RECONSTRUCTING MERSENNE'S CLAVICHORD

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This is the text of a paper delivered at the International Clavichord Symposium, Magnano, 2011 and printed in De Clavicordio X *(published 2012). The theme of the Symposium, announced in advance, was 'The Early Clavichord'.*

In this paper I shall describe an attempt to reconstruct an early-seventeenth-century clavichord from the description given by Marin Mersenne in his great work on music, *Harmonie Universelle*, published in Paris in the 1630s. As far as I know, this has not previously been attempted. While Mersenne's clavichord is probably not an 'early' one in terms of the theme of this Symposium, the problems of making a reconstruction, particularly of interpreting a documentary and iconographic source which may be incomplete and ambiguous, are similar to those faced by my colleagues here, and I hope you will forgive this foray into the Baroque.

Marin Mersenne (1588–1648) was undoubtedly one of the principal intellectual figures of the early seventeenth century. He was born into a peasant family near Oizé, in the Pays de Loire region of France. It seems that from an early age he showed signs of eagerness to study, and his parents accordingly sent him to the grammar school at Le Mans and later to the Jesuit College of La Flèche, where one of his fellow students was René Descartes. In 1611 he joined the mendicant order of Minims. The order sent him first to Paris for further studies, and then in 1614 to their convent at Nevers, where he taught theology and philosophy for five years. In 1620 he returned to Paris, and for the rest of his life the order seems to have imposed no further duties on him, encouraging him to pursue his studies and to write.

Mersenne's first publications were theological works, but from about 1625 he devoted himself to mathematics and the newly developing field of science. He became an ardent opponent of irrational doctrines such as alchemy and astrology, and a strong supporter of the new method of advancing knowledge by scientific experiment, though he avoided open conflict with the doctrines of the Catholic church. He was a friend and constant supporter and defender of Descartes, and his circle of correspondents included most of the intellectual figures of the age, including Galileo, Fermat, Huygens, Pascal, Gassendi, Torricelli and Hobbes. Mersenne carried out experiments himself, but his particular importance in the history of science lies in the encouragement he gave to other researchers, and the stimulating influence of his suggestions and questions. Such was his devotion to scientific method that he even directed in his will that after his death his body should be dissected in the interests of anatomical research.[1]

[1] Biographical details are taken for the most part from the *New Advent Catholic Encyclopedia*, available on-line at http://www.newadvent.org/cathen/10209b.htm (accessed 23 August 2011) and from the article *Marin Mersenne* by John J. O'Connor and Edmund F. Robertson in the History of Mathematics Archive at the University of St Andrews, available on-line at http://www-history.mcs.st-andrews.ac.uk/Biographies/Mersenne.html (accessed 23 August 2011).

Mersenne was keenly interested in music, and like everything else he subjected it to rational enquiry. In 1637 his monumental work on the subject, *Harmonie Universelle*, the fruit of at least thirteen years of labour [see Fig. 1], was at last published, with financial support from his aristocratic friend and patron Nicolas Claude Fabri de Peiresc.[2] It consists essentially of four *traités* (treatises), each with its own dedicatory letter and preface; each *traité* is divided into *livres* (books), of which there are nineteen in all, some of them only tangentially related to music.[3]


HARMONIE
VNIVERSELLE,
CONTENANT LA THEORIE
ET LA PRATIQVE
DE LA MVSIQVE.
Où il eſt traité de la Nature des Sons, & des Mouuemens, des Conſonances, des Diſſonances, des Genres, des Modes, de la Compoſition, de la Voix, des Chants, & de toutes ſortes d'Inſtrumens Harmoniques.
Par F. MARIN MERSENNE de l'Ordre des Minimes.
A PARIS,
Chez SEBASTIEN CRAMOISY, Imprimeur ordinaire du Roy, ruë S. Iacques, aux Cicognes.
M. DC. XXXVI.
Auec Priuilege du Roy, & Approbation des Docteurs.

Fig. 1. The title-page of Marin Mersenne's *Harmonie Universelle*. The date given on this copy is 1636, but the work was probably published in 1637

Publication of *Harmonie Universelle* was complicated by the fact that the only printer in Paris with music types — Pierre Ballard — declined the work, which had to

[2] Marin Mersenne, *Harmonie Universelle, contenant la Theorie et la Pratique de la Musique, ou est traité de la Nature des Sons, & des Mouuemens. des Consonances, des Dissonances, des Genres, des Modes, de la Composition, de la Voix, des Chants, & de toutes sortes d'Instrumens Harmoniques*, Paris: Sebastien Cramoisy, [1637]: henceforth '*H.U.*' The title-pages of most copies bear the date 1636, but Mersenne's correspondence shows that printing was not complete in February of the following year, and the first copies were probably issued in March 1637. In some surviving copies the printer/publisher is given as Pierre Ballard; in a few it is given as Richard Charlemagne. A facsimile of the author's own copy, edited by François Lesure, was published by Éditions du Centre de la Recherche Scientifique, Paris, 1963. In his introduction, Lesure speculates that Ballard and Charlemagne purchased a number of copies of *H. U.* from Cramoisy with their own names on the title-page for re-sale in their own shops. A previous publication, *Traité de l'Harmonie Universelle*, issued in 1627, includes a first draft of some sections of *H.U.*, but does not include the sections on musical instruments.

[3] The first treatise *des mouvemens* (3 *livres* with a subsidiary *Traité de Mechanique*) deals with the nature of sound and hearing; the acceleration of falling bodies; the rotation of the earth; the vibration of strings etc. The second treatise on *chant* (2 *livres*) deals exhaustively with vocal music, among other things the physiology of human and animal voices, types of vocal music, vocal diction, acoustics of buildings, and even the manner in which God and the angels communicate. The third treatise (6 *livres*) is concerned with the theory of music, consonance and dissonance, scales, harmony, rhythm and composition. The fourth treatise is the *Traité des Instrumens*, consisting of eight *livres*. It is arranged as follows:

Book 1: the nature of instrumental sounds and the use of the monochord;

Books 2, 3 and 4: stringed instruments;

Book 5: wind instruments;

Book 6: the organ;

Book 7: percussion instruments;

Book 8: an essentially unrelated *Liure de l'Vtilité de l'Harmonie*.

be entrusted to the King's printer, Sebastien Cramoisy, with Ballard called in to help in the numerous places where music examples were required. Delays (which Mersenne complains about in more than one letter to Peiresc[4]) were the inevitable result; and delays gave the opportunity for Mersenne to intervene with further thoughts, corrections and clarifications. Moreover, at the same time as *Harmonie Universelle* was going through the press at Cramoisy's, Mersenne was overseeing the production, by a different printer, of a Latin version, *Harmonicorum Libri XII*.[5] This uses many of the same illustrations that appear in the *Harmonie*, and one can readily appreciate the scope for confusion and delay as copper plates and music type were transported across Paris from one printer to another. A letter from Mersenne to Peiresc dated 12 October 1635[6] makes it clear that the Latin version is essentially an abridgement or summary of the original French, compiled for the benefit of foreigners who were not fluent in that language; it is nonetheless worth consulting because it occasionally contains details which do not appear in the *Harmonie*.[7]

Perhaps because of the circumstances under which it was produced, the page numbering of the *Harmonie* is illogical, and there are numerous typographical errors throughout the book.[8] It is the fourth part, the *Traité des Instrumens*, that most concerns us here, but before examining its contents, I should like to make one further point about Mersenne: his interest in music was far from being purely academic and intellectual. I do not know whether he had any ability as a player, but he was an appreciative listener, keenly sensitive to the power of music, as emerges, I think, from this passage in the General Preface to *Harmonie Universelle*, where he speaks of the harpsichord playing of Jacques Champion de Chambonnières:

> … after hearing the harpsichord played by Sieur de Chambonnières … I cannot express my feelings except by saying that there is no need to listen to anything else afterwards, if what you desire is sweet melody and beautiful harmony skilfully blended together, with beauty of movement, excellent touch, and a lightness and rapidity of the hand joined with a most delicate ear, so that one may say that this instrument has found its ultimate master.[9]

The eight books of the *Traité des Instrumens* include descriptions and depictions[10] of more than 65 string, wind and percussion instruments, including a *manichordion* or clavichord. This was by no means a rare instrument in early-seventeenth-century Paris. Archival information shows beyond doubt that French

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[4] See the introduction by François Lesure to the 1963 facsimile edition of *H.U* (note 2 above).

[5] Marin Mersenne, *Harmonicorum Libri XII in quibus agitur de Sonorum Natura Causis et Effectibus: de Consonantiis, Dissonantiis, Rationibus, Generibus, Modis, Cantibus, Compositione, orbísque totius Harmonicis Instrumentis*, Paris: Guillaume Baudry, 1648. Facsimile, Geneva: Editions Minkoff, 1972. Henceforth '*Harmonicorum*'.

[6] Quoted by Lesure, *op. cit.* (see note 2), p. VII.

[7] *Harmonicorum* is divided not into treatises, but into two parts. Eight *libri* deal with the subjects covered in the first three *traités* of *H.U.*; page numbering then recommences, and the remaining four books deal with musical instruments. These four books were first issued separately by Baudry as *Harmonicorum Instrumentorum Libri IV* in 1636. Much of the material in *Harmonicorum* is truncated and smaller type is used.

