Contributions from
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Paper 15

Italian Harpsichord-Building in the 16th and 17th Centuries

John D. Shortridge

Figure 1.—Outer case of Albana harpsichord. (*Smithsonian photo 46794*)

Italian Harpsichord-Building in the 16th and 17th Centuries

By John D. Shortridge

The making of harpsichords flourished in Italy throughout the 16th and 17th centuries. The Italian instruments were of simpler construction than those built by the North Europeans, and they lacked the familiar second manual and array of stops.

In this paper, typical examples of Italian harpsichords from the Hugo Worch Collection in the United States National Museum are described in detail and illustrated. Also, the author offers an explanation for certain puzzling variations in keyboard ranges and vibrating lengths of strings of the Italian harpsichords.

THE AUTHOR: *John D. Shortridge is associate curator of cultural history in the United States National Museum, Smithsonian Institution.*

PERHAPS the modern tendency to idealize progress has been responsible for the neglect of Italian harpsichords and virginals during the present day revival of interest in old musical instruments. Whatever laudable traits the Italian builders may have had, they cannot be considered to have been progressive. Their instruments of the mid-16th century hardly can be distinguished from those made around 1700. During this 150 years the pioneering Flemish makers added the four-foot register, a second keyboard, and lute and buff stops to their instruments. However, the very fact that the Italian builders were unwilling to change their models suggests that their instruments were good enough to demand no further improvements. Anyone who has heard a properly restored Italian harpsichord or an accurately made reproduction will agree that the tone of such instruments is of exceptional beauty.

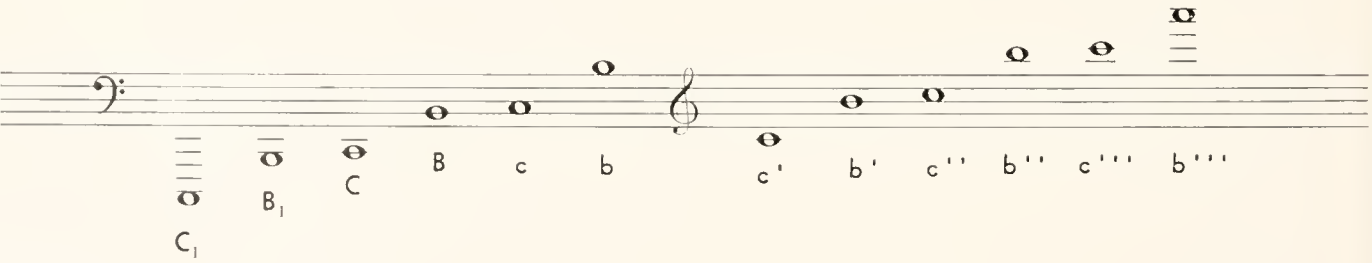
This paper consists of a description of the structural features of two typical Italian instruments and a general discussion of the stringing and tuning of Italian harpsichords and virginals that is based on certain measurements of 33 instruments housed in various museums in the United States. To the curators and other staff members of these institutions I express my sincere gratitude for making it possible for me to measure valuable instruments entrusted to their care or for supplying similar information by mail.

The first type of instrument described below usually has been designated in modern books about musical instruments and in catalogs of instrument collections as a spinet, the term virginal being applied to the rectangular instruments having the keyboard along the long side. Since both of these types have basically the same arrangement of keyboard, wrest plank, hitch

Figure 2.—Polygonal virginal in outer case. (*Smithsonian photo 46792.*)

pins, strings and jacks, and since both types were known as virginals in 17th-century England, it is logical to reserve the term spinet for another kind of instrument, namely the one with the wrest plank and tuning pins in front over the keyboard, and with the strings stretched diagonally. Such instruments were popular in England in the late 17th and early 18th centuries and were known in English as spinets during the period of their popularity. By using the term polygonal virginal we can distinguish, when necessary, the five-sided Italian model from the rectangular instruments usually produced in northern Europe. Some rectangular virginals were made in Italy; one Flemish polygonal virginal, made by the elder Hans Ruckers in 1591, survives. Long instruments, resembling the grand piano in shape, are called harpsichords. Of course it is understood that both types of virginals as well as the spinet and the harpsichord were keyed chordophones employing the plucking action of jacks and plectra.

Throughout this paper the different octaves are indicated according to the following system:



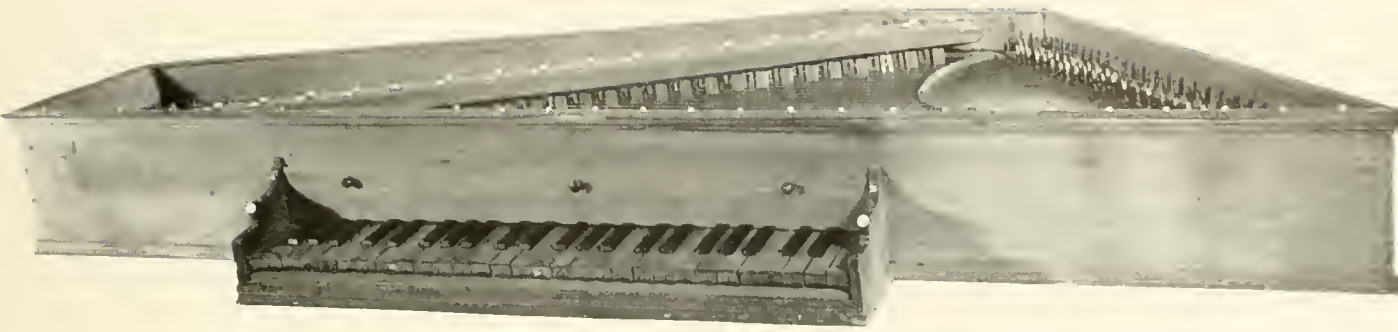


Figure 3.—Polygonal virginal removed from outer case. (*Smithsonian photo MNH 283.*)

The Typical Italian Polygonal Virginal

To give a clear idea of the construction of the Italian polygonal virginal, a detailed description of one particular example is presented here. This virginal is included in the Hugo Worch collection at the U.S. National Museum. The maker's name is not known, but the instrument is believed to have been built around 1600.

As is true of the great majority of Italian virginals and harpsichords of the 16th and 17th centuries, the instrument proper is removable from its outer case. The outer case (fig. 2), of sturdier construction than the virginal which it was designed to protect, is made of wood about $\frac{1}{2}''$ thick and is decorated with paintings of female figures and garlands. The original legs are missing.

