by a stable case. Because of the flexibility of the thin bentside, the soundboard's vibrations are impeded less than they would be if the soundboard were anchored to a heavy, rigid case. Before the bottom was removed from the 1720 Cristofori piano at the Metropolitan Museum of Art in August, 1978, this complex case structure was studied through the use of a fiber-optic probe and X-ray photography. Figure 13 is an X-ray photograph that clearly shows the inner bentside and the space separating it from the outer case. Photographs made at the Metropolitan Museum of the case interior of the 1720 piano, photographs supplied by the Museo degli Strumenti Musicali taken during the restoration of the 1722 piano, and photographs made by the author through a hatch in the bottom of the 1726 piano in Leipzig all show that the cases of the three instruments are constructed in a similar manner (see figs. 14–19).

Soundboard ribbing differs in each of the surviving pianos. In the piano of 1720, nine ribs parallel to the diagonal braces supporting the case sides are notched and pass over the cutoff bar. The soundboard and ribbing of this piano are not original, but are replacements added during the restoration in 1938 conducted by Curt Sachs. One of the restorers who worked on the piano, Wolfgang Staub, was interviewed in 1979, and he recalled that all the removed parts (which included the soundboard, ribs, wrestplank, and bottom) were accurately copied.[21] The original wrestplank was pre-

21. According to Mr. Staub, the present bridge is original.

FIGURE 13. X-ray photograph of the 1720 Cristofori piano showing the gap between the inner and outer bentsides. Courtesy of the Metropolitan Museum of Art.

served, and it is clear that the replacement is a good facsimile of the original. Only a section of the original soundboard (3.5 mm. in thickness) was preserved. Analysis carried out at the Center for Wood Anatomy Research, Forest Products Laboratory (Madison, Wisconsin) indicates that the

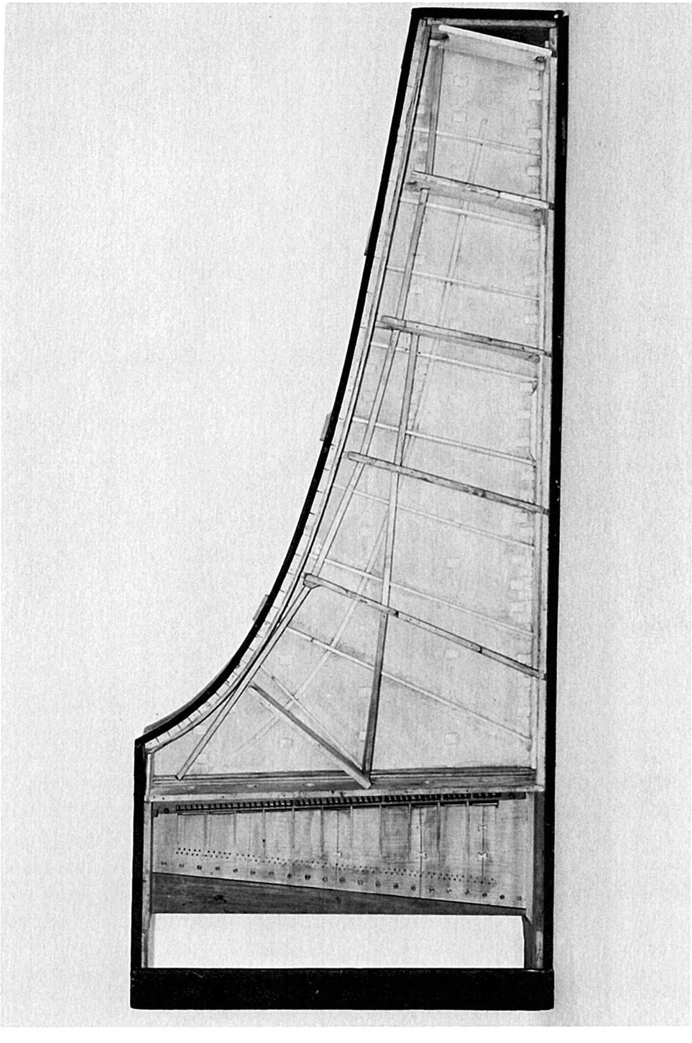


FIGURE 14. Bottom view of the interior of the 1720 Cristofori piano (bottom removed). Photograph by the author.

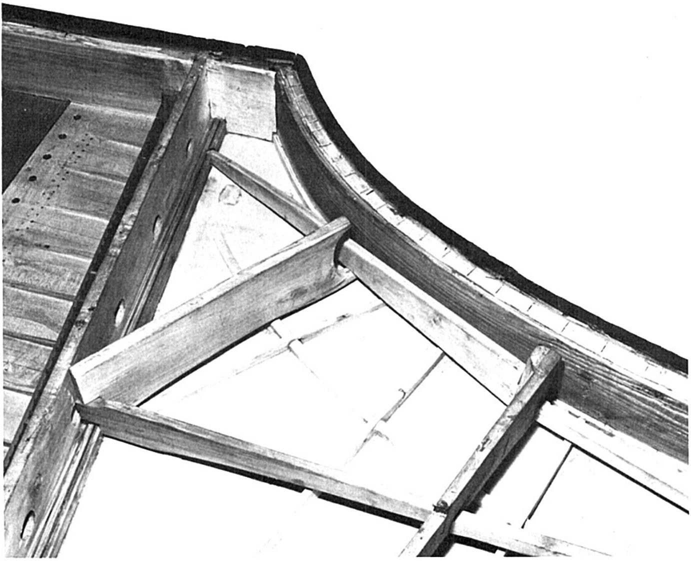


FIGURE 15. Bottom view of the interior of the 1720 Cristofori piano (bottom removed). Photograph by the author.