[8] Some, but by no means all, of these errors are picked up in the General Preface, the Prefaces to each volume, and the list of corrections inserted between books 7 and 8 of the fourth *Traité*.

[9] *... apres auoir oüy le Clauecin touché par le sieur de Chanbonniere [sic] ... ie n'en peux exprimer mon sentiment, qu'en disant qu'il ne faut plus rien entendre apres, soit qu'on desire les beaux chants & les belles parties de l'harmonie meslées ensemble, ou la beauté des mouuemens, le beau toucher, & la legereté, & la vitesse de la main iointe à vne oreille tres-delicate, de sorte qu'on peut dire que cet Instrument à rencontré son dernier Maistre* (General Preface [p. 14]). All translations from French or Latin are by me unless otherwise stated.

[10] Some of the illustrations are woodcuts, some are copperplate engravings.

musicians of Mersenne's day fairly often owned clavichords, and some contemporary French makers were making them.[11] It is true that, as Bernard Brauchli has put it, a style of composition was developing at this time in France which 'specifically exploited the possibilities inherent in plucked keyboard instruments' such as the harpsichord and virginal, and as a result the clavichord was declining in importance.[12] Nonetheless it remained in use in France throughout the seventeenth and eighteenth centuries, and only disappeared after the 1789 revolution.

There is no reason, then, to suppose that the *manichordion* was a particularly unfamiliar instrument to Mersenne. In *Harmonie Universelle*, he devotes to it two pages of description, accompanied by an engraving occupying one complete page [Fig. 2].[13] This shows an instrument with a compass of 49 notes, C–c^3 without a short octave.[14] Vertical boards are placed obliquely across the rear corners; behind these, and on either side of the keyboard, are open compartments (Mersenne comments that these can be used to store spare strings, tuning pins, a tuning hammer and 'many other things').[15] The strings run transversely across behind the keys in line with the long axis of the instrument; at the left-hand end they pass over an oblique bridge, and on the right they rest on five soundboard bridges, which are arranged at right angles to the string band. The heights of the bridges increase progressively, with the lowest towards the left and near the back bearing the treble strings.

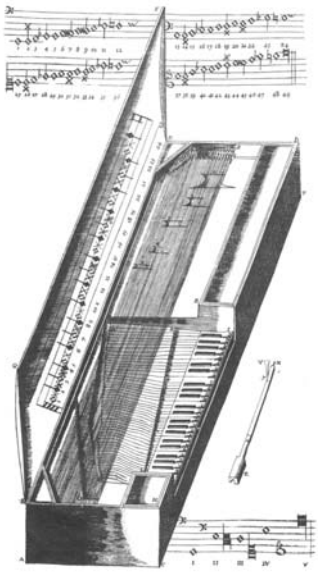

Fig. 2. The engraving of a *manichordion* in *Harmonie Universelle* (*Liure Troisiesme des Instrumens*, p. 115). The notation near the top of the page gives the complete compass of the instrument: the notation on the inside of the lid is irrelevant and seems to have been shown there merely for convenience

[11] For a summary of the archival evidence for the clavichord in France during the sixteenth, seventeenth and eighteenth centuries, see Francis Knights, 'Some Observations on the Clavichord in France', *Galpin Society Journal* XLIV (1991), pp. 71–6.

[12] Bernard Brauchli, *The Clavichord* (Cambridge: Cambridge University Press, 1998), p. 132.

[13] *H.U., Traité des Instrumens, Liure Troisiesme*, pp. 114–16.

[14] The 49-note compass C–c^3 is confirmed by the numbered notes shown on the two staves immediately above the clavichord in the engraving. However, Mersenne's text says 'the clavichord has a keyboard with 49 or 50 finger-keys' (*le Manichordion a son clauier de quarante neuf ou cinquante touches*). The Latin version is unequivocal: 'it has 50 keylevers, of which the handles [i.e. the keys] can be seen (*habet eiiam 50 pinnulas, quarum manubria deteguntur*). It is not clear what lies behind this discrepancy. The most musically useful place for an additional key would be in the bass octave where, for example, the C# key could be divided to provide C# and AA. Somewhat alarmingly, the engraving shows an anomalous additional accidental note in the top octave: this must surely be a simple error.

[15] *des chordes, des cheuilles, vn marteau & plusieurs autres choses*. Maria Boxall (see note 21) comments that they could also be used to store small music books.

This illustration and the accompanying description have had what I might describe as a mixed press from modern commentators. In 1975 John Henry van der Meer stated categorically, without giving reasons, that:

> [the clavichord] illustrated in Mersenne is a hexagonal Italian one in an outer case.[16]

Edwin Ripin also thought the clavichord might be of Italian origin. Writing in *The New Grove Dictionary of Music and Musicians* (first published in 1984) he commented as follows:

> Mersenne … provided a description of a clavichord so vague and inconsistent that one wonders if he had ever actually seen one; and the instrument in his illustration, despite its vaulted lid and alleged chromatic bass octave, looks more like the hexagonal, thin-cased Dominicus Pisaurensis instrument of 1543 set into a protective outer case than it does an instrument made either in France or in the 17th century.

Members of this audience who are performers — or authors — will understand only too well the lasting effect of a bad review, particularly when it comes from such a respected source. Ripin's remarks have been reprinted, notably in the widely used paperback volume *Early Keyboard Instruments*,[17] and at least one other distinguished author has taken them as authoritative[18]; to this day they can be read on the internet by those who have access to *Grove Music On-line*.[19] As a result, Ripin's view that Mersenne is not to be trusted as a reporter on the instruments of his own time and place has met with wide acceptance.

Bernard Brauchli does not assign the clavichord to Italy in the careful account he gives of Mersenne's *manichordion* in his book *The Clavichord*, published in 1998.[20] Nor does he imply that Mersenne might never have seen a real clavichord. However, he states:

> The instrument is not drawn to scale, and unfortunately [Mersenne] gives neither measurements nor proportions.

It was not until 2001 that a champion emerged to restore the reputation of Mersenne's clavichord. This was Maria Boxall, writing in the *Galpin Society Journal* of that year.[21] Perhaps because her contribution was in the form of an appendix to a much longer article on the origins of diatonic fretting, it has not yet received the attention which, in my opinion, it deserves. In it, Boxall shows that the *manichordion* is indeed drawn to scale, in an early form of isometric projection. In this type of projection, horizontal and vertical distances are accurately scaled, wherever they happen to be in the drawing; so in an isometric representation of a rectangular object such as Mersenne's clavichord, if a pair of dividers is applied first to one end and then

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[16] John Henry van der Meer, 'The Dating of German Clavichords', *The Organ Year Book*, Vol. VI (1975), pp. 100–113, at p. 100.

[17] Edwin M. Ripin *et al*., *Early Keyboard Instruments* (London: Macmillan, 1989), p. 155.

[18] See, for example, Patrizio Barbieri, 'The *Sordino*: the Unsuspected Early Italian Tangent Piano 1577–1722', *Galpin Society Journal* LXIII (2010), pp. 49–60, at p. 54, col. 1.

[19] Accessed 21 August 2011 at www.oxfordmusiconline.com; this is available to subscribers only.

[20] Brauchli, *op. cit.*, pp. 121–3.

[21] Maria Boxall, 'The Clavichord in Mersenne's *Harmonie Universelle*' (Appendix II to the article 'The Origins and Evolution of Diatonic Fretting in Clavichords'), *Galpin Society Journal* LIV (2001), pp. 192–9.

to the other, they are seen to be of equal length, and similarly with the front and back [Fig. 3]. To the eye accustomed to perspective drawing, such an isometric representation may seem distorted, unrealistic and 'out of scale', but it is actually more useful as a method of conveying dimensions and proportions.[22]