Our main interest is in the virginal proper (fig. 3), the construction of which is comparable in some ways to that of the violin. The very thin sides of the virginal are held together at the corners by blocks, and the soundboard is supported by a lining.

The cross section drawing (fig. 4) shows the $\frac{9}{16}''$ thick bottom and the sides which are $\frac{1}{8}''$ thick. The lining, $\frac{1}{2}''$ by $1\frac{1}{8}''$, runs around four sides of the instrument, the wrest plank replacing it on the fifth side. The soundboard thickness, measured inside the holes through which the jacks pass, varies from $\frac{1}{16}''$ in the bass to $\frac{1}{8}''$ in the treble. The manner in which variations in thickness are distributed over the entire soundboard has not been determined. The cross section drawing also shows the beautifully executed mouldings that make the sides appear to be thicker than they really are.

The positions of the knee braces, the shape of which can be seen in figure 4, are shown along either side of the keyboard in figure 5. These braces are $\frac{3}{4}''$ thick. The positions of the blocks, small pieces with the grain running perpendicular to the bottom, and the wrest plank, which is $1\frac{1}{4}''$ thick, are also shown. The two ribs are attached to the underside of the soundboard in the positions indicated. The jack guide, built up of separate pieces held together by long strips down either side, is glued to the underside of the soundboard and extends as far as the lining in the treble but stops a little short of it in the bass (fig. 5). The jack guide is $\frac{15}{16}''$ thick.

The layout of the soundboard in figure 6 gives the relative positions of the bridges, tuning pins, hitch pins, strings, jacks, and jack rail. There is, of course, one jack and one string per key. The jacks presently in this virginal, not being original, will not be described. Typical Italian jacks will be described later. The bridges are $\frac{5}{16}''$ wide and vary in height from $\frac{7}{16}''$ in the bass to $\frac{3}{8}''$ in the treble. A cross

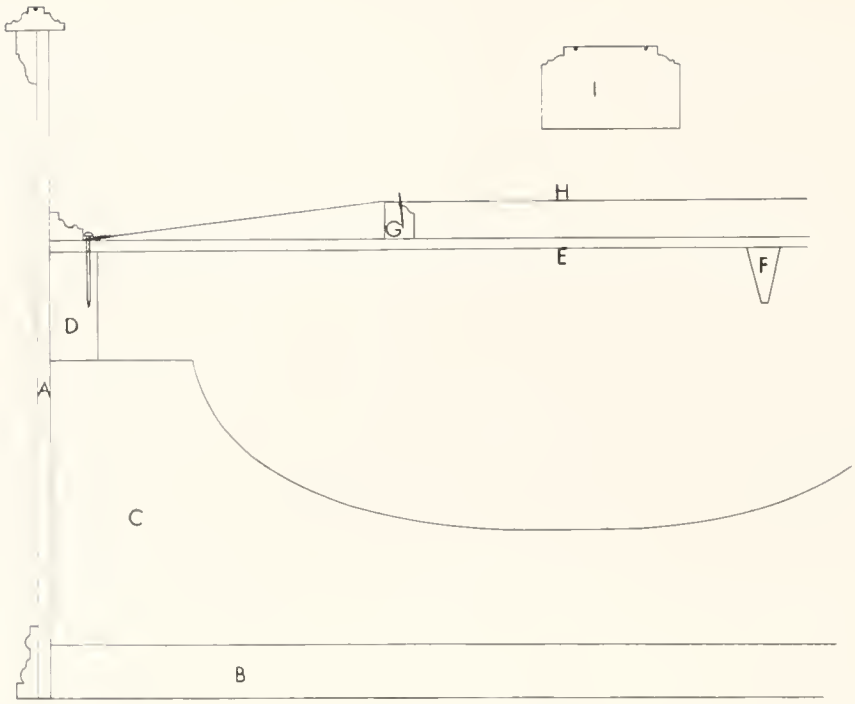


Figure 4.—Cross section of polygonal virginal. A, side; B, bottom; C, knee; D, liner; E, soundboard; F, rib; G, bridge; H string; I, jack rail. Scale, 1:2.

section of one of the bridges appears in figure 4. The jack rail, also shown in figure 4, extends over the jacks 1⅛″ above the soundboard. It serves not only to prevent the jacks from flying out during play but also to terminate the downward fall of the fronts of the keys. The keys do not drop far enough to touch the key frame, but instead are stopped by the jacks striking the jack rail.

The keyboard has an apparent compass of four octaves and one note from *E* to *f* ′ ′ ′. Short octave tuning would have extended the compass down a major third to *C* in the bass, with the *E* key sounding *C*, the *F*♯ key sounding *D*, the *G*♯ key sounding *E*, and the remaining keys sounding their proper pitches. These three keys will hereafter be referred to as *C*/*E*, *D*/*F*♯ and *E*/*G*♯.

The lowest eight keys have small wire eyes attached to their undersides near the front. A corresponding slot is cut through the inner and outer cases, allowing the eyes to be connected to a short pedal keyboard which has not survived.

The keys themselves vary in length from 10″ in the bass to 18½″ in the treble; they are mounted on a trapezoidal key frame which is removable from the instrument. The balance rail and balance rail pins are on a diagonal, resulting in a gradual but noticeable change in the touch from one end of the keyboard to the other. The rack, ½″ thick and 1¾″ high, is fastened along the back of the key frame and has one vertical saw cut for each key. Projecting from the back of each key is a small sliver of wood which rides in its proper saw cut and serves to guide the key. The natural keys are veneered with boxwood and have arcaded boxwood fronts. The sharps are small blocks of hardwood stained black.

The sides, soundboard, ribs, jacks, guide, jackrail, and mouldings are made of cypress, the wrest plank and bridges are of walnut, and the framework, bottom, keys, and key frame are of pine.

The photographs (figs. 2, 3) show the decorative use of ivory studs. On the soundboard appears the Latin inscription *Vita brevis, ars longa.* A laminated parchment rose, 3³⁄₁₆″ in diameter, is placed in the soundboard in the position indicated in figure 6. A typical example of this decorative device is shown in figure 12.

The above-described virginal is typical of Italian practice. Other examples studied generally have differed from it only in small details, except in the case of compass and vibrating lengths of strings. These factors will be discussed in detail in a following section.

Figure 5. INTERIOR OF POLYGONAL VIRGINAL. A, lining; B, wrest plank; C, rib; D, jack guide; E, knee; F, rack. Broken lines indicate positions of corner blocks and brace under wrest plank. Scale, 1:8.