soundboard is cypress.[22] From glue marks on the preserved section of the original soundboard, it was possible to determine its initial position. Originally glued to the belly rail, the old section of the soundboard shows marks of the first rib in the treble. From the glue mark, the first rib was evidently parallel to the structural brace nearest it. The replacement rib is angled away from the brace, and thus it is clear that it was positioned incorrectly by the restorers. The soundboard ribbing in the piano of 1722 differs from the ribbing in the 1720 piano in that the ribs do not cross the cutoff bar. They are ten in number and are parallel to the structural braces nearest

22. Wood samples were taken in August, 1978, when the bottom of the piano was removed to verify and clarify information revealed by X-ray photographs of the case. The results of the Center's analysis indicate that the original soundboard is cypress; the diagonal braces are poplar; the inner bentside, spine, and outer bentside are all fir; and the heavy liner glued to the outer bentside is poplar. Other wood identifications reported in the present article are the results of visual examinations made by the author.

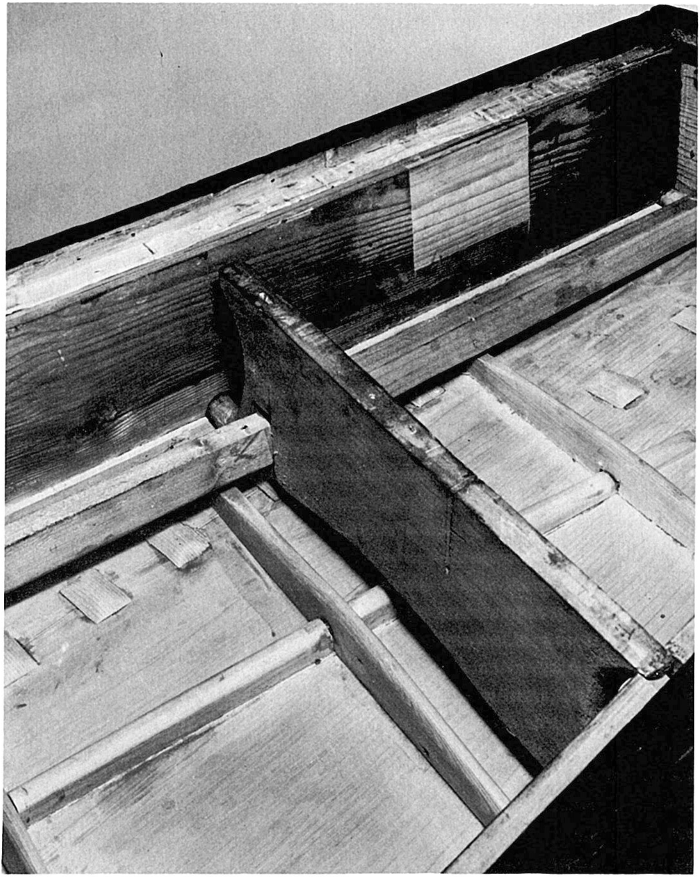


FIGURE 16. Bottom view of the interior of the 1720 Cristofori piano (bottom removed), showing the case buttress. Photograph by the author.

them. Only the treble section of the underside of the 1726 soundboard was observed (through a removable hatch in the bottom). Some confusion exists about the method of ribbing employed, as glue marks indicate that sections of ribbing running from the cutoff bar to the bentside have been re-

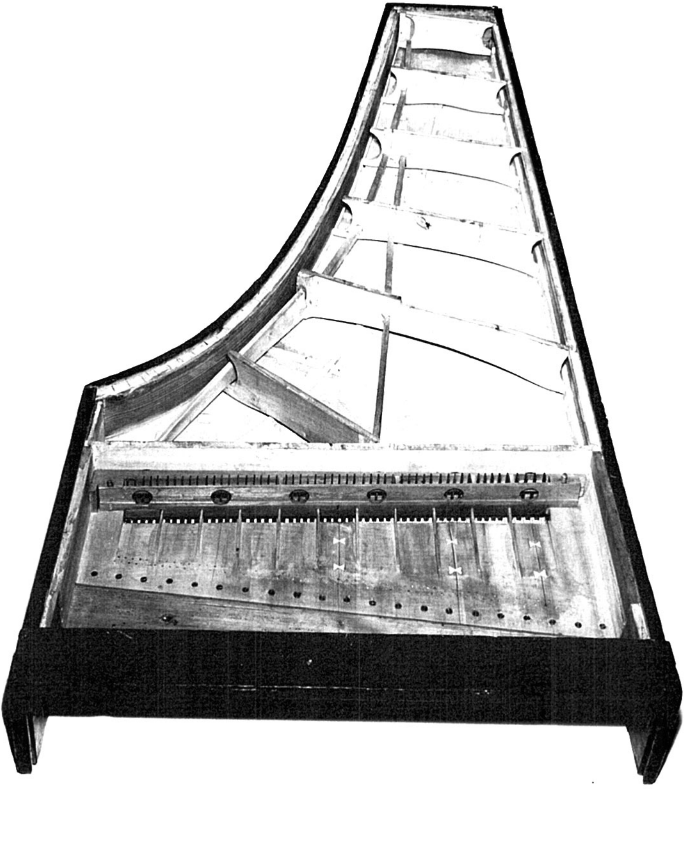


FIGURE 17. Bottom view of the interior of the 1720 Cristofori piano (bottom removed). Photograph by the author.

moved. The restorers at Leipzig reported (in 1978)[23] that the removed sections were not original, and that the bracing presently in the instrument is original. The photograph of the underside of the 1726 soundboard (fig.