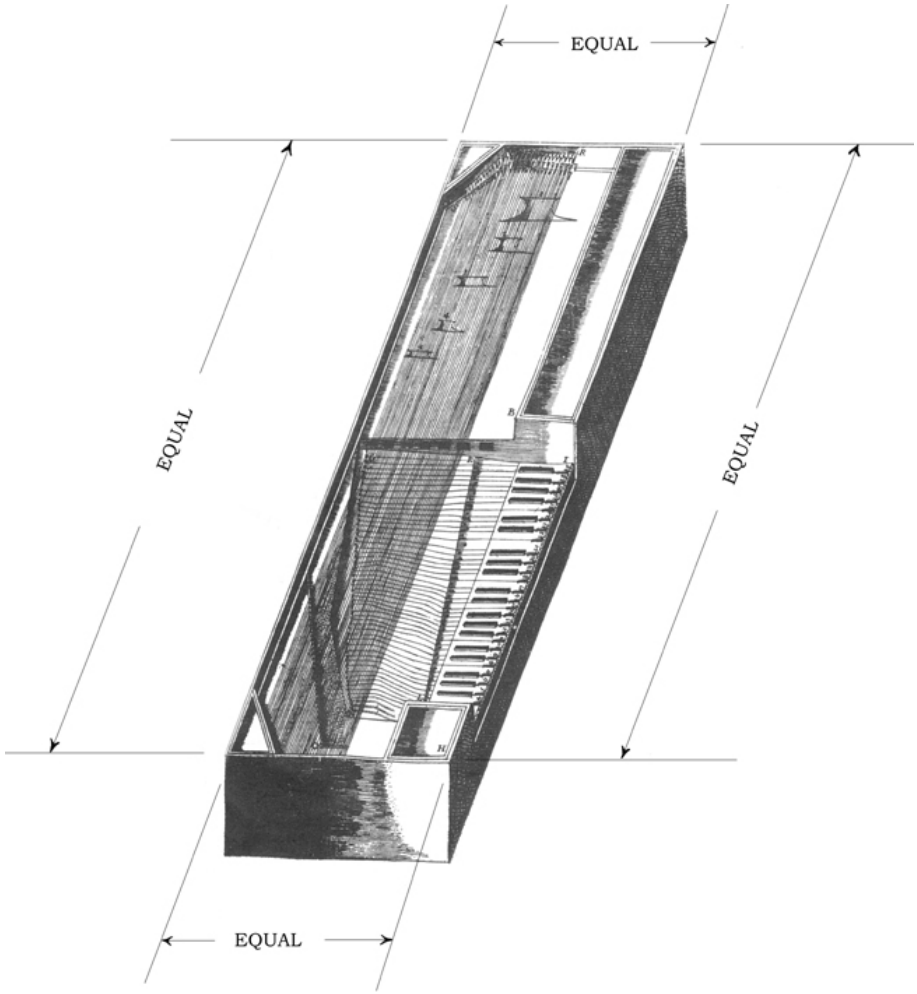

Fig. 3. Isometric projection: lengths that are equal on the object are shown as equal on the depiction

Boxall's article goes on to show that Mersenne's description, far from being vague as alleged by Ripin, is precise, detailed and in no way improbable; there are certainly inconsistencies, but they can be fairly easily resolved if one is prepared to accept that there are typographical slip-ups of the kind that occur throughout the *Harmonie*.

The more I read and carefully considered Maria Boxall's article, the more likely it seemed that what Mersenne was describing was an actual existing clavichord that he had personally examined, and not a figment of his imagination or a muddled attempt to represent something that he had merely heard about, as Ripin had suggested. Yet, if so, it would have been strikingly different from any clavichord that has actually survived.

[22] Isometric projection is also used for Mersenne's depiction of the virginal (*épinette*) but the harpsichord (*clauecin*) is shown in perspective.

The proof of any pudding is said to be in the eating, and it seemed to me as a clavichord maker that the next step was to attempt to produce an instrument based, as closely as possible, on Mersenne. I have at last been able to do this, some ten years after Maria Boxall's article appeared, and the result is presented here at this Symposium. As far as I know, there have been no previous attempts to reconstruct Mersenne's *manichordion*. In the rest of this paper, I shall try to explain the process by which I extracted the details of the design from Mersenne, and the reasoning that lies behind certain choices which had to be made during the course of construction.

The first thing that had to be decided was whether the instrument could be an Italian clavichord enclosed in a separate protective outer case, as suggested by van der Meer.[23] If so, the inner instrument would have a symmetrical six-sided shape, defined by the oblique pieces across the two rear corners. Most known clavichords with cases of this shape are indeed of Italian origin[24]; I am not aware that any of them comes with a rectangular outer case, but that may just be an accident of survival. However, there is no sign, in the description or the engraving, of a separate inner instrument, or even of the appearance of one (the effect called by Frank Hubbard 'false inner-outer'[25]); and in the Latin version Mersenne says plainly that

> The instrument … consists of a box made of five boards, namely a bottom and four sides.[26]

In any case, since no French seventeenth-century clavichords have survived, the evidence of what they were like is lacking; it would not be surprising if they resembled the Italian ones in some respects.[27] Accordingly, I did not think that the shape and appearance of the instrument, and specifically the oblique pieces at the corners, were very strong indications of Italian origin.

There is, however, one piece of evidence in the engraving which might point to Italy. If you examine the keyboard, you will see that the accidental blocks seem to be made of a light-coloured material capped with slips of black, whereas the natural keys appear to be white, or at any rate light in colour [Fig. 4]. Compare this with the

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[23] *op. cit.*, p. 100.

[24] Italian clavichords of this shape are listed in Appendix 3. There are two other surviving clavichords with symmetrical hexagonal cases, both anonymous and undated, that are believed to be of German origin: (1) Washington DC, Smithsonian Institution No. 65.590; and (2) Nuremberg, Germanisches Nationalmuseum, No. MIR 1047. A third clavichord of the same type was illustrated in the October 1962 issue of the UK magazine *Collector's Guide*, p. 46, but its present whereabouts are unknown. All of these probably post-date Mersenne. See Michael O'Brien, 'The Smithsonian Clavichords', *Early Keyboard Journal*, Vol. 10 (1992), pp. 147–50; Martin Kares, *Verzeichnis der Europäischen Musikinstrumente im Germanischen Nationalmuseum Nürnberg*, Vol. 3, *Klavichorde* (Wilhelmshaven: Florian Noetzel, 1999), pp. 57–9; and the letter from 'W. P., Brussels' in the section 'The Inquiring Collector', in *Collector's Guide*, October 1962 (the magazine later changed its title to *Antique Dealer and Collector's Guide*).

[25] See Frank Hubbard, *Three Centuries of Harpsichord Making* (Cambridge, Massachusetts, and London: Harvard University Press, 1965), p. 20.

[26] *Hoc instrumentum … constat arcâ 5 asseribus, nempe fundo, & 4 lateribus, compaginatâ. Harmonicorum, Liber Primus de Instrumentis Harmonicis*, p. 63.

[27] Edward L. Kottick, in his book *A History of the Harpsichord* (Bloomington: Indiana University Press, 2003), has publicized a theory, originally advanced by John Koster, that certain features found in early keyboard instruments from all over Europe may be derived from a common style of construction dating from the time these instruments were first invented; at different dates, it is suggested, the various national schools developed their own characteristic styles. Thus if similar features are found in an Italian and in a French clavichord, it may be that they are both following an earlier tradition, and it is not necessary to invoke Italian influence or an Italian origin to explain the similarity.

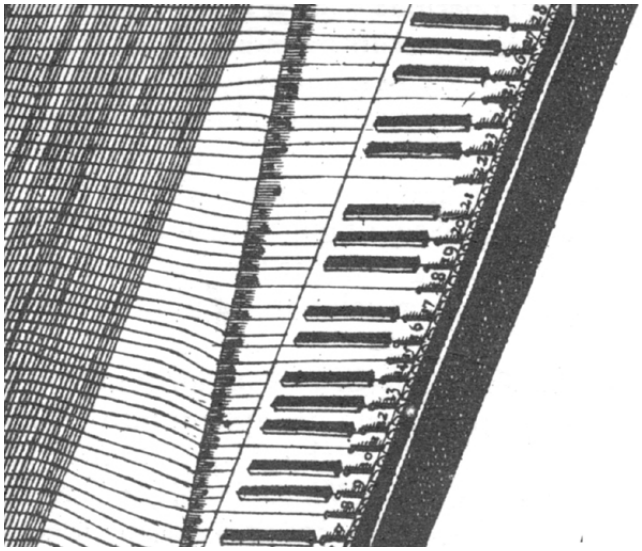

Fig. 4. Keyboards of the *manichordion*

keyboard of the virginal shown a few pages earlier [Fig. 5]: there the accidentals are of a dark material, capped with white slips, and the naturals, although not actually shown as black, are hatched by the engraver in a way that might suggest a dark colour. Now, most surviving seventeenth-century French keyboard instruments have naturals of a dark material such as ebony and accidentals capped with ivory or bone; Italian keyboards at this time had light naturals (generally of box-wood) and dark sharps. Yet white naturals and dark sharps were not entirely unknown in France before Mersenne's time, as appears from several keyboard-instrument drawings by Jacques Cellier, in manuscripts dating from the 1580s.[28]

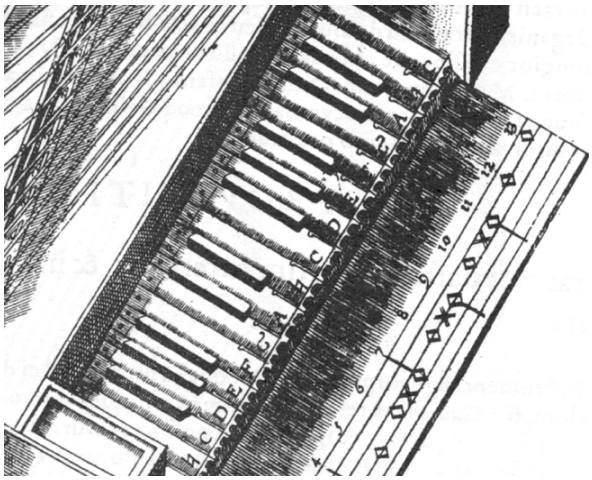

Fig. 5. Keyboards of the *épinette* (virginal)

[28] Three MSS with drawings of keyboards by Jacques Cellier (*c.* 1550–*c.* 1620) are known:

1. Reims, Bibliothèque Municipale, MS 971: fol. 34r, reproduced in David Ledbetter, *Harpsichord and Lute Music in 17th-century France* (London: Macmillan Press, 1987), frontispiece;

2. Paris, Bibliothèque Nationale de France, MS fr. 9152: fol. 182r, reproduced in Bernard Brauchli, *op. cit.*, p. 83; see also Thurston Dart, 'Some Sixteenth-century French Drawings', *Galpin Society Journal* X (1957);

3. London, British Library, MS Add. 30342. See Susi Jeans and Guy Oldham, 'The Drawings of Musical Instruments in MS Add. 30342 at the British Museum', *Galpin Society Journal* XIII (1960), pp. 26–31. All of these show light-coloured naturals and dark accidentals.