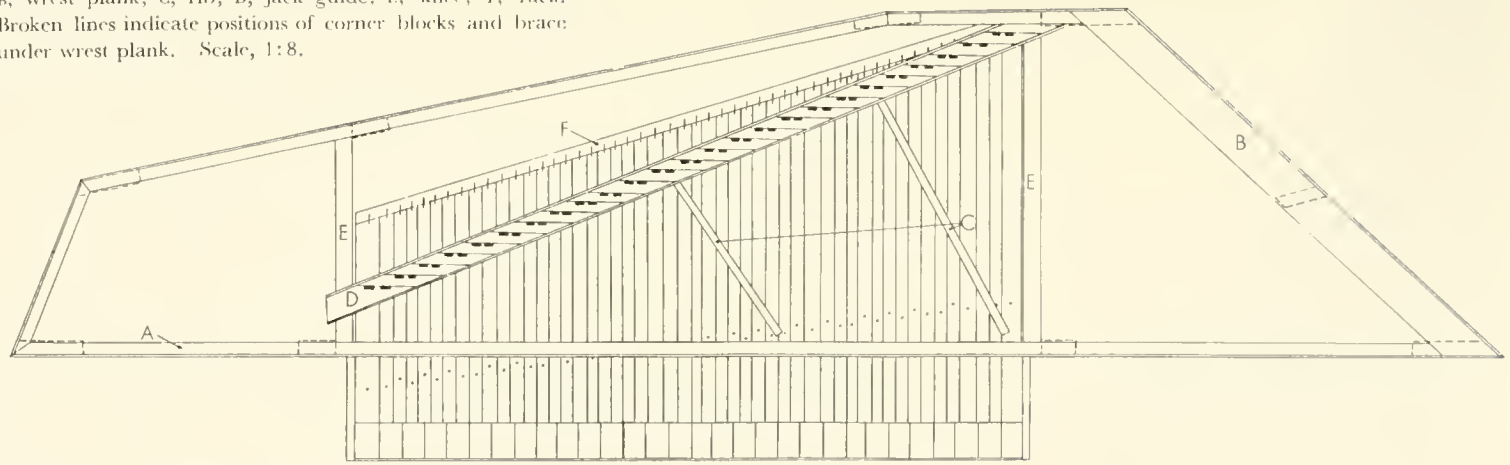


Figure 6. SOUNDBOARD LAYOUT OF POLYGONAL VIRGINAL. Scale, 1:8.

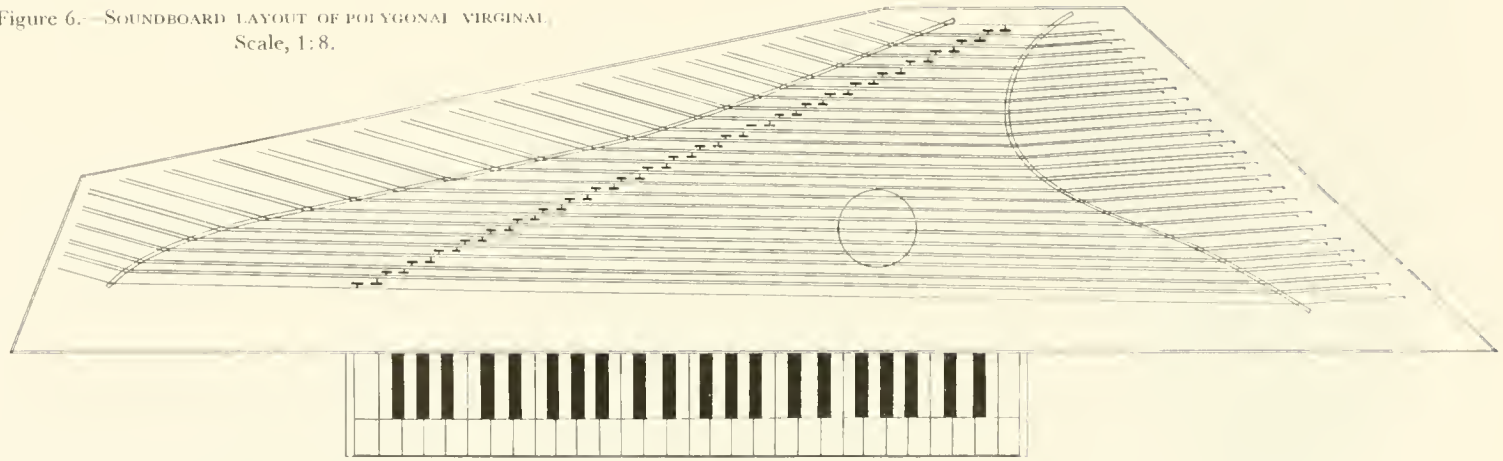
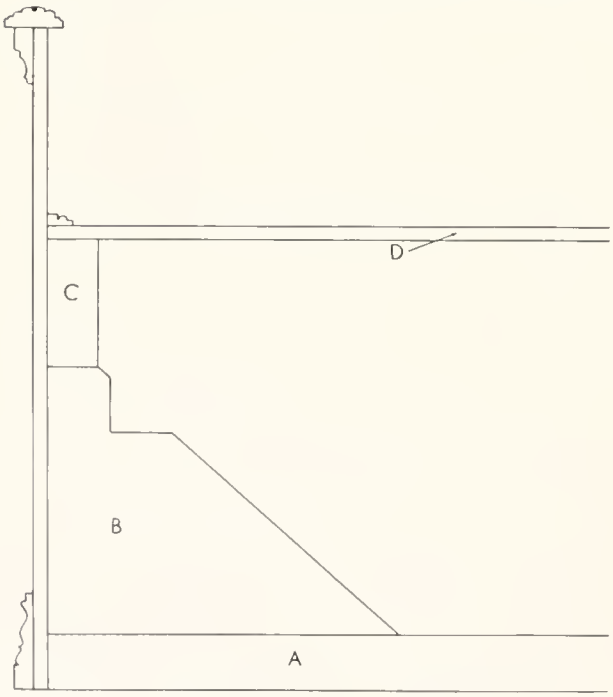


Figure 7.—Ridolfi harpsichord removed from case. (*Smithsonian photo MNH 238–A.*)

The Typical Italian Harpsichord

The instrument chosen to illustrate the stylistic features of the Italian harpsichord is also in the collection of the U.S. National Museum. This harpsichord, purchased for the Museum in 1892 by Dr. G. Brown Goode, was made in 1665 by Giacomo Ridolfi, who claimed Girolamo Zenti as his teacher. The inscription on the nameboard reads "Jacobus Rodolphus Hieronymi de Zentis Discipulus MDCLXV Facieba."