23. Personal communication with the author.

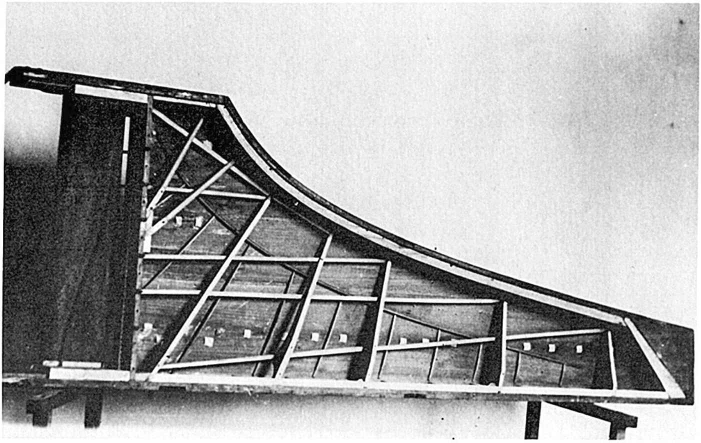


FIGURE 18. Bottom view of the interior of the 1722 Cristofori piano (bottom removed). Photograph courtesy of the Museo degli Strumenti Musicali, Rome.

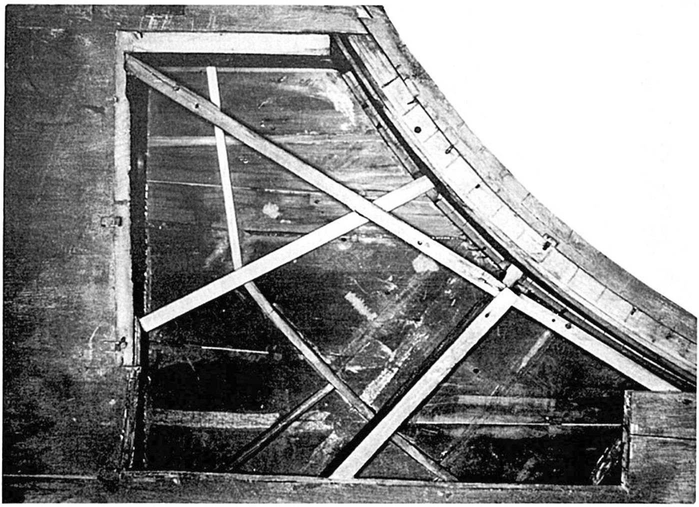


FIGURE 19. Bottom view of the interior of the 1726 Cristofori piano (bottom removed). Photograph by the author.

19) shows the bracing, glue marks, and a new section of cutoff bar that has been added. It is interesting that the curved part of the cutoff bar visible through the opening in the bottom of the 1726 piano consists of four straight sections butted together to form a curve.

Maffei's article makes mention of numerous structural elements of Cristofori's case design. The use of an inverted wrestplank is noted, as is the method of hitching the strings to a structure that is elevated and isolated from the soundboard.[24] Also described was Cristofori's use of soundholes in the belly rail rather than in the soundboard. Cristofori, Maffei states, believed in the need for soundholes. Without them "the air, not having an escape, could not yield, but would remain fixed; and hence the sound would be somewhat obtuse and short, instead of resonant."[25] Cristofori preferred to place openings in the belly rail rather than in the soundboard, as this method admitted less dust into the cavity of the instrument. These openings can be found in the three surviving pianos. It is clear that numerous innovations in case structure evident in the three surviving pianos were devised prior to 1711, and the only clear inconsistency between Maffei's description and the surviving instruments appears in the hammer action itself.

The provenance and history of restorations of the Cristofori piano of 1720 are only partially known. The piano was purchased by Mary Crosby Brown in 1895 for her collection of musical instruments. In 1889 she had given her collection of approximately 280 instruments to the Metropolitan Museum of Art, but she continued to collect and donate instruments to the Museum until around 1904. By that time the Crosby Brown Collection contained about 3,400 instruments, including the Cristofori piano. Mrs. Brown amassed her collection through contacts with friends, consulates, and dealers throughout the world. Around 1894, she asked a cousin, Mrs. Launt Thompson, who was living in Florence, to find and purchase a Cristofori piano for her collection. A group of letters addressed to Mrs. Brown from her cousin describes her attempts to locate an authentic Cristofori piano.[26] A letter dated August 5, 1894, mentions that she had found such an instrument and was about to purchase it for 800 francs. Her last-minute

24. Maffei, "Nuova invenzione," in Rimbault, *The Pianoforte*, p. 100: "Le corde sono più grosse delle ordinarie, e perchè il peso non nocesse al fondo, non sono raccomadate ad esso, ma alquanto più alto" (The strings are thicker than usual, and, in order that their tension may not injure the bottom, they are not trusted to this, but fixed somewhat higher). This is strongly suggestive of the elevated hitchpin rail of surviving Cristofori pianos.