Whether or not it was actually made in Italy, Mersenne's clavichord is obviously related to those Italian clavichords which have all the strings running transversely across, in line with the axis of the case, and several bridges arranged at right angles to the string band (for a list of Italian clavichords of this type, see Appendix 3). Some of them, incidentally, are hexagonal in shape, but others are rectangular. This way of arranging the bridges need not be thought of as an Italian speciality; it derives ultimately from the very earliest type of clavichord, shown in fifteenth-century depictions from various parts of Europe. Mersenne's clavichord is an enlarged and developed example of this type, perhaps representing the final stage in a tradition of making clavichords in this way.[29]

On balance, while admitting the possibility of an Italian origin, I decided to proceed on the assumption that the instrument was made in seventeenth-century France. To check the plausibility of my interpretation of Mersenne's engraving, and to help decide details about which no direct information was to be had, I referred to published details of extant seventeenth-century French harpsichords, and in particular to an excellent drawing by Christopher Nobbs of a harpsichord attributed to Claude La Brèche.[30] Admittedly, this dates from the 1690s, over half a century after Mersenne, but its general style does not differ significantly from surviving French harpsichords from earlier in the century, all of which unfortunately post-date Mersenne.

The first step was to reconstruct the design of the case. It is clear from the engraving that the overall proportion of length to width is exactly 3:1, a beautiful and harmonic relationship, as Maria Boxall says in her article. She suggested that this could be interpreted as 60 units × 20, and that the unit could be the Paris *pouce* or inch. I carefully measured the engraving, and found that the width of the keywell (measured at the top edge) was exactly equal to the width of the soundboard front, and the toolbox at the left-hand end occupied one-tenth of the whole length. Now, Boxall gave the width of the keywell as 25 units and the width of the box as 6 units; however, this creates a difficulty, since it results in an overall length of only 56 units, not 60 (25 + 25 + 6 = 56). If the toolbox was indeed 6 units wide, the keywell and soundboard front would need to be 27 units each, which would produce the required length of 60 units (27 + 27 + 6 = 60) and would also have the virtue of corresponding exactly to the proportions I had measured from the engraving. However, in that case these units were unlikely to be Paris *pouces*. The keywell has to accommodate 29 natural keys: fitting these into a space 27 *pouces* wide would result in an excessively wide octave-span — about 176 mm, considerably wider than that of the modern piano, and much wider than that of typical French seventeenth-century keyboard instruments such as the La Brèche harpsichord.

Could the unit be some arbitrary one, a 'maker's inch' unknown to metrology? Rather than make such an assumption, I decided to approach the problem from another angle.

Stephen Birkett and William Jurgenson, writing, as it happens, in the same invaluable issue of the *Galpin Society Journal* as Maria Boxall, argued that before the nineteenth century keyboard-instrument makers began by marking the layout of their

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[29] A hint that clavichord design was changing is in Mersenne's remark that *l'on peut faire vn seul cheualet au lieu de ces cinq* ('one can make a single bridge instead of these five').

[30] Now in the Württembergisches Landesmuseum, Stuttgart, No. 1984-5.

instruments on the bottom boards, using geometrical methods.[31] According to this theory, the starting point — and the only length that was actually measured — was the width of the keywell: all other dimensions were determined by a series of manoeuvres with straightedge, try-square, beam compass and dividers. Consequently the various dimensions — apart from the keywell width — will not necessarily be exact multiples of the local measurement unit. It has to be said that this analysis of old builders' methods has not yet met with universal acceptance; other writers have placed a greater emphasis on understanding the design of surviving instruments by interpreting their dimensions in terms of known local measurement units.[32] Nonetheless, I decided to see if the Birkett–Jurgenson methods could be applied to Mersenne's clavichord.

If the keywell width was the starting point, that at least was presumably measured using the Paris *pouce*. It turned out that a keywell measurement of 24 *pouces* (rather than 25) produces an octave-span for the instrument of just under 157 mm: a typical French octave-span, and almost exactly that of the La Brèche harpsichord. The soundboard front would then also measure 24 *pouces*, easily marked off along the case front with the beam compass. We now have three marks along the line representing the case front, with the extreme marks being 48 *pouces* apart. As mentioned, the toolbox at the left-hand end takes up one-tenth of the complete length: the maker would therefore have to divide this 48-*pouce* distance into nine parts, with compass and ruler or with dividers, to find the toolbox width, which would then be added at the left end. The width of the box arrived at in this way would be $24 + 24 \div 9 = 5⅓$ *pouces*. This distance also defines the position of the 'middle board' — the board that supports the front edge of the soundboard. Now 5⅓ might seem an odd length[33]; but I noticed that the depth of the case was exactly 1½ times the width of the box; and $1½ \times 5⅓$ is exactly 8, so the case would be 8 *pouces* high — a dimension that the maker might well have set with an ordinary Paris ruler, since even if geometrical methods were used to arrive at the horizontal or plan dimensions, it is not clear to what extent they were also used for the vertical ones. The total length of the instrument would be $48 + 5⅓ = 53⅓$ pouces; to fix the width, the maker could simply divide this into three and mark out the distance perpendicular to the front at each end.

The results of this were so plausible and coherent, and so closely in accordance with the engraving, that I decided to go ahead on this basis. Once the outline of the case had been established, most of the rest of the design fell into place quite easily. The position of the string band, for example, was defined by the fact that the lowest bass string is exactly halfway across the instrument, and the topmost treble string is one *pouce* from the inside of the spine: this allows plenty of space for the 70 strings (35 courses) prescribed by Mersenne. The depth of the keyboard opening is half the height; the distance of the treble bridge from the right-hand case end wall is one-third of the whole length, and so forth. Some dimensions were simply scaled up from measurements of the engraving: in this way I arrived at approximations for the lengths of the heads and tails of the natural keys, the size and position of the seven windows in the belly rail, the position and orientation of the oblique corner pieces and of the

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[31] Stephen Birkett and William Jurgenson, 'Why Didn't Historical Makers Need Drawings? Part I — Practical Geometry and Proportion', *Galpin Society Journal* LIV (2001), pp. 242–84. Part II, 'Modular Dimensions and the Builder's *Werkzoll*' appeared in the following issue (pp. 183–239).

[32] For an example of this kind of approach, see Grant O'Brien, 'The use of simple geometry and the local unit of measurement in the design of Italian stringed keyboard instruments: an aid to attribution and to organological analysis', *Galpin Society Journal* LII (1999), pp. 108–71.

[33] It might seem a little less odd when expressed as 5 *pouces* and 4 *lignes*, one *ligne* being a twelfth of a *pouce*.

left-hand bridge, and also of the oblique line of the balance pins. I estimated the thickness of the sides in the same way as 4 *lignes*, or just over 9 mm.

The case was made of walnut, following the La Brèche and other seventeenth-century French keyboard instruments, with the bottom and some frame parts of poplar. The internal structure is, of course, not visible in the engraving and no details are given in Mersenne's text, so this was essentially designed from scratch, bearing in mind the need to ensure stiffness. One thing seems clear, though: the *manichordion* almost certainly did not have a so-called 'secondary soundboard' under the keys, since the oblique position of the balance rail would have cut right across it. In this way, it differs from its putative Italian forebears such as the Dominicus Pisaurensis of 1543. It must, however, resemble them in one way: the soundboard cannot be flat. It must slope down to the tuning pins, with a bend about one-third of the way along from the belly rail. This is unavoidable, given the low treble bridge and the long distance between it and the tuning pins, and the fact that the strings run directly across the bridge without any bridge-pins or side-bearing. In order to make acoustic contact and produce a clear note, they must press down on the top edge of the bridge, making an angle at that point; and since there is no sign here of the 'pressure bars' found on Neapolitan clavichords or the 'hold-downs' present on some Latin-American ones, there is no way of achieving this except by sloping part of the soundboard downwards. One can deduce that this must have been the case in Mersenne's instrument, but if so, it does not seem to be very clearly depicted in the engraving. The only hint of it might be that on the sloping corner piece at the right-hand end, the edges of the rim (the part of the case side that projects above the soundboard) are not shown as parallel, as they would be if the soundboard was indeed flat [see Fig. 6].