Figure 8.—Cross section of Ridolfi harpsichord. A, bottom; B, knee; C, lining; D, soundboard. Scale, 1:2.



Like the virginal described above, this harpsichord is separable from its outer case. The outer case rests on a separate stand consisting of three gilt cupids and a floral garland. Since the painted decoration of this case is not original, another outer case, belonging to a harpsichord made by Horatius Albana in 1633, was selected for the illustration (fig. 1).

Two unison strings per key and two registers of jacks are provided. The apparent compass of the keyboard is from *C/E* to *c ′ ′ ′*. The remains of pedal connections can be seen on the lowest eight keys.

The sides of the harpsichord are $\frac{5}{32}''$ thick; the bottom is $\frac{9}{16}''$ thick. The sides and lining are supported by knees that do not extend clear across the bottom of the instrument as they do in the virginal.

The knees are small triangular pieces, as shown in figure 8. Since the added tension of the second set of strings demands a somewhat more substantial framework than that employed in the virginal, a series of braces are attached to the floor. These are connected to the lining by several diagonal braces (fig. 9). This produces a remarkably strong but very light structure. The keys (not shown) are of more constant length than those of the virginal; therefore, the touch is much more uniform.

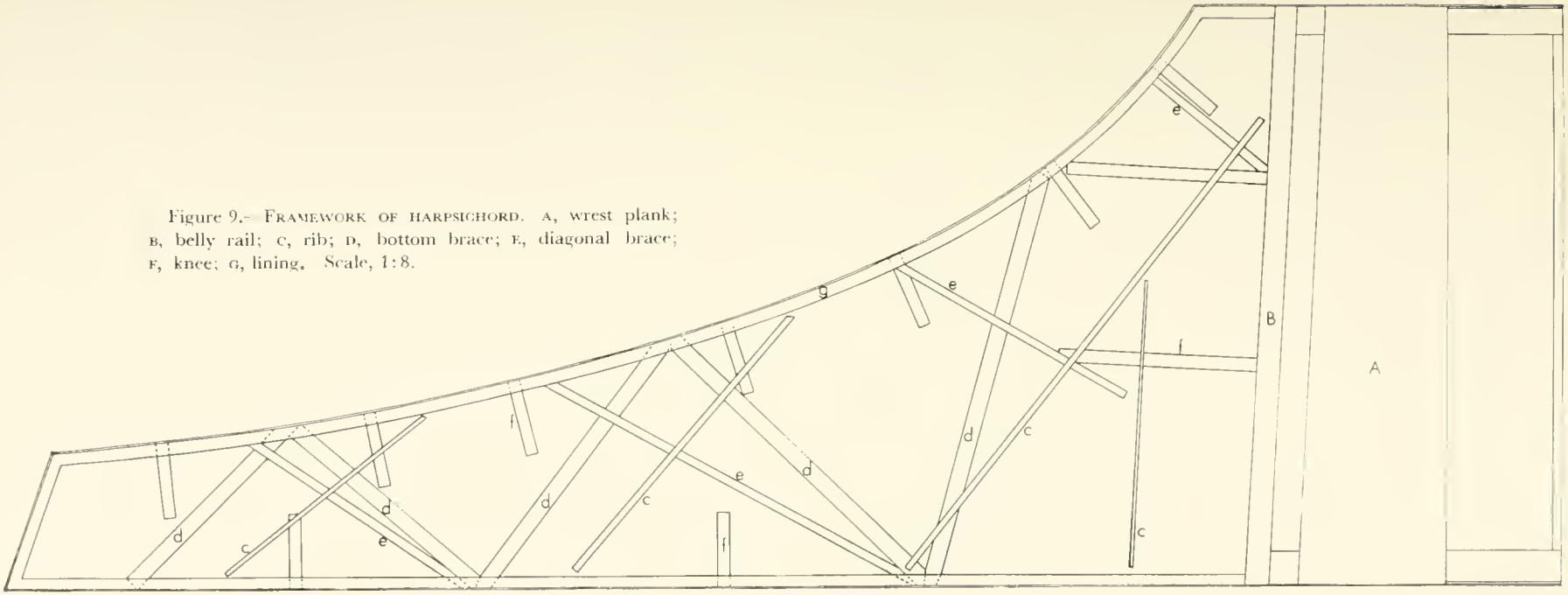


Figure 9.—Framework of harpsichord. A, wrest plank; B, belly rail; C, rib; D, bottom brace; E, diagonal brace; F, knee; G, lining. Scale, 1:8.