25. Ibid.

26. These letters are preserved in the files of the Department of Musical Instruments, Metropolitan Museum of Art, New York.

reservations about the instrument's authenticity, and the dealer's refusal to issue her a guarantee that she was purchasing an instrument made by Cristofori, caused her to continue her search. We learn from a later letter that a dealer named Franciolini had tried to sell her a fake Cristofori piano, and it can be assumed that the unnamed dealer in the August 5th letter was in fact Franciolini. A letter dated December 7, 1894, mentions a fruitless search in Siena. By June 11, 1895, Mrs. Thompson had located an authentic Cristofori piano owned by a private party and guaranteed to be authentic by the Bargello, where it had been displayed. The letter of that date mentions that the piano was valued at 20,000 francs, but that the owner was offering it for sale for 8,000 francs. Letters dated June 19, July 7, and July 24 deal with matters of payment and shipping. Another letter to Mrs. Crosby Brown, dated November 23, 1895, from Diego Martelli, the private party left nameless in Mrs. Launt Thompson's letters, gives information concerning the history of the Cristofori piano and how his family had come to possess it.[27] Evidently, Diego Martelli's grandfather purchased the piano at a public sale that took place at the Grand Ducal Palace in Siena in 1819, and the piano remained in the family until it was sold to Mrs. Crosby Brown. A.J. Hipkins reported that Dr. Fabio Mocenni, the grandfather of Diego Martelli, obtained the piano from a piano tuner in Siena in exchange for wine.[28] The source of Hipkins's statement may well have been Puliti, who mentions the exchange of wine in 1874.[29] According to the letter, Puliti first saw the 1720 piano in 1872, when it was in the possession of Ernesta Mocenni, Diego's mother. The story of the piano's acquisition may have been related to Puliti by Ernesta Mocenni, and as she was only a generation removed from its purchaser, her father, the story involving the wine may not be as apocryphal as it sounds.

The hammer action of the piano of 1720 has undergone a number of alterations, many of which appear to be early, and all of which preceded the major restorations known to have been made in 1875 by Ponsicchi in Florence[30] and at the Metropolitan Museum in 1938 by Curt Sachs. Drawings of the 1720 action published by Puliti in 1874[31] verify that no substan-

27. *Catalogue of Keyboard Musical Instruments in the Crosby Brown Collection*, p. 305. The original letter is bound in the Metropolitan Museum of Art's copy of Puliti's *Cenni storici*.

28. Hipkins, "Cristofori," *Grove's Dictionary*.

29. Puliti, *Cenni storici*, p. 119.

30. The following inscription is located on the hammer rail of the 1720 piano: "Restaurato l'Anno 1875 / da Cesare Ponsicchi / Firenze."

31. Puliti, *Cenni storici*, p. 127. Puliti's observations are extremely important in dating alterations made to the piano. He mentions (p. 119) that the instrument was greenish-gray in color; thus, the black paint presently on the instrument dates after 1874.

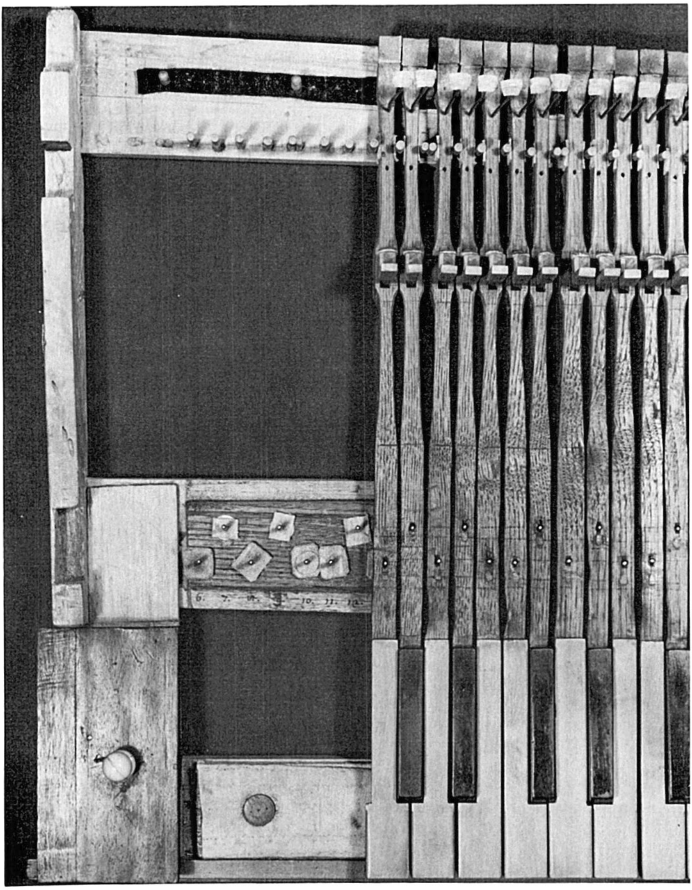


FIGURE 20. The key frame (left side) of the 1720 Cristofori piano. Photograph by the author.

tial changes in the action's design were made during the subsequent restorations. The hinged hammers and solid wooden hammer heads are clearly shown in Puliti's drawings, thus proving that these non-original structures were installed prior to 1874.

