

ABSTRACT

The "librum Baudeceti" (book of Baudecetus) in Arnaut de Zwolle's c.1440 manuscript, from which instructions for a clavichord are taken, is probably refers to Baude Cordier or Baude Fresnel de Rains, a harp player employed at the Burgundian court until his death (in 1397/8). The instructions for Baude's clavichord division are not the basis of Arnaut's better-known clavichord design (B-b², 37 notes). An order of work is established, which is different from the present binding of the manuscript, with Arnaut's clavichord preceding the *clavisimbalum* and Baude's design. Baude describes a well-ordered division of a monochord starting at c, comprising 35 notes. This could be interpreted as a c-f² compass (only 30 notes), but understanding the 35 notes to refer to the entire Guidonian range in use (F,G,A-f²). Evidence from the c.1390 Norrlanda organ, from treatises (c.1430), Arnolt Schlick (1511), and Praetorius (1619) show that B_b was played from a "white" key, which explains the compass of a pedal clavichord (c.1464). This information allows us to interpret Baude's compass as c-b_b², with b_b² as a "white" note for Baude's clavichord, exactly 35 notes. Although a firm conclusion for the compass is not possible, this study collates information on the use and conception of the keyboard from 1390 to 1511.

Arnaut de Zwolle's instructions for making a clavichord (c.1440) are usually held to be the first practical description, at least of those which have survived to our time. In his manuscript Arnaut also reports on a design from a "librum Baudeceti" (book of Baudecetus), which must have pre-dated his own instrument. It is therefore interesting to examine these instructions more closely in order to see what can be gleaned about the development of clavichords before Arnaut's time.

Lindley, drawing on biographical information from Wright, appears to have been the first to suggest that "librum Baudeceti" might refer to Baude Cordier, or Baude Fresnel de Rains [Rheims], the "ceti" implying "of the cetra".¹ Baude was employed as a harper at the Burgundian Court between 1384 and his death in 1397 (or 1398).² Meeüs inferred that because Arnaut was later in the Burgundian Court's employment, and could have seen any writings by Baudecetus there, the identification of "librum Baudeceti" with Baude Cordier was less fanciful than Lindley had dared to conclude.³ If the attribution to Baude de Rains is correct, then the instructions in Baude's "book" can be dated as before 1397 and provide one of the earliest records of the clavichord and its tuning. In any event, we can infer that the instructions precede Arnaut.

¹ Lindley, pp. 43-44, note 8, citing Wright, pp. 124 and 136.

² Wright summarises his findings on p. 166. He gives the alternative forms of Baudet or Baudenet, with a surname Fresnel on p.124. I refer to "Baudecetus" as a nominative form of "Baudeceti" since this is all we have from Arnaut. The attribution to Baude Fresnel is probably correct, but unprovable at present. Baudecetus will, for simplicity, now be referred to as "Baude", without implying that the authorship has been decided.

³ Meeüs, 1985, see p. 16. Koster, 2008, p. 9, is more cautious, suggesting that Baude might only have been the owner of the book, not its author, although this has no effect on the arguments in this article.

The text on the "composition of a clavichord according to the book of Baudecetus" (Co[m]po[sitio] clavicordior[um] s[ecundum] lib[ru]m Baudeceti) is to be found at the bottom of fol. 128 v° in the manuscript, which includes Arnaut's well-known instructions for the design and tuning of a clavichord (see Fig. 1).⁴

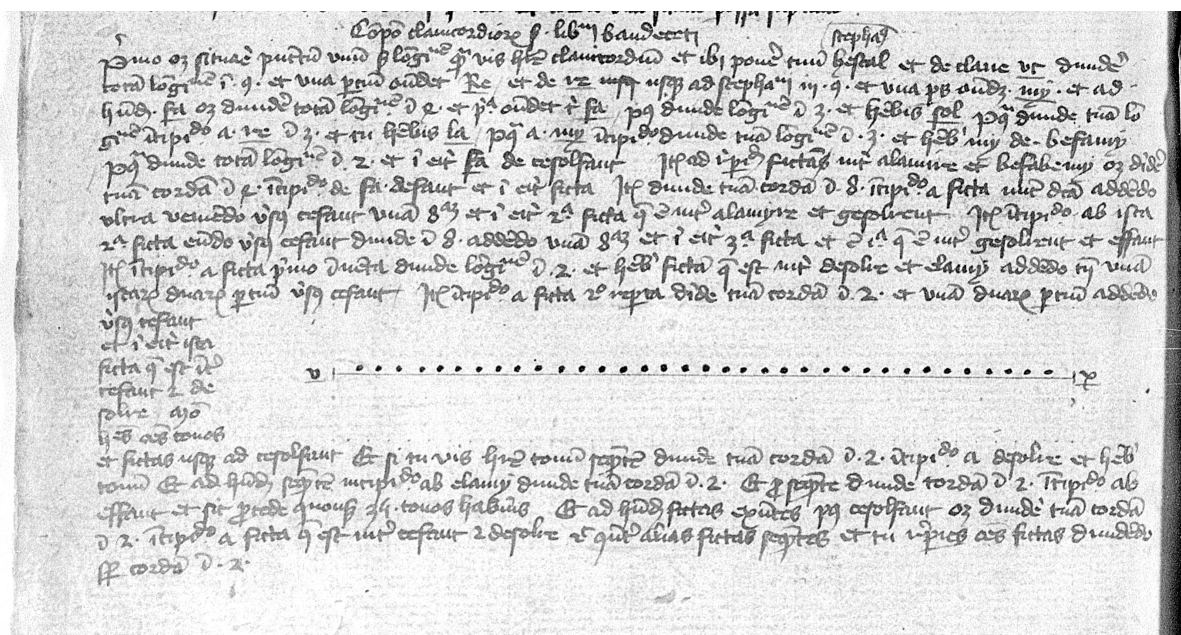


Plate 1. Part of fol. 128v° containing all of Baude's instructions
(Source: gallica.bnf.fr / BnF, enhanced jpeg)

Baude's instructions, which are limited to the description of the string division, have attracted much less study than Arnaut's design of a clavichord.⁵ Le Cerf and Labande in their facsimile edition were unable to suggest a compass for the clavichord, having interpreted the instructions that the compass was composed of 35 *natural* keys, a very large range for the 15th century. In Ripin's pioneering study Baude's instrument was only briefly discussed, but his suggestion of a B-f² compass (31 notes) does not accord with Baude's instructions for a 35-note range.⁶ Mondino analysed the stringing instructions and produced an Italian translation, but had difficulty in establishing a compass for what he also took to be a range including 35 *natural* keys, as had Le Cerf and Labande before him.⁷ In both Mondino's and Ripin's discussion the relationship of Baude's to Arnaut's design was unclear. Koster clearly distinguished Baude's work from Arnaut's, and suggested a range of c-b², but in his explanation for this 36-note compass

⁴ The manuscript Latin 7295 is online at <https://gallica.bnf.fr/ark:/12148/btv1b90725989> (May 2021), but the Le cerf and Labande facsimile edition, with a transcription of the Latin text (by Labande) and translations into French, offers the easiest access to the text for the modern reader.

⁵ Only fleeting remarks are in Ripin, p. 526 note 15. Lindley, p. 13 reported the tuning of Baude's instructions. Mondino pp. 59-62, gives the Latin text and an Italian translation. Koster, 2002, p.16, give the compass as c-b³. (Peter Bavington kindly reminded me of this publication, personal communication 13.05.2021). The most