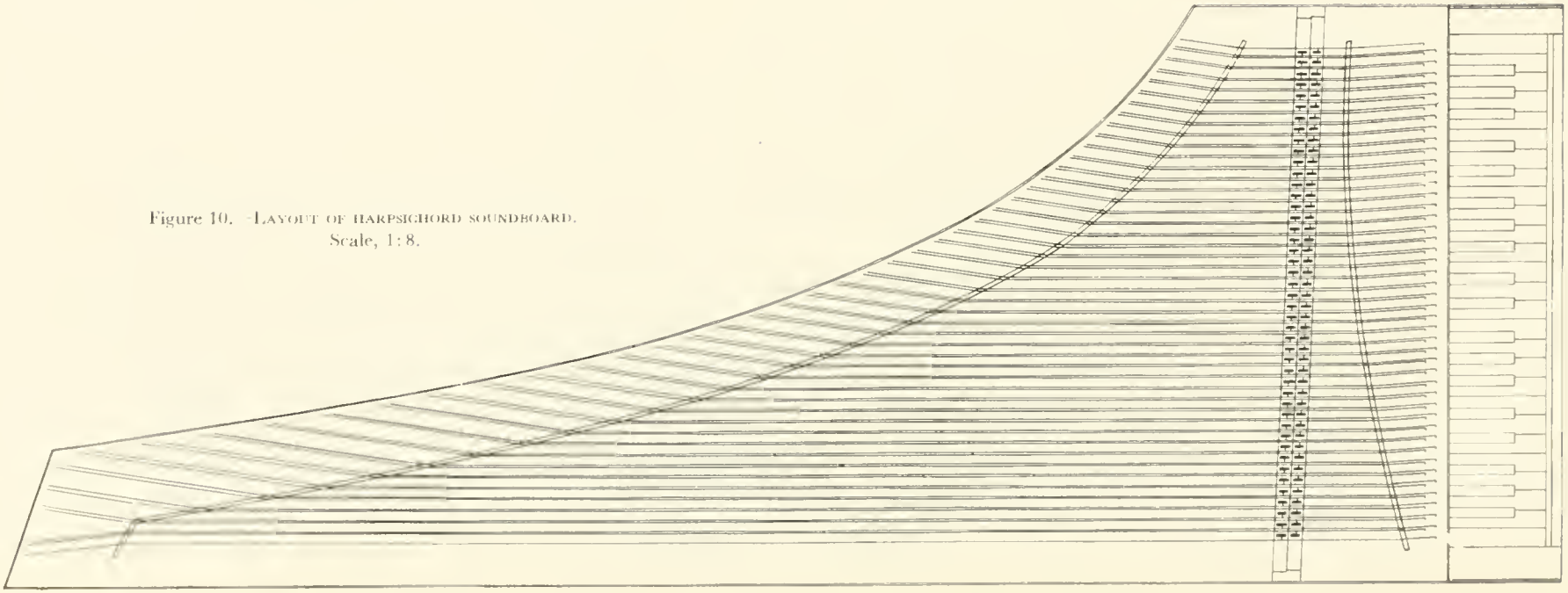


Figure 10.—Layout of harpsichord soundboard. Scale, 1:8.

The wrest plank is supported by two end blocks, against which the partition behind the action (called the belly rail) is also placed. The soundboard is glued to the top of the belly rail. The wrest plank is veneered with cypress, giving the appearance that the soundboard extends over it. The jack guides also rest on the end blocks in the space between the wrest plank and the belly rail. Figures 8 and 11 clarify the arrangement of these structural features.

Figure 10 shows the layout of ribs, bridges, and strings on the soundboard. The soundboard is about $\frac{1}{8}''$ thick. The bridge on the wrest plank tapers in height from $\frac{3}{8}''$ in the treble to $\frac{7}{16}''$ in the bass and in width from $\frac{5}{16}''$ to $\frac{7}{16}''$. The soundboard bridge measures about $\frac{3}{8}''$ by $\frac{1}{4}''$ and has virtually no taper. The soundboard does not have a rose, although that decorative device is fairly common on Italian harpsichords.

The jack guides are built up of spacer blocks held together by thin strips along the sides. There is now no provision for moving the guides, although plugged-up holes visible in the right end of each guide suggest that they originally could be disengaged. In Italian harpsichords generally, the jack guides were controlled by knobs projecting through the sides of the case. Sometimes these harpsichords had levers pivoted on the wrest plank and attached to the guides. The Ridolfi case has not been patched and there are no holes in the wrest plank where levers could have been attached; so, the guides probably were not intended to be movable.

The jacks are simple slips of walnut measuring about $\frac{3}{16}''$ by $\frac{7}{16}''$ by $3\frac{1}{8}''$. The arrangement of the tongue, spring, plectrum, and damper are shown in figure 11. The dampers are small pieces of buckskin held in slots at the tops of the jacks. The plectra, perhaps not original, are of leather. Of course, there are no adjusting screws or capstans of any variety.

The direction in which the plectra of each row of jacks should be pointing is not known. Two clavicytheria having two registers of strings and a single row of double tongue jacks have been examined by the author. Each of these jacks has two plectra, one pointing to the right and one to the left. Turning these jacks around does not alter the order of direction. The plectra nearest the keyboard points the same way whether the jack is upside down or not. In the clavicytherium at the Smithsonian Institution the plectra nearest the keyboard points to the player's left. In a clavicytherium at the Boston Museum of Fine Arts the opposite is true. Probably both arrangements were used in harpsichords also.

String Lengths and Pitch Standards

The vibrating lengths of the strings of the polygonal virginal and of the Ridolfi harpsichord can be roughly determined from the drawings. For purposes of comparison, a tabulation of the vibrating lengths (in inches) of the *C* strings on both instruments follows:

	Polygonal virginal	*Harpsichord*
c ′ ′ ′	$6\frac{5}{8}$	$5\frac{1}{16}$
c ′ ′ (pitch *C*)	$12\frac{15}{16}$	10
c ′ (middle *C*)	$25\frac{9}{16}$	$20\frac{1}{2}$
c	$43\frac{5}{16}$	$42\frac{1}{16}$
C E	$50\frac{5}{16}$	$61\frac{1}{4}$

The lengths shown for the harpsichord represent the shorter of the two strings with which each key is provided.

In order to produce a uniform tone color throughout the compass of a stringed instrument, it is necessary, among other things, to have the tension of all the strings reasonably uniform. In the treble this is accomplished by varying the string lengths. Since the length of a vibrating string is inversely proportional to its frequency, each string is made about half as long as the string an octave below, two thirds as long as the string a fifth below, etc. This principle cannot be carried all the way into the bass since the lowest strings would be inconveniently long, so somewhere below middle *C* the strings are gradually shortened and the diameters of the wires are increased in compensation.

As the above comparison shows, the string lengths are approximately doubled at each descending octave down to *c′* on the virginal and *c* on the harpsichord. The shape of the case allows the harpsichord to have longer bass strings than the virginal; between *c′* and *c* the string length is doubled in the harpsichord. However, in the virginal the *c* string is considerably less than twice as long as the string an octave above. In fact, the bass strings of the virginal are shortened to such an extent that the lowest string of the harpsichord is much longer than the lowest string of the virginal, although in the treble the virginal has longer strings than the harpsichord.

If the length of one treble string of an instrument of this sort is known, the lengths of all but the bass strings

can be readily inferred; we can approximately describe the lengths of two-thirds to three-fourths of the strings of either of the above instruments by giving the length of one string. It has become customary to use *c′′* for this purpose, and to refer to it in such cases as pitch *C*.

In examining a number of Italian harpsichords and virginals dating from 1540 to 1694, lengths for pitch *C* ranging from 8″ to 13¾″ have been found. This seems to be a great discrepancy for instruments that are otherwise so standardized. Since a uniform standard of pitch did not yet exist in the 16th and 17th centuries, we would expect the string lengths employed to be varied somewhat in order to accommodate the instruments to higher or lower tunings. Also, a preference for the sound of thinner, longer wires or shorter, thicker ones may have caused some builders to increase or decrease the string lengths on their instruments in proportion to the string diameters chosen. We have no precise evidence concerning the original wire gauges of the strings of Italian harpsichords and virginals. Although the variety of pitch *C* lengths encountered on the instruments studied can partially be accounted for by these two factors, a third and more important cause existed.