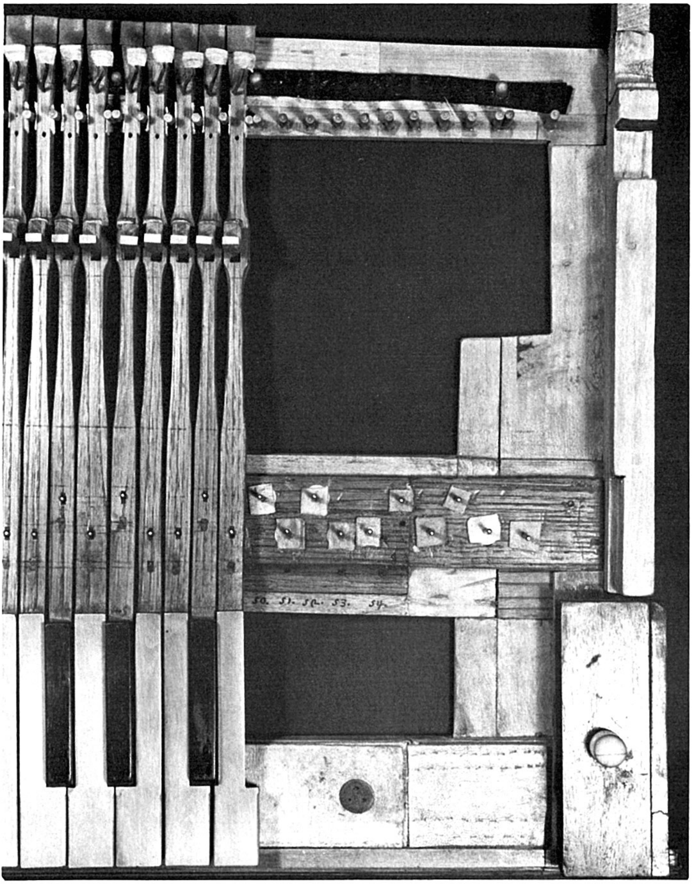


FIGURE 21. The key frame (right side) of the 1720 Cristofori piano. Photograph by the author.

The keyframe and keyboard also show evidence of early alteration (see figs. 20, 21). The key levers are made of chestnut and are unusually constructed in that the front sections (or "heads") of the natural key levers beneath the boxwood plating have been grafted to the narrower sections forming the remainder of the key levers. The grain of the wood of the wide chestnut blocks forming the natural key heads is not continuous with the adjoining sections forming the remainder of the key levers, and the natural key platings and the accidental key blocks overhang the underlying chestnut sections of the key levers. Thus, it would appear that the key levers were not sawn out in the traditional manner, but were individually formed without concern for the variation in width and shape of each key in the octave. This unusual construction may be a reflection of the experimental nature of the piano's design (it may indicate that all the levers were shortened from the front, for example).

A balance-rail cap is glued to the underside of the hammer rail. It contains depressions for projecting balance-rail pins and chamferings enabling the key levers to rock upwards. The number and staggering of the pin holes in the cap indicates a range of fifty-three notes, with an apparent compass of *FF–b''*, with *FF*♯ and *GG*♯ omitted. The balance rail consists of two layers, the lower rail of poplar and an upper section of chestnut. The keyframe was X-rayed to determine whether there was any evidence of balance-pin holes in the poplar rail that were out of registration with the chestnut section above it (evidence that the present chestnut section is not original). No such holes were found. The chestnut section has fifty-four pin holes, and the poplar rail is numbered 1–54. The piano's present compass of C–*f'''* is an obvious alteration, as the first presently occupied pin is numbered 6, and an extension in the treble (made from the bass end of the chestnut rail) enables the compass to be extended upwards. Plugged holes in the chestnut section and the key levers indicate that the entire keyboard was repinned in the earlier fifty-four-note compass, with an apparent range of *FF–c'''*, *FF*♯ and *GG*♯ omitted (as determined by the staggering of pin holes in the poplar rail, observed in the X-ray photograph, and in the chestnut section, now located in the treble). The fiftieth, fifty-first, fifty-third, and fifty-fourth key levers, occupying unnumbered pins, have been redrilled twice, thus reflecting their original repinning and later repinning when moved to the treble. The forty-ninth key lever, occupying the pin marked 54, has been redrilled three times. The chestnut rail has three holes at pin numbered 54. Evidently the key was repinned with all the others, and was again repinned (and moved slightly to the left, perhaps to provide better spacing for the five key levers moved to the treble). The present fifty-second key has only one balance-rail hole and shows no evidence of having been repinned. The five uppermost keys, excluding the fifty-second one, have had a section of their upper surface in the vicinity of the balance-pin hole inlaid with a strip of chestnut, undoubtedly to provide fresh surfaces in which to cut the balance-pin mortises.[32] The disparity between the ranges of the balance rail (in its original configuration) and the balance-rail cap cannot be explained.