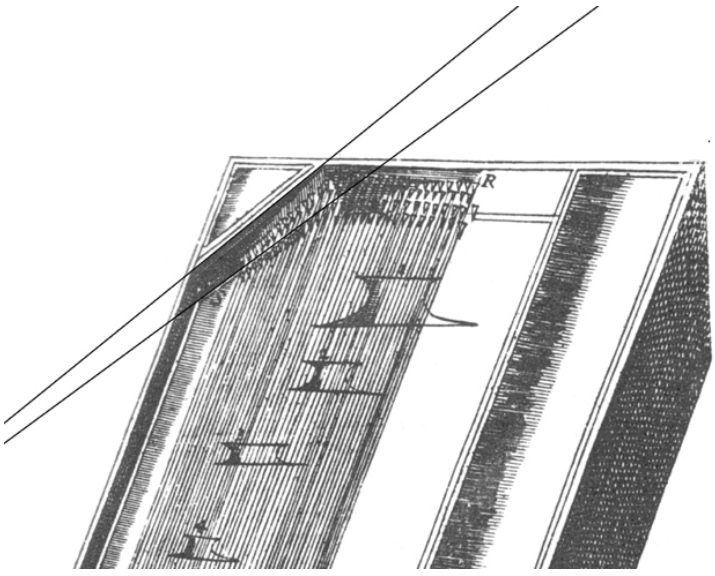

Fig. 6. Possible indication of a sloping soundboard

The engraving and Mersenne's description give no information about the soundboard thicknesses or barring. I decided to fit one fairly substantial bar directly across under the soundboard at the point where it is bent, similar to that found in the Italian instruments mentioned: the effect of this is to create two separate areas in the soundboard, one for the treble bridge and one for the four remaining bridges. Experiments showed that generally these two areas vibrate independently; notes sounding through bridges 2 to 5 (counting from the treble) did not evoke any

significant response in the treble area, and vice versa. To support the downward pressure exerted by the strings, I put a second bar across the sloping part of the soundboard, midway between bridges 3 and 4. Later, after the instrument was strung and playing, I found that the notes on bridge No. 1 were failing to sound properly: they were weak in volume and tone was variable, but mostly rather poor. Extensive experiments showed that the only way to improve these treble notes was to add a third bar roughly midway between the left edge of the soundboard and the point where it is bent: this had to be done after the construction was complete, and to gain access it was necessary to cut an opening in the bottom board. You can imagine with what trepidation I attacked the instrument in this way.

As to the bridges themselves, approximate heights were derived by scaling up from the engraving. They were made of apple wood, and fitted with a strip of brass in the top edge. The scoops at either side of each bridge, so clearly shown in Mersenne's engraving, are not merely decorative; they provide clearance between the end of the bridge and the adjacent overlengths, and also extend the footprint of each bridge sideways on the soundboard, helping to reduce the 'bridge-end effect', i.e. the loss of tone quality sometimes found on courses which cross a bridge close to its end.

Having positioned the bridges on the soundboard, my next task was to find out where the tangents should be; to do this, one must first establish the nature of the fretting. Mersenne says that there are 70 strings arranged in courses of two, i.e. 35 courses in all, to serve the 49 notes. His description of the fretting is not altogether transparent:

> … notes 37 and 38 [c^2 and $c\#^2$] have but one course; similarly with notes 39 [d^2], 40 [$e\flat^2$], 42 [f^2], 43 [$f\#^2$], 44 [g^2], 45 [$g\#^2$], 47 [$b\flat^2$], 48 [b^2] and 49 [c^3].[34]

If we take account of the fact that notes 41 [e^2] and 46 [a^2] are not included, the most likely meaning is that the top octave is fretted as follows:

> c^2–$c\#^2$ / d^2–$e\flat^2$ / e^2 (alone) / f^2–$f\#^2$ / g^2–$g\#^2$ / a^2 (alone) / $b\flat^2$–b^2–c^3 (three together).

This is the interpretation arrived at by both Maria Boxall and Bernard Brauchli,[35] and I am happy to accept it as much the most likely solution. It results in an unusual, but not unique, form of diatonic fretting with notes E and A free.[36] The

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[34] *... le 37. & 38. n'ont qu'vn mesme rang de chordes ce qui arrive semblablement à la 39. 40. 42. 43. 44. 45. 47. 48 & 49.*

[35] *opera cit.*, p. 196 and p. 123 respectively.

[36] Among the surviving fretted clavichords with free Es and As are the following:

1. Franz König, Ingolstadt, 1739: Munich, Deutsches Museum, No. 1908-16816. See Hubert Henkel, *Deutsches Museum, Katalog der Sammlungen, Musikinstrumenten-Sammlung, Besaitete Tasteninstrumente* (Frankfurt am Main: Verlag Erwin Bochinsky, 1994), pp. 40–41.
2. Anonymous, Brussels, Musical Instrument Museum, No. M.1618. See Victor Mahillon, *Catalogue descriptif et analytique du Musée instrumentale du Conservatoire royal de musique de Bruxelles*, Ghent, 1880–1922, Vol. 3, pp. 186–7. Donald H. Boalch, *Makers of the Harpsichord and Clavichord 1440–1840*, third edition ed. Charles Mould (Oxford: Clarendon Press, 1995) has an entry on p. 462, col. 1, suggesting that the instrument bears a signature *Franciscus König*, but this appears to be unconfirmed and Mahillon does not refer to it.
3. David Tannenberg, 1761: Nazareth PA, Moravian Historical Society, No. 730. Tannenberg's signature was discovered within the instrument in 2004: see Laurence Libin, 'New Insights into Tannenberg's Clavichords, *Magnano Proceedings VII* (Musica Antica a Magnano, 2004), pp. 129–55.
4. Anonymous, Washington DC, Smithsonian Institution No. 94,886; see Michael O'Brien, 'The Smithsonian Clavichords', *Early Keyboard Journal*, Vol. 10 (1992), pp. 150–52. This instrument has also been attributed to Tannenberg.

pattern of diatonic fretting is broken by the linking of the three topmost notes, but this is something very often found in diatonically fretted clavichords which are otherwise regular. It can hardly be true, though, as Mersenne goes on to say, that

> The other keys have their own course of strings[37]

— since this would require 39 courses and there are only 28 left for the three lower octaves. Both Boxall and Brauchli propose that the fretting continued downwards with the same pattern until the 18th course (f–f#), in which case the number of notes and courses matches very nicely; this seemed the most likely solution, and I planned the reconstruction accordingly.[38]

The distances between adjacent tangents on the same course depend, of course, on the size of the semitone: in view of the date, I assumed strict quarter-comma meantone with diatonic semitones in the ratio 15:14 (117 cents) and chromatic semitones in the ratio 23:22 (76 cents).[39]

As previously stated, the positions of the bridges were determined from the engraving, and the number of courses supported by each of them is very clearly prescribed by Mersenne. The position of the tangents, and hence of the distal ends of the keylevers on which they are mounted, was found starting from the top note (c^3), whose tangent must, of course, be placed reasonably close to the left-hand edge of the soundboard: the other tangents on this course were then positioned using the appropriate ratios to find their sounding lengths. The first tangent on the next course was placed a little further to the left than the last tangent on the course above, so as to allow for the width of the keylever, and the appropriate ratios were again applied; and so on down the compass. It turned out to be remarkably straightforward to find positions for all the fretted notes that fitted conveniently into the area defined for them by the engraving. The tangents of the remaining notes — the unfretted notes — were fitted in the remaining space, allowing a reasonable interval between them for the width of each keylever.

For the design pitch, I chose $a^1 = 392$ Hz; this, or something close to it, is likely to have been the organ pitch or *ton de chapelle* of Mersenne's time.[40] Even at this comparatively low pitch, it was clear that the sounding length of the top treble course would be too long for brass wire, and it would therefore have to be strung in iron. With each subsequent course on the same bridge, the relative scaling — that is, the sounding lengths in relation to the pitch of the note — gets a little shorter. With the first course on the next bridge down, the scale lengthens slightly, but overall there is a progressive shortening of the relative scale as you descend, and a point is reached when iron wire will no longer give a clear note and a change to brass wire must be

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See also Brauchli, *op. cit.*, pp. 190–91, and Maria Boxall, 'The Origin and Evolution of Diatonic Fretting', *Galpin Society Journal* LIV (2001), pp. 172–3. It is unlikely that any of these four clavichords has a direct connection with Mersenne, but their existence indicates that the 'E and A' fretting of the *manichordion* was not unique.

[37] *Toutes les autres marches ont vn rang particulier de chordes.*

[38] A possibility which was considered but rejected is that some courses might consist of single strings, in which case it would be possible to have more unfretted notes. It is possible to interpret Mersenne's words *... d'autant qu'il y a plusieurs rangs de deux chordes à l'vnisson* ('inasmuch as there are many courses of two strings in unison') in this way. However, from the discussion later in the same paragraph of the way the courses (*rangs*) are arranged on each of the five bridges, it seems clear that in fact *all* the courses consist of two strings. See note 46 (Appendix 1).

[39] See Peter Bavington, *Clavichord Tuning and Maintenance* (London: Keyword Press, 2007), pp. 190–91.

[40] See Bruce Haynes, *A History of Performing Pitch: the Story of "A"* (Lanham, Maryland, and Oxford: Scarecrow Press, 2002), p. 97.

made.[41] In the reconstruction this transition is made midway along the third bridge, between notes a and b♭. Further down there is another transition, from plain brass to twined strings for the lowest four notes of the compass; these consist of a long wire folded in half, with the two half-lengths tightly twined together (I prefer to say twined rather than twisted, since in my view it is best not to twist the wire itself).[42] This is, incidentally, the earliest evidence for the use of such strings on clavichords.