Among the 33 instruments about which information has been secured, a correlation is discernible between the apparent manual compass and the pitch *C* string lengths. Sixteen of the instruments ascend to *f′′′*. For these, the length of the pitch *C* string varies from 10¼″ to 13¾″. The remaining instruments, with either *a′′′* or *c′′′′* as the highest notes, have pitch *C* strings ranging from 8″ to 11⅜″ in length. If the average tension and wire diameter of the two groups are assumed to have been about equal, the difference in string lengths would suggest a corresponding difference in pitch, the instruments having the compass extended to *f′′′* sounding somewhat lower than the others.

There is some historical evidence that this actually was the case. In his *Theatrum Instrumentorum* Michael Praetorius[1] pictures a polygonal virginal, which appears to be very much like the many Italian examples that survive today, and a rectangular virginal that seems to be Flemish. He specifies that both are *so recht Chor-Thon* (at regular choir pitch). Praetorius also shows a harpsichord[2] that looks like a typ-

[1] Michael Praetorius, *Theatrum Instrumentorum*, Wolfenbüttel, 1620, pl. 14.

[2] *Ibid.*, pl. 6.

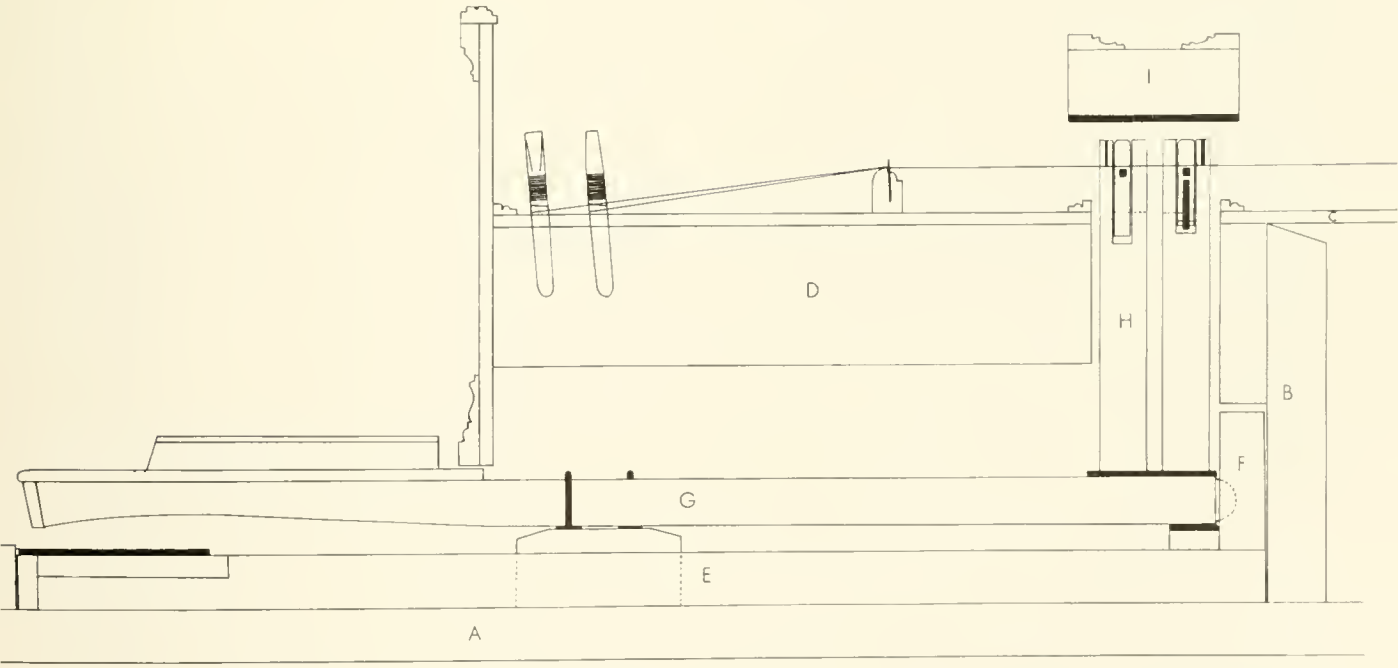


Figure 11.—Action of harpsichord. A, bottom; B, belly rail; C, soundboard; D, wrest plank; E, key frame; F, rack; G, key; H, jack; I, jack rail. Scale, 1:2.

ical Italian instrument except for the presence of a set of strings tuned an octave above unison pitch, a rare feature on Italian harpsichords. This harpsichord is described as *so eine Quart tieffer alss Chor-Thon* (a fourth lower than choir pitch), clearly indicating that single manual keyboard instruments a fourth apart in pitch were in existence. Since no reason is given for the harpsichord being tuned a fourth lower than the two virginals, we may assume that the author considered the matter commonplace enough as to demand no further elaboration and that instruments a fourth apart in pitch were not rare.

Praetorius does not state that the harpsichord in his illustration was tuned to a low pitch standard, which was actually used for certain purposes or in particular localities. He discussed the numerous pitches in use before and during his time, but the only one that he mentioned as being a fourth below choir pitch he considered obsolete and suitable only for plainsong. If the harpsichord was not intended to be tuned to this standard and used for this purpose, it must have been tuned to choir pitch and treated as a transposing instrument.

Querinus van Blankenburg,[3] writing in 1739, states:

> At that time [the beginning of the 17th century], men had so little experience in transposition that in order to be able to transpose a piece a fourth downwards they made a special second keyboard in the harpsichord for this purpose. This seems incredible, but the very remarkable proof is the fact that the famous Ruckers from the beginning of the last century for a period of more than thirty years made harpsichords only in this way.[4]

That the second manual of the two-manual harpsichord originated as a device for transposition is well known. In an article titled "Transposing Keyboards on Extant Flemish Harpsichords," Sibyl Marcuse [5] discusses surviving examples that show how the second keyboard was arranged. The upper keyboard was the principal one, with the lower keyboard sounding a fourth below. The strings acted upon by a *c* key on the upper manual were sounded by an *f* key on the lower; so, in changing from the upper manual to the lower, the player would have to move his hands to the left the distance of a perfect fourth in order to strike the same keys, thus producing the downward transposition. The compass of the upper manual was *E/C* to *c′′′*. Since the lower keyboard was shifted to the left, space was provided for five additional keys at its treble end. The apparent treble range of the lower keyboard was therefore extended to *f′′′*, although the lower *f′′′* and upper *c′′′* keys worked on the same strings and produced the same pitch. Room was also made for five extra bass keys at the lower end of the upper manual. However, since short octave tuning was employed and it was desirable to be able to use the same fingering in the bass on both manuals, the tails of the *C/E*, *D/F♯* and *E/G♯* keys of the upper manual had to be bent to the left in order to work on the strings played by the *F*, *G*, and *A* keys respectively of the lower manual. The vacant space to the left of the upper manual *C/E* was filled by a block of wood. Hence the five extra bass strings not used by the upper manual were those played by the *C/E*, *D/F♯*, *E/G♯*, *B*, and *c♯* keys of the lower keyboard.