Once the keyframe was altered and the key levers moved, the hammers and their respective strings were then activated by keys a fourth higher in note name. Since the present soundboard of the 1720 piano is not original, it could not be determined if the bridge had been moved to reestablish the original string lengths and thus maintain the original pitch of the instrument. When the string lengths and bridge positions of the 1722 and 1726 pianos were measured, it became evident that the bridge had been moved to maintain the original scaling over much of the instrument's range. Measurements taken from all three pianos, comparing string length and bridge position relative to the bentside, are shown in tables 2 and 3. While the bridge of the 1720 piano veers away from the bentside when compared to the other two pianos (see figs. 22, 23), the string lengths are relatively similar. From the tabulated figures, it is evident that the distance from bridge to

TABLE 2
Measurements of String Lengths and Striking Points in the Three Cristofori Pianos

Pitch	*1720 Piano*	*1722 Piano*	*1726 Piano*
C	188.5 cm. / 163.5 mm.	182.0 cm. / 123 mm.	196.1 cm. / 133 mm.
F	187.9 cm. / 151.5 mm.	158.4 cm. / 111 mm.	160.8 cm. / 108 mm.
c	110.0 cm. / 134.5 mm.	112.3 cm. / 88 mm.	112.5 cm. / 73 mm.
f	83.8 cm. / 118.5 mm.	85.2 cm. / 71 mm.	84.1 cm. / 57 mm.
c'	56.7 cm. / 91.5 mm.	56.7 cm. / 45 mm.	56.8 cm. / 38 mm.
f'	42.9 cm. / 73 mm.	42.1 cm. / 32 mm.	42.2 cm. / 29 mm.
c''	28.6 cm. / 51 mm.	28.2 cm. / 23 mm	28.0 cm. / 17 mm.
f''	21.4 cm. / 39 mm.	21.1 cm. / 17 mm.	21.3 cm. / 13 mm.
c'''	15.1 cm. / 26 mm.	14.2 cm. / 10 mm.	14.2 cm. / 7 mm.
f'''	12.2 cm. / 19 mm.		

NOTE: Measurements are tabulated as: string length / striking point. All three pianos are double-strung throughout; lengths given are of the longer string of each pair.

32. In addition to the three compasses revealed in this examination, additional confusion is created by Hipkins's article on Cristofori in *Grove's Dictionary*. Hipkins states that the piano of 1720 had a keyboard compass of *D* to *f'''*. This must be a result of his misreading of Puliti, who writes (*Cenni storici*, p. 120) that the compass of the instrument was "Do" to "Fa." A nineteenth-century photograph, brought to my attention by Dr. Hubert Henkel, clearly shows the 1720 piano's *C*–*f'''* range, the range present when Hipkins wrote his article.

TABLE 3
Measurements of the Distance from the Bridge to the Bentside at Designated Strings on the Three Cristofori Pianos

Pitch of String		*1720 Piano*	*1722 Piano*	*1726 Piano*
C♯	(Lowest note on long bridge)			11.5 cm.
D	(Lowest note on long bridge)		11.8 cm.	
F♯	(Lowest note on long bridge)	11.1 cm.		
F			11.8 cm.	11.0 cm.
c		17.1 cm.	11.8 cm.	10.7 cm.
f		16.6 cm.	11.9 cm.	10.9 cm.
c'		15.4 cm.	11.8 cm.	10.2 cm.
f'		14.6 cm.	12.0 cm.	10.1 cm.
c''		13.3 cm.	12.3 cm.	10.0 cm.
f''		12.3 cm.	12.3 cm.	9.9 cm.
c'''		10.7 cm.	11.8 cm.	9.1 cm.
f'''		8.9 cm.		

NOTE: Measurements made perpendicular to bridge.

bentside varies among the three surviving pianos, and thus it is not possible to reconstruct the original bridge position of the 1720 piano from either of the other instruments. However, by roughly reestablishing the original position of the bridge by the use of markers, it becomes clear that the string lengths would closely match those of the 1722 and 1726 pianos if the original compass was restored. Thus, the alteration in compass of the 1720 piano was made in order to extend the range of the instrument in the treble at the expense of the bass, and not to provide transposed tuning. From the character of the workmanship of the keyboard and bridge alterations, it would appear that they date from the eighteenth century. One thing observable through X-ray photography is the position of the bridge relative to the cutoff bar. While the bridge was carefully repositioned, the cutoff bar was not moved, and consequently it intersects the bridge. Evidently, it was too difficult to gain access to the underside of the soundboard to alter the position of the cutoff bar and soundboard ribs. The alteration of the position of the bridge, although reestablishing the original pitch, altered the proportional relationship between the striking point and the overall length of the string. The inadvertent alteration of this proportion alters the tonal characteristics of the instrument somewhat, as does the shifting of the bridge relative to the cutoff bar and soundboard ribs.