The tangents themselves, extending some 45 mm above the keylevers, are unusually long by later standards. Mersenne describes their material as *airain*, which I have interpreted as brass.[43] The tangent that is depicted in the engraving is clearly flattened at the top with a hammer: the reason for this became clear with the making of the reconstruction. To be sufficiently stiff, such long tangents need to be cut from rather thick brass sheet, but it is desirable to have a narrower surface in contact with the string, and this is produced by forging the tops.

Like its putative Italian precursors, Mersenne's clavichord has a bridge at the left-hand end of the case over which all the string courses pass. It has a long oblique section and a shorter section perpendicular to the axis of the instrument for the bass strings. Mersenne states quite clearly that this bridge is furnished with bridge-pins,[44] yet since the engraving shows no side-bearing, their purpose is not immediately clear. I think the most likely explanation for their presence is that they help to prevent the string courses being pulled forward by the tangents. The height of the tangents above the keylevers means that there is a marked horizontal component in their motion, and without the control created by the bridge-pins there is a risk that the strings would be displaced, sliding about on the tops of the bridges, with a bad effect on the tone production. Accordingly I arranged the pins in front of each string, with barely perceptible side-bearing; just enough to keep the strings in contact: this seems to have worked well.

Was the left-hand bridge intended to rest on free soundboard? Bernard Brauchli considers this possibility, and suggests that the string lengths between the hitchpins and the left-hand bridge, which are not damped or listed, might have contributed some sympathetic vibration, though he is doubtful about the effectiveness of such a system.[45] As an experiment, I originally left an area of free soundboard under this bridge. I did notice a kind of 'white noise' emanating from this area when the instrument was played, but since the main effect seemed to be to amplify action noise in an undesirable way, I decided to reduce the effect by gluing a substantial block underneath.

Mersenne shows the clavichord without any frontboard behind the keys, but I came to the conclusion that there almost certainly was one, and it had simply been removed for clarity from Mersenne's illustration, as apparently was done for the depiction of the *épinette* or virginal a few pages earlier in the volume. Accordingly I

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[41] The iron wire fitted to the reconstructed instrument was manufactured by Voss Industries Inc. and supplied by the Instrument Workshop of Ashland, Oregon, USA; the brass wire was manufactured by Malcolm Rose of Lewes, UK. Gauges were chosen entirely by trial and error.

[42] Mersenne describes these strings as *redoublées & retorces* ('doubled and twisted together'); confusingly, he puts them not on the bass bridge but on the next higher bridge. Maria Boxall resolves this anomaly, convincingly in my view, by suggesting that some words have been displaced in Mersenne's text (*op. cit.*, pp. 195–6): see note 47 (Appendix 1).

[43] Brauchli (*op. cit.*, p. 123) translates the word as 'bronze'. Boxall (*op. cit.*, p. 194), translating the corresponding passage in the Latin version, has the word 'annealed' for the Latin *aeneas*, which, I suggest, is also equivalent to 'brass'.

[44] *couuert de pointes de fer*.

[45] Brauchli, *op. cit.*, p. 123.

made a cut-down frontboard for the instrument, based on those found in seventeenth-century French harpsichords like the La Brèche.

With the listing in place, of red cloth as prescribed by Mersenne, the reconstructed *manichordion* can now be played [Fig. 7]. The sound is generally clear and rather strong, contrary to Mersenne's statement that it is 'so small and soft that it can hardly be perceived even by the player himself'. There is some variation in quality between the notes on the various bridges. Many details of the design could be interpreted differently, and it is too much to hope that it is accurate in every detail; but there is a reasonable chance that the reconstruction resembles the instrument Mersenne was observing in more ways than those in which it differs. I hope that it will be found to be sufficiently useful as a musical instrument to redeem Mersenne's reputation as a factual observer and reporter.

Fig. 7. The completed reconstruction

Appendix 1: Mersenne's description of a *manichordion* from *Harmonie Universelle:* original French text and English translation

Note: the original printed text uses the long form of the lower-case S except at the end of a word. U and V are regarded as variant forms of the same letter: V is used at the start of a word, otherwise U. The letter J is only used at the end of a word, its place normally being taken by I. These conventions have been retained in the transcription.

(i) Original French text

PROPOSITION IV
Expliquer la figure, la matière, & les parties du Manichordion

Le Manichordion a ſon clauier de quarante neuf ou cinquante touches ou marches, comme le Clauecin, quoy qu'il ſoit different en beaucoup de choſes, comme l'on void dans cette figure A B C D, dont les deux coſtes ſont A C E, & C H T B, & les deux autres, qui ſont de B à D, & de D à E ne paroiſſent pas. La table R D M ſouſtient les cinq cheualets, marquez par 1, 2, 3, 4, & 5, dont le premier eſt le plus haut, & les autres vont en ſe diminuant. Les 70. chordes ſont entortillées aux 79. cheuilles R S, & toutes les chordes paſſent & ſont appuyées ſur les cheualets. Les ſept petites mortaiſes M K ſeruent pour faire ſortir les ſons, & les chordes vont aboutir à P Q O.

Mais il faut remarquer ce qui eſt de plus particulier en cet inſtrument, à ſçauoir les morceaux d'eſcarlatte ou d'autre drap, qui couurent toutes les chordes dans l'eſpace compris entre O N P M, & qui eſtouffent tellement leur son, qu'il ne ſe peut entendre de loin, & qu'il eſt fort doux: c'eſt pourquoy il eſt fort propre pour ceux qui deſirent d'apprendre a ioüer de l'Epinette ſans que les voiſins le puiſſent apperceuoir; de là vient que l'on peut la nommer *Epinette ſourde*, ou *muette*.

Or encore qu'il y ayt 70. chordes, neantmoins chaque marche ou ſautereau n'a pas la ſienne particuliere, d'autant qu'il y a pluſieurs rangs de deux chordes à l'vniſſon, & que le 37. & 38. n'ont qu'vn meſme rang de chordes: ce qui arriue ſemblablement à la 39. 40. 42. 43. 44. 45. 47. 48. & 49. Toutes les autres marches ont vn rang particulier de chordes. Quant aux cheualets, le premier porte ſix rangs de chordes, c'eſt à dire 12. Le ſecond en a 9. rangs, ou 18, dont les 8. premieres ſont redoublées & retorces, de ſorte qu'il y a 20. chordes en double. Le 3. cheualet ſouſtient 8. rangs de chordes, c'eſt à dire 16. Le 4. contient trois rangs, ou 6. chordes, & le cinquieſme en a 9. rangs: or l'on peut faire vn ſeul cheualet au lieu de ces cinq.

Il faut encore remarquer que la perſpectiue cache les cinq premieres marches, car le clauier eſt eſgal à celuy du Clauecin. Mais les marches qui ſont attachees auec les pointes de fer I L, n'ont pas des ſautereaux comme luy, mais ils ont des crampons comme celuy d'airain Y V, qui touchent & hauſſent les chordes. L'on void les 49. crampons dans la ligne M N. X monſtre la pointe de la marche Z, que l'on met dans le diapaſon, qui paroiſt vn peu par delà les crampons, R L monſtrent les pointes qui attachent les marches à vne barre de deſſouz: & les lignes tortuës qui vont depuis ces pointes iuſques aux crampons, ſignifient les branches des marches. A B I & H peuuent ſeruir de coffrets pour mettre des chordes, des cheuilles, vn marteau & pluſieurs autres choſes.

Quant aux chordes, leur ſon eſt determiné par la partie qui eſt depuis les crampons iuſques aux cheualets, car la partie qui reſte entre les crampons, & l'eſcarlate ne ſonne point: de là vient qu'vne meſme chorde peut ſeruir à pluſieurs crampons, dont chacun fait vn ſon different ſelon la diſtance du point où il touche la chorde, iuſques au cheualet de ladite chorde.

Il n'eſt pas neceſſaire d'expliquer l'eſtenduë de cet inſtrument qui eſt en bas, par ce qu'elle ne differe qu'en diſpoſition de clefs d'auec celle du Clauecin, c'eſt pourquoy ie viens à ſon eſtenduë d'enhaut, laquelle i'ay miſe tout au long ſans laiſſer aucune note: c'eſt à dire que i'ay remply les quatre Octaues d'enbas, en mettant onze notes entre les deux notes de chaque

Octaue. Les 29. nombres, dont chacun eſt vis à vis de chaque note, monſtrent l'ordre deſdites notes, qui toutes ſont eſloignées l'vne de l'autre d'vn demy ton: de ſorte que ie ne penſe pas qu'il y ayt autre choſe neceſſaire pour entendre tout ce qui appartient à cet inſtrument.

Il faut encore remarquer le petit cheualet droit O P, lequel eſt couuert de pointes de fer, qui determinent la longueur harmonique des chordes, qui paſſent iuſques à Q O, où leurs boucles ſont attachées a d'autres pointes de fer. Quant aux morceaux de drap qui ſont ſignifiez par tous les points compris entre P O N, on les entortille autour des chordes, afin de les aſſourdir, et d'empeſcher qu'elles ne ſonnent depuis le drap iuſques aux crampons marquez dans la ligne N M, dont chacun eſt de leton ſemblable au crampon Y V. L'on a couſtume de leuer le petit couuercle D S pour mettre des chordes dans ſon petit coffre: mais ces menuës pratiques dependent de la volonté du Facteur.