Of the 16 Italian harpsichords and virginals studied that ascend in the treble to *f′′′*, 13 range to *C/E* in the bass, thus having exactly the same compass as the lower (transposing) keyboard of the Flemish two-manual instruments. Twelve of the 14 Italian examples having *c′′′* as the highest key stop on *C/E* in the bass and are identical in apparent compass to the Ruckers upper manual.

The correlation of compass and string length of the Italian instruments, the statements of Praetorius, and the similarity of the Italian keyboard ranges to those of the Ruckers transposing harpsichords have been considered. A plausible conclusion is that the Italian instruments extending to *f′′′* were transposing instruments sounding a perfect fourth lower than the prevailing pitch standard. Adopting the terminolgy used for orchestral wind instruments, these could be referred to as harpsichords in *G*.

The evidence of the correlation between string length and compass becomes much more convincing if we assume that the Italian builders abandoned the practice of making transposing harpsichords about the same time that the Ruckers family stopped employing the transposing lower manual. In the quotation previously given, Querinus van Blankenburg tells us that the Ruckers did not make transposing instruments later than the 1630's. Of the 10 dated Italian instruments with the keyboard extended to *f′′′*, only three were made after the third decade of the 17th

[3] Querinus van Blankenburg, *Elementa Musica*, The Hague, 1739.

[4] Translation by Arthur Mendel in "Devices for Transposition in the Organ before 1600," *Acta Musicologica*, 1949, p. 33.

[5] Sibyl Marcuse, "Transposing Keyboards on Extant Flemish Harpsichords," *Musical Quarterly*, July 1952.

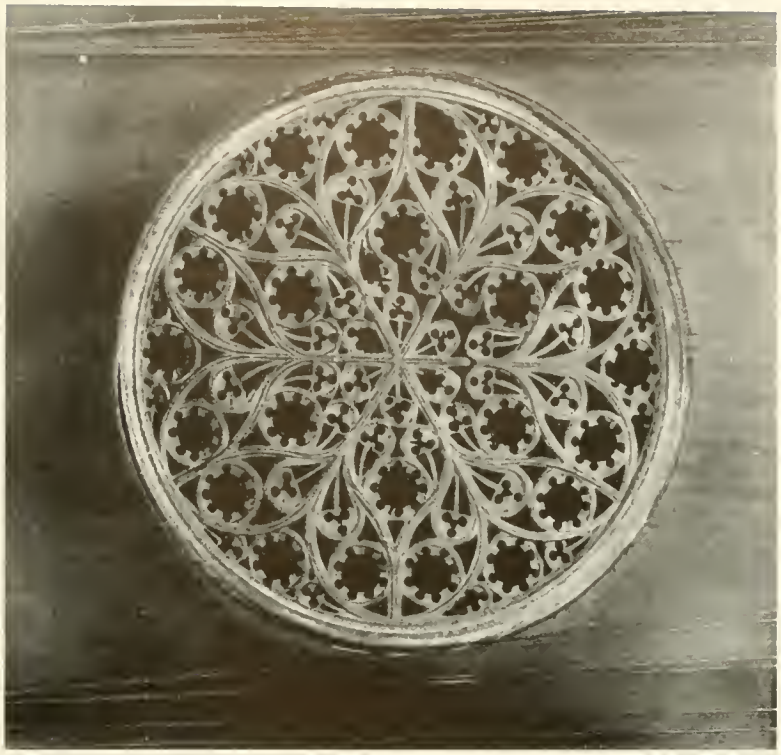


Figure 12.—Typical decorative device, known as rose, that appeared in soundboards of virginals and harpsichords (*Smithsonian photo 46795.*)

century. Each of these has a shorter pitch *C* string than any of the seven earlier instruments. These three harpsichords, dated 1654, 1658, and 1666, are accordingly considered nontransposing instruments, with the extra treble keys representing an actual extension of the upward range. The six undated instruments with *f* ′ ′ ′ in the treble are classified as transposing instruments because of their pitch *C* lengths and are accordingly believed to have been made before about 1635.

The 33 instruments on which this study is based are classified in the list on page 107. They are grouped according to whether the highest key is *f* ′ ′ ′ or *c* ′ ′ ′, with the exceptions of the three harpsichords mentioned in the preceding paragraph and three instruments that go only to *a* ′ ′. That the three instruments ending on *a* ′ ′ belong with the nontransposing group is indicated by their string lenghts.

The listing gives additional information about each example. String lengths of instruments having two registers are for the shorter of the two pitch *C* strings.

Information has been secured on two Italian virginals which were not included in the tabulation. Their measurements are completely at variance with the pattern consistently set by the other 33 examples studied. One, made by Giovanni Domenico in 1556, is in the Skinner collection; it has a pitch *C* string $14\frac{1}{16}''$ in length and an apparent compass of *C*/*E* to *c* ′ ′ ′. The other, with the same apparent compass and a $7\frac{1}{2}''$ pitch *C* string, is at Yale University. Whether these instruments are exceptional in terms of the pitch to which they were tuned, the tension which was applied to the strings, or the thickness and weight of the strings themselves, has not been determined.

The average of the pitch *C* lengths of the transposing instruments in the list is 12.78″; that of the nontransposing group is 10.45″. This suggests a separation between the two groups of about a major third since the first average is roughly $\frac{5}{4}$ of the second. However, the fact that the separation of the two averages is not great enough to positively indicate

a perfect fourth—the first average would have to be $\frac{4}{3}$ of the second to do so—does not disprove the theory of transposition by a fourth. In the first place, a considerable variety of pitches is no doubt represented in both groups since a universal pitch standard did not exist in the 16th and 17th centuries. Also, a margin of error of only a semitone is as good as could be expected considering the small number of examples on which the averages are based.