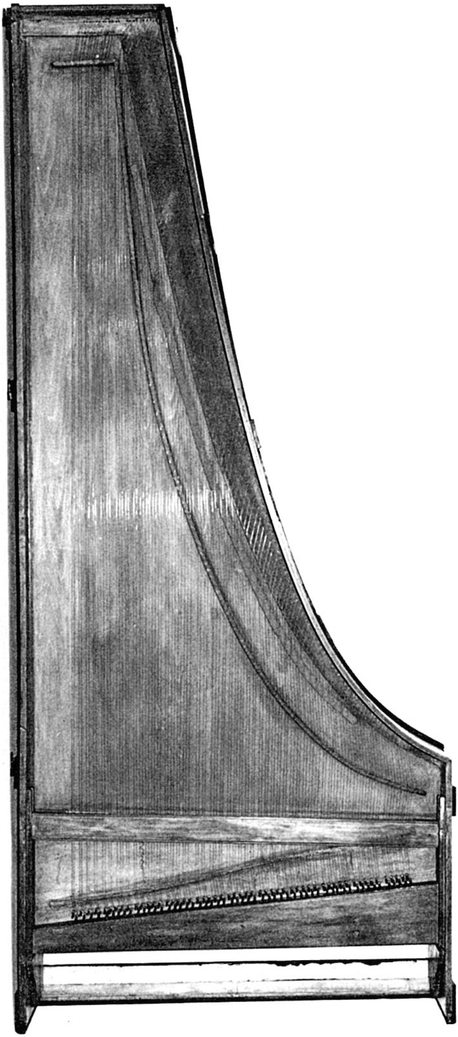


FIGURE 22. Plan view of the 1720 Cristofori piano. Photograph by the author.

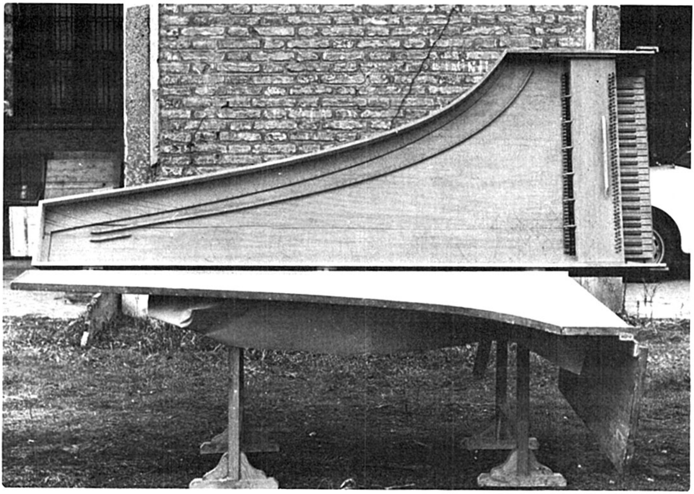


FIGURE 23. Plan view of the 1722 Cristofori piano. Photograph courtesy of the Museo degli Strumenti Musicali, Rome.

Not much is known about the early use of Cristofori's pianos. During Prince Ferdinando's life, the Medici court was a highly musical one, and Cristofori's pianos were certainly in a position to receive attention from a large musical audience. But, according to Maffei, it was not accepted by all:

> Some professors have not given to this invention all the praise it deserves; because, in the first place, they did not see how much ingenuity was required to overcome the difficulty, and what marvellous delicacy of hand was required to adjust it with so much nicety; and secondly, because it appeared to them that the tone of such an instrument was more soft and less distinct than the ordinary ones.[33]

Maffei also gives his opinion of the function of the piano:

> This is properly a chamber instrument, and is not intended for church music, nor for a great orchestra. How many instruments there are, used on such occasions, which are not esteemed among the most agreeable? It is certain that, to accompany a singer, and to play with one other instrument, or even for a moderate concert, it succeeds perfectly; although this is not its principal intention,

33. Maffei, "Nuova invenzione," in Rimbault, *The Pianoforte,* p. 96.

> but rather to be played alone, like the lute, the harp, viols of six strings, and other most sweet instruments.[34]

Evidently the shortcomings of the early Cristofori pianos described by Maffei were considered serious enough to prevent immediate excitement among composers, performers, and builders. Undoubtedly, the complexity of its construction was a factor that kept it from catching on immediately. Ferrini, a pupil of Cristofori, evidently carried on his master's piano-making skills,[35] and thus the "Florentine School" of piano making consisted, as far as we know, of two builders. Yet, several of the few pianos constructed in the early years of the instrument's development found their way into the hands of some important musical figures of the day. The famous castrato singer Farinelli was known to have owned such an instrument.[36] Charles Burney mentions in *The Present State of Music* that

> Signor Farinelli has long left off singing, but amuses himself still on the harpsichord and viol d'amour: he has a great number of harpsichords made in different countries, which he has named according to the place they hold in his favour, after the greatest of the Italian painters. His first favourite is a *piano forte*, made at Florence in the year 1730, on which is written in gold letters, *Rafael d'Urbino*. . . . He played a considerable time upon his Raphael, with great judgment and delicacy, and has composed several elegant pieces for that instrument.[37]

Burney continues:

> In the afternoon I went to take a melancholy leave of the Cavalier Farinelli. He kindly importuned me to stay longer at Bologna, and even chid me for going away so soon. I found him at his Raphael, and prevailed on him to play a good deal: he *sings* upon it with infinite taste and expression.[38]

An inventory of keyboard instruments owned by Queen Maria Barbara of Spain, compiled in 1758, lists twelve keyboard instruments that Domenico Scarlatti would have had the opportunity to use at court.[39] Of these instruments, five were pianos made in Florence. The inventory indicates that the keyboard ranges of the pianos extended from forty-nine to fifty-