Ie viens au couuercle E G F D, ſur lequel l'on void vne Octaue grauee, laquelle eſt remplie de tous les degrez Diatoniques, Chromatiques, & Enharmoniques que l'on peut s'imaginer … [the text continues with a detailed explanation of the musical notation shown in the engraving on the lid of the clavichord; there are no further details of the instrument itself].

(ii) English translation

PROPOSITION IV
To explain the appearance, material and parts of the clavichord

The clavichord has a keyboard with 49 or 50 finger-keys [*touches*] or activators [*marches*] like the harpsichord, though it differs in many things, as can be seen from the figure A B C D, of which two sides are A C E [H] and C H T B, and the other two, running from B to D and from D to E, cannot be seen. The soundboard R D M supports the five bridges, indicated by 1, 2, 3, 4 and 5, of which the first is the highest and the others get progressively lower. The 70 strings are wound on to 79 [sic] tuning pins R S, and all the strings pass over and rest upon the bridges. The seven little openings M K serve to let out the sounds, and the strings extend to P Q O.

But one must observe something that is most peculiar to this instrument, namely the pieces of scarlet or other cloth which cover all the strings in the space defined by O P N M, and which damp their sound so that it cannot be heard from a distance and is very soft: that is why it is very suitable for those who wish to learn to play the virginal [*epinette*] without the neighbours hearing. From this it comes to be known as the 'dumb virginal' or *muette*.

Although there are actually 70 strings, nonetheless each key or jack [sic: *sautereau*] does not have its own string, inasmuch as there are many courses of two strings in unison[46]; thus Nos. 37 and 38 have but a single course of strings, and similarly Nos. 39, 40, 42, 43, 44, 45, 47, 48 and 49. All the other keys have their own course of strings. As for the bridges, the first carries six courses of strings, that is 12 [strings]. The second has 9 courses or 18, of which the first 8 are doubled and twisted together, so that there are 20 paired strings.[47] The third bridge supports 8 courses, that

[46] This seems to leave open the possibility that some courses might have single strings; but the account of how the strings are arranged on the five bridges makes it clear that *all* courses consist of two strings.

[47] Maria Boxall (*op. cit.*, pp. 195–6) resolves the anomaly in this account by proposing that the words *dont les 8. premieres sont redoublées & retorces, de sorte qu'il y a 20 chordes en double* ('of which the first 8 are doubled and twisted together, so that there are 20 paired strings') have been transposed in the text, and belong after *c'est à dire 12*, so that they refer to the six courses on the first bridge: 'If the very lowest eight strings on the instrument … are understood to be doubled and twisted, this adds eight strings to the twelve already on that bridge, which arrives at Mersenne's total of twenty'.

is 16 [strings]. The fourth contains three courses or 6 strings, and the fifth has 9 courses: but one can make a single bridge instead of these five.

It is also necessary to observe that the view hides the first five keys, for the keyboard is the same as on the harpsichord. But the keylevers (which are fitted with iron pins) I L do not have jacks like that instrument but tangents [*crampons*] like the brass one Y V, which touch and raise the strings. 49 tangents can be seen in the line M N. X shows the pin of the lever Z which goes into the rack, which appears a little beyond the tangents. R L indicates the pins which connect the keylevers to a rail below: and the wavy lines which run from these points to the tangents indicate the course of the keylevers. A B I and H can serve as boxes to contain strings, tuning pins, a [tuning] hammer and many other things.

As for the strings, their sound is determined by the part which is between the tangents and the bridges, since the part that lies between the tangents and the scarlet [cloth] produces no sound: that is how a single string can serve several tangents, each of which produces a different sound according to the distance from the point where it touches the string to the bridge of the said string.

There is no need to explain the compass of this instrument, which is shown below,[48] since it does not differ in the disposition of the clefs from those of the harpsichord; accordingly I come to the compass above, which I have set out at length without omitting any note: that is to say, I have filled out the four octaves from [the notation] below, putting eleven notes between the two notes of each octave. The 29 [sic: *recte* 49] numbers by each note show the order of the said notes, which are all one semitone apart: so that I do not think that there is anything else necessary for understanding everything relating to this instrument.

One should also note the small straight bridge O P, provided with iron pins on top, which determines the harmonic length [sic] of the strings, which pass to Q O, where their loops are attached to other iron pins. As for the pieces of cloth which are represented by all the marks enclosed within P O N, they are wound around the strings to damp them and prevent them sounding from the cloth up to the tangents shown in the line N M, each of which is of brass similar to the tangent Y V. It is usual to raise the little cover D S to put strings in its little box: but these practical details depend on the wish of the maker.

I come to the lid E G F D, upon which one sees an octave engraved, which is completed with all the diatonic, chromatic and enharmonic degrees one can imagine … [the text continues with a detailed explanation of the musical notation shown in the engraving on the lid of the clavichord; there are no further details of the instrument itself].

[48] This refers to the musical notation at the bottom of the page, showing the five Cs of the compass on a six-line stave.

Appendix 2: The description of the clavichord in *Harmonicorum Libri XII*: Latin text and English translation

See the note on orthography at the start of Appendix 1.

(i) Original Latin text:

PROPOSITIO XLII
Manichordij Figuram, conſtructionem, partes, Harmoniam, Vſum: Diapaſon diatonicè, chromaticè, & Enharmonicè diuiſum explicare, & peculiarem Italici Clauicymbali formam afferre

Hoc inſtrumentum A B C D perinde conſtat arcâ 5 aſſeribus, nempe fundo, & 4 lateribus, compaginatâ: habet eiiam 50 pinnulas, quarum manubria deteguntur.

Tabula R D M 5 [*recte* S] ſuſtinet equuleos his numeris l, 2, 3, 4 & 5 deſignatos, quorum primus eſt altior, reliquíque progreſſu fiunt humiliores. Porrò 70 chordis inſtruitur, quæ 70 clauis R S implicantur, quæque prædictis equuleis ſuſtinentur, vt ab iis ſolùm illarum ſumatur Harmonica longitudo vſque ad laminas æneas in linea M N conſpicuas, quæ *crampons* à Gallis appellantur: Laminam verò Y V ſeorſim delineatam habes, vr [*recte* vt] ex ea de reliquarum figuris fiat iudicium. X notat cuſpidem, cuius ope pinna Z Diapaſon ingreditur, cuius inciſura regitur, vt de pinnis Clauicymbali dictum eſt. R L demonſtrant foramina regulæ cuſpidum, quibus pinnæ velut in æquilibrio detinentur, vel vt ſcalmis ad motum perpendicularem vtuntur.

Quamuis autem 70 chordas numerauerimus, quarum ſex ordines, hoc eſt 12 chordæ, primo equuleo, 9 ſecundo, 8 tertio, tres quarto, nouem denique quinto ſuſtinentur, non habet tamen pinnula, lamináve quæpiam ſuam chordam, ſed vna chorda quandoque tribus aut 4 pinnulis deſtinatur, quandoquidem plurimi chordarum ordines ſunt Vniſoni: ſed iſtæ laminæ eadem vtentes chordâ, quam ſucceſſiuè, non autem ſimul percutiunt, variant tonos eâ proportione quâ hæ magis ab equuleo, quàm iſtæ diſtant, neque enim partes fidium inter laminas & pannum P O N interiectæ ſonum edunt, ſed eæ ſolùm quæ inter laminas, & equuleos intercipiuntur.

Supereſt equuleus O P aculeis onuſtus, quibus fidium longitudines diriguntur, híncque abeunt, ad vltimas cuſpides Q O, quibus illarum fibulæ induntur. Panni limbi P O N chordis ſingulis implicantur vt obſurdeſcant, & illarum ſoni ferè penitus intereant, & extinguantur. Quod ad operculum E G F D attinet, oſtendit Diapaſon in ſingulos trium generum gradus diſtinctum …

Integrum verò Monochordi ſyſtema 5 notis ad calcem figuræ ſculptis ita complectimur, vt quælibet nota ſuâ claue propriâ gaudeat: cuius ope nota prima diſtat à ſecunda integro Diapaſon, quemadmodum tertia à ſecunda, quarta à tertia, & à quarta quinta. Adde quòd in ſuperiore parte quatuor Octauæ præcedentes ſuis omnibus notis 13, ſeu gràdibus 12 fruantur, ex quibus omnia ad Monochordum ſpectantia facilè concluduntur.

Incipit autem quælibet Octaua à littera C, hoc eſt C *ſolvtfa*, & vltima vox præcedentis eſt prima ſequentis: hinc fit vt in eo ſyſtemate reperiantur 52 notæ quòd vltima vnius Diapaſon initio ſequentis repetatur, cùm tamen iſtæ notæ 49 Manichordij ſonis exprimantur.

Illius autem vſus in eo ſitus eſt vt fidicines priùs ſe, ſuáſque vires in eo explorent quàm vt in publicum prodeant, eſt enim Manichordij ſonus adeò paruus, & debilis vix vt ab ipſo fidicine percipiatur, qui eo canere poteſt vicinis omnino neſcientibus, eo

igitur vtantur qui ſibi ſolis canere deſiderant, quíque verentur audiri Muſici, aut Harmoniæ dediti: dum Italicum Clauicytherium D A B C explicandum aggredior …

(ii) English translation. This has been kept as literal as possible, consistent with correct grammar and reasonable comprehensibility.[49]

PROPOSITION XLII
To explain the Clavichord's shape, construction, parts, harmony, and the octave divided diatonically, chromatically and enharmonically; and to introduce an unusual type of Italian harpsichord

This instrument A B C D similarly[50] consists of a box made of five boards, namely a bottom and 4 sides: it has 50 keylevers [*pinnulae*] of which the handles [i.e. the keys] can be seen.