A further possible justification for the relationship of the two averages is found in Praetorius' discussion of the pitch standards with which he was familiar.[6] He states that choir pitch was a major second lower than chamber pitch and that *tertiam minorem* was a minor third lower than chamber pitch. Praetorius says of *tertiam minorem:* [7]

> But in Italy and in various Catholic choirs in Germany, the said lower pitch is much in use. For some Italians, not unjustly, take no pleasure in high singing, and maintain it is not beautiful, and the words cannot be properly understood, and it sounds like crowing, yelling, singing at the top of one's voice . . .

Possibly some of the nontransposing instruments were tuned to choir pitch and others to *tertiam minorem*, while the transposing instruments were set a fourth lower than choir pitch.

Three of the instruments listed are ottavinas, small instruments tuned an octave higher than usual. Ottavinas correspond to a four-foot register. Mersenne [8] mentions that they existed in two sizes, one a fifth above the usual pitch and the other an octave above. The three ottavinas included in the table are considered to be of the size sounding an octave above the usual pitch because they have *C/E* to *c′′′′* ranges and pitch *C* string lengths about half the average length of the other instruments in the nontransposing group. Although no examples were found for inclusion in this study, it is probable that some ottavinas a fifth above the usual pitch—and therefore an octave higher than the transposing instruments in our listing—survive. Such instruments would be expected to have apparent ranges of *C/E* to *f′′′′* and pitch *C* strings between $5\frac{3}{4}''$ and $6\frac{3}{4}''$ in length.

[6] Michael Praetorius, *Syntagma Musicum*, Wolfenbüttel, 1614–1620, vol. 2 (Organographia), chapter 2.

[7] Translation by Arthur Mendel in "Pitch in the 16th and early 17th Centuries, Part II," *Musical Quarterly*, April 1948.

[8] Marin Mersenne, *Harmonie Universelle*, Paris, 1636, p. 101.

DATA ON THE 33 INSTRUMENTS STUDIED

Date	Pitch C length (in inches)	Apparent compass	Type	Registers	Maker	Present location
			TRANSPOSING INSTRUMENTS			
1540	11 11/16	C/E–f′′′	Polygonal virginal	8′	Vi . . . ies	Metropolitan Museum of Art
1569	13¼	C/E–f′′′	Polygonal virginal	8′	Annibale Rossi	Juilliard School of Music
1602	13¼	C/E–f′′′	Rectangular virginal	8′	Ioannes Baptista Bononien	Smithsonian Institution
1610	13½	C/E–f′′′	Polygonal virginal	8′	Pasquino Querci	Harding Museum, Chicago
1613	11½	C/E–f′′′	Harpsichord	8′8′	Pasquino Querci	Smithsonian Institution
1617	13¾	C/E–f′′′	Polygonal virginal	8′	Giovanni Battista Boni	Yale University, New Haven, Conn.
1620	13 9/16	C/E–f′′′	Polygonal virginal	8′	Francesco Poggio	Rhode Island School of Design, Providence
	11 15/16	C/E–f′′′	Polygonal virginal	8′	Anonymous	Skinner Collection, Holyoke, Mass.
	12 15/16	C/E–f′′′	Polygonal virginal	8′	Anonymous	Smithsonian Institution
	13″	C/E–f′′′	Polygonal virginal	8′	Anonymous	Boston Museum of Fine Arts
	11½	C–f′′′	Polygonal virginal	8′	Anonymous	Folger Library, Washington, D.C.
	12¾	C/E–f′′′	Polygonal virginal	8′	Anonymous	Cincinnati Art Museum
	13⅝	C/E–f′′′	Polygonal virginal	8′	Anonymous	Smithsonian Institution
			NONTRANSPOSING INSTRUMENTS			
1548	11	C/E–c′′′	Polygonal virginal	8′	Domenicus Pesaurensis	Metropolitan Museum of Art
1554	[a] 10½	C/E–c′′′	Harpsichord	8′8′	Padre Stoppacio	Vassar College, Poughkeepsie, New York
1585	[b] 11½	C/E–a′′	Ottavina	4′	Franciscus Bonafinis	Metropolitan Museum of Art
1602	10½	C/E–c′′′	Harpsichord	. . .	Christoforus Rigunini	Stearns Collection, Ann Arbor, Mich.
1615	[b] 9¾	C/E–a′′	Ottavina	4′	Pasquino Querci	Metropolitan Museum of Art
1625	10⅛	C/E–c′′′	Harpsichord	8′	Valerius Peres	Skinner Collection, Holyoke, Mass.
1633	11⅜	C/E–c′′′	Harpsichord	8′8′	Horatius Albana	Smithsonian Institution
1645	11	C/E–c′′′	Harpsichord	8′8′	Horatius Albana	Vizcaya, Miami, Fla.
1654	10¼	C/E–f′′′	Harpsichord	8′8′	Anonymous	Smithsonian Institution
1658	11⅛	C/f′′′	Harpsichord	8′8′	Hieronymus de Zentis	Metropolitan Museum of Art
1665	10	C/E–c′′′	Harpsichord	8′8′	Giacomo Ridolfi	Smithsonian Institution
1666	10 15/16	A_1–f′′′	Harpsichord	8′8′	Hieronymus de Zentis	Metropolitan Museum of Art
1682	10⅞	C/E–c′′′	Harpsichord	8′8′	Giacomo Ridolfi	Rhode Island School of Design, Providence
1683	8	C/E–c′′′	Polygonal virginal	8′	B. Obici	Harding Museum, Chicago
1690	10 13/16	C/E–c′′′	Harpsichord	8′	Giovanni Andrea Menegoni	Smithsonian Institution
1693	10 5/16	G_1–c′′′	Harpsichord	8′8′	Anonymous	Smithsonian Institution
1694	9⅞	C–c′′′ (minus C♯)	Harpsichord	8′8′4′	Nicolaus de Quoco	Smithsonian Institution
	9¾	C/E–a′′	Clavicytherium	8′8′	Anonymous	Smithsonian Institution
	[b] 10⅜	C/E–c′′′	Clavicytherium (Ottavina)	4′	Anonymous	Boston Museum of Fine Arts
	11	C/E–c′′′	Polygonal virginal	8′	Anonymous	Smithsonian Institution

[a] This length is approximate. It is double the length of the shortest string on the instrument.

[b] In order to arrive at a meaningful average value for the string lengths of the nontransposing group, it was necessary to double the measured lengths of the pitch C strings of the three instruments tuned an octave higher.