34. Ibid.
35. Giovenale Sacchi, "Vita del Cav. Don Carlo Broschi," *Raccolta ferrarese di opuscoli* 15 (Venice, 1784): 47.
36. Ibid.
37. Charles Burney, *The Present State of Music in France and Italy* (London, 1773), facsimile ed. (New York: Broude Bros., 1969), p. 210.
38. Ibid., p. 229.
39. Ralph Kirkpatrick, *Domenico Scarlatti* (Princeton: Princeton University Press, 1953), p. 361.

six keys. The earliest known music published expressly for the piano was an edition of twelve sonatas by Lodovico Giustini entitled *Sonate da cimbalo di piano e forte detto volgarmente di martelletti,* published in Florence in 1732.[40] The sonatas were dedicated to Don Antonio of Portugal, a patron and pupil of Scarlatti. Thus, it would appear that the early Florentine piano was closely tied in with music in the Spanish and Portuguese courts and was a favorite of Scarlatti's royal patrons. Carlos Seixas and Padre Antonio Soler, close associates of Scarlatti and involved in royal musical life in Portugal and Spain, were therefore undoubtedly aware of the early pianos of Cristofori or his pupil, Ferrini.[41]

Had Cristofori not developed his piano mechanism, the inventive work of several of his contemporaries, Marius and Schröter, might nonetheless have made sufficient impact to spur the development of the piano. Certainly there was a need for a loud, dynamically flexible keyboard instrument, and sufficient technical ability was available at the onset of the eighteenth century for the design and construction of such an instrument. Cristofori's ingeniously devised "gravecembalo col piano e forte" was capable of subtle, though not dramatic, variations in loudness and permitted reasonably rapid repetition and playing speed. While the piano did not begin to threaten the position of the harpsichord until late in the eighteenth century, Cristofori's pianos created a stir soon after their inception and quickly acquired a following in the courts of Florence, Lisbon, and Madrid.

The Metropolitan Museum of Art

40. Lodovico Giustini, *Sonate da cimbalo di piano e forte detto volgarmente di martelletti* (Florence, 1732), facsimile ed., ed. Rosamond Harding (Cambridge: Cambridge University Press, 1933).

41. The inventory of Queen Maria Barbara's instruments indicates that the pianos were located in the palaces at Aranjuez and Escorial, and therefore could hardly have escaped attention (Kirkpatrick, *Domenico Scarlatti,* p. 361).

Appendix

Inscriptions on the Three Cristofori Pianos

1720 Piano. On hammer rail, one line in ink between scribe marks spaced 6 mm. apart: "BARTHOLOMAEVS DE CHRISTOPHORIS PATAVINVS INVENTOR FACIEBAT FLORENTIAE MDCCXX." On hammer rail, left side, in ink: "Restaurato l'Anno 1875 / da Cesare Ponsicchi / Firenze."

1722 Piano. On board that supports hammers, visible through cutout in new "nameboard," two lines in ink between scribe marks 5 mm. apart: "BARTHOLOMAEVS DE CHRISTOPHORIS PATAVIVS INVENTOR FACIEBAT FLORENTIAE/MDCCXXII."

1726 Piano. On nameboard, one line in ink between scribe lines 5.5 mm. apart: "BARTHOLOMAEVS DE' CHRISTOPHORIS PATAVINVS INVENTOR FACIEBAT FLORENTIAE M.DCCXXVI."

Diameters of Existing Strings (Not Original) on the Three Cristofori Pianos

*1720 Piano.** Wire removed ca. 1970, according to Metropolitan Museum of Art records:

C–B	Brass, 0.02 in.
c–b'	Steel, 0.0175–0.018 in.
c''–b''	Steel, 0.0125 in.
c'''–f'''	Steel, 0.01 in.

1722 Piano.

C–C♯	Brass, 0.55 mm.
D–A	Brass, 0.5 mm.
B♭–e	Steel, 0.4 mm.
f–e'	Steel, 0.35 mm.
f'–c'''	Steel, 0.306–0.31 mm.

*Henry Edward Krehbiel reported in *The Pianoforte and Its Music* (New York: Charles Scribner's Sons, 1911), p. 40: "Seven or eight thicknesses of strings were used in the clavichords, spinets, and harpsichords of the seventeenth century, but the Cristofori pianoforte discloses but three diameters. The evidence adduced by this instrument, however, is not unimpeachable in this respect, since Signor Ponsicchi may have found it necessary, or thought it wise, to alter the stringing so far as diameters were concerned, when he restored it in 1875."

1726 Piano.

C–F♯	Brass, 0.5–0.456 mm.
G–A♯	Steel, 0.42 mm.
B–d	Steel, 0.4 mm.
d♯–a♯	Steel, 0.372 mm.
b–a♯′	Steel, 0.34 mm.
b′–f♯″	Steel, 0.326 mm.
g″–c‴	Steel, 0.278 mm.

Case Dimensions of the Three Cristofori Pianos

Piano	***Length***	***Width***	***Height of Case Sides***
1720	228.6 cm.	95.6 cm.	23.5 cm.
1722	225.7 cm.	81.3 cm.	21.5 cm.
1726	239.0 cm.	80.1 cm.	20.5 cm.