The soundboard R D M 5 [*recte* S] supports 5 bridges [*lit.* little horses] designated by the numbers 1, 2, 3, 4 and 5, of which the first is the highest, and the rest become progressively lower. Furthermore it is fitted with 70 strings, which are wound onto the 70 tuning pins R S, and which are supported on the aforesaid bridges, so that it is from these alone that their harmonic length is calculated, up to the brass blades visible along the line M N, which are called *crampons* by the French: but you have a tangent Y V illustrated separately, so that from it a judgement can be made about the shapes of the others. X indicates the pin, by means of which the key Z is entered into the rack, being guided by the slot there, as has been explained in connection with the keylevers of the harpsichord. R L shows the openings of the balance pins, by means of which the keylevers are held in equilibrium, as it were, just as poles are used to ensure perpendicular motion.

Although we have enumerated 70 strings, of which six courses [*ordines*], that is 12 strings, are supported on the first bridge, 9 on the second, 8 on the third, three on the fourth and lastly nine on the fifth, nevertheless each key or tangent does not always have its own string, but sometimes one string is the destination of three or 4 keylevers, seeing that there are many courses in unison:[51] but these tangents using the same string, although in sequence, do not however strike at the same time; the sounds vary in proportion as they are distant from the bridge; for the sections of the strings that lie between the tangents and the cloth P O N do not give forth sound, but only those between the tangents and the bridges.

There remains the bridge O P fitted with pins, by which the lengths of the strings are regulated; from this they run to their final points Q O, where their loops are hitched. The strips [*lit.* fringes] of cloth P O N are woven around individual strings to damp them, and their sounds almost die completely and are extinguished. As for the lid E G F D, an octave is shown in single notes with the distinct steps of the three genera … [here follows an accoount of the diatonic, chromatic and enharmonic scales as displayed on the inside of the clavichord lid].

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[49] I am most grateful to Professor Charles Burnett of the Warburg Institute, London, for help with this translation of Mersenne's Latin text.

[50] i.e. similarly to the case of the virginal, described in the preceding section.

[51] Mersenne's point is that each course consists of two strings in unison, so that even though there are 70 strings in all, there would not be enough courses for each note to have one to itself.

The complete compass of the clavichord, however, is shown in the 5 notes engraved at the bottom of the figure in such a way that each note enjoys its own clef: the first note in this system is a whole octave distant from the second, likewise the third from the second, the fourth from the third and the fifth from the fourth. Also in the upper part [of the figure] each of the four octaves enjoys its 13 notes or 12 steps, from which everything about the clavichord can readily be understood.

Each octave, then, begins with the note C, that is C *sol-ut-fa*, and the last note of the preceding one is the first note of the following one. Thus it is that in this system 52 notes are found, since the last note of one octave is repeated at the start of the next: although, however, these notes are expressed by the 49 sounds of the clavichord.

Its usefulness lies in this: that players can test themselves and their abilities on it before they come forth in public; for the sound of the clavichord is so small and soft that it can hardly be perceived even by the player himself, who can play on it without the neighbours knowing at all. It is therefore used by those who wish to play by themselves, and those musicians who dislike being overheard, or those who are dedicated to harmony [?composers]. Now I proceed to the explanation of an Italian clavicytherium …

Appendix 3: Surviving and documented Italian clavichords with multiple bridges arranged at right angles to the axis of the case

Note: there are scattered references to these instruments in many published articles; it would be impractical to list all of these. A selection of the most important references is given here.

Hexagonal in shape

1. Dominicus Pisaurensis 1543, Leipzig Grassimuseum, No. 1

See Hubert Henkel, *Clavichorde:* Musikinstrumenten-Museum der Karl-Marx-Universität Leipzig, Katalog, Band 4 (Leipzig: VEB Deutscher Verlag für Musik, 1981), pp. 21–3 and plates 1, 44, 46 and 59; Donald H. Boalch, Makers of the Harpsichord and Clavichord 1440–1840, third edition ed. Charles Mould (Oxford: Clarendon Press, 1995), p. 293; Grant O'Brien, 'The Case, Stringing and Fretting Design of the 1543 Venetian Clavichord by Dominicus Pisaurensis', *Magnano Proceedings V* (Musica Antica a Magnano, 2002), pp. 91–107.

2. Anonymous, attributed to Giovanni Celestini, Brussels Museum of Musical Instruments, No. 1620

See Victor Mahillon, *Catalogue Descriptif et Analytique du Musée Instrumental du Conservatoire Royal de Musique de Bruxelles*, Ghent, 1880–1922, Vol. 3, pp. 188–9; the attribution to Celestini is made by Denzil Wraight in his doctoral thesis *The Stringing of Italian Keyboard Instruments c. 1500–c. 1650* (submitted to Queen's University of Belfast 1997): see *Part Two: Catalogue of Instruments*, p. 105.

3. Anonymous, bearing a signature of Dominicus Pisaurensis, Paris Musée de la Musique, No. E.1608

The instrument at present has a single curved bridge, but that is a later modification. See Boalch, *op. cit.*, p. 295; Denzil Wraight, 'The Identification and Authentication of Italian String Keyboard Instruments' in Howard Schott (ed.), *The Historical Harpsichord,* Vol. 3 (Stuyvesant NY: Pendragon Press, 1992), pp. 78–9; and Wraight, doctoral thesis (*op. cit.*), pp. 146–7. Some information and photos are available on the internet at http://mediatheque.cite-musique.fr/masc/default.asp?INSTANCE=CITEMUSIQUE (accessed 14 November 2011).

4. Clavichord 'Italienischer Mensur' illustrated in Michael Praetorius' *Syntagma Musicum*

Michael Praetorius, *Syntagma Musicum II: De Organographia*, Wolfenbüttel, 1619, p. 61; *Theatrum Instrumentorum* (illustrations to *De Organographia*), Wolfenbüttel, 1620, Plate XV. (Facsimile, ed. W. Gurlitt, Kassel: Bärenreiter, 1980; English translation by David Z. Crookes, Oxford: Clarendon Press, 1986.) The relevant plate is reproduced in Frank Hubbard, *Three Centuries of Harpsichord Making*, Cambridge MA and London: Harvard University Press, 1965, Plate XXVI. See also Maria Boxall, 'The Origins and Evolution of Diatonic Fretting in Clavichords', *Galpin Society Journal* LIV (2001), Appendix I, 'The Clavichords of Michael Praetorius's *Sciagraphia*', pp. 186–92.

Rectangular

5. Anonymous, bearing a signature of Onesto Tosi, Boston Museum of Fine Arts No. 17.1796

See John Koster, *Keyboard Musical Instruments in the Museum of Fine Arts, Boston* (Boston: Museum of Fine Arts, 1994), pp. 22–6 and Colour Plate 3; Boalch, *op. cit.*, pp. 659–60.

6. Anonymous, probably made in Naples, Leipzig Grassimuseum, No. 2

See Henkel, *op. cit.*, pp. 23–6 and plates 2, 45, 46, 56 and 59; Boalch, *op. cit.*, p. 513 (where it is listed under Hans Müller); Thomas Friedemann Steiner, 'Clavichords No. 2 and 3 in the Leipzig Collection: some complementary thoughts about their origins', *Magnano Proceedings* (Musica Antica a Magnano, 1993), pp. 41–7; Denzil Wraight, 'The Identification and Authentication …', pp. 137–43.

7. Anonymous, Leipzig Grassimuseum, No. 3

See Henkel, *op. cit.*, pp. 26–8 and plates 3 and 56; Boalch, *op. cit.*, p. 513; Steiner, *op. cit.*, and Wraight, 'The Identification and Authentication … ', pp. 137–43.

8. Anonymous, Bologna, Tagliavini Collection, No. A.1

See Luigi Ferdinando Tagliavini, 'An Anonymous Sixteenth-Century Italian Clavichord in the L. F. Tagliavini Collection, Bologna', *Magnano Proceedings* (Musica Antica a Magnano, 1993), pp. 29–40; J. H. van der Meer and L. F. Tagliavini, *Collezione Tagliavini: Catalogo degli strumenti musicali* (Bologna: Bononia University Press, 2009), Vol. I; also Vol. III (concise English catalogue compiled by Michael Latcham), pp. 18–19.

9. Anonymous, formerly in the Benton-Fletcher Collection, London

This instrument was almost certainly destroyed in an air raid in May 1941. It was described and illustrated shortly before its loss in G. H. Benton Fletcher, 'A London Museum of Early Keyboard Musical Instruments', *The Sphere*, 12 March 1938, and shortly afterwards in 'Some Early Keyboard Instruments — I' (author not stated), *Apollo*, July–December 1943. See Peter Bavington, 'The Missing Benton Fletcher Clavichord', *British Clavichord Society Newsletter 33* (October 2005), pp. 6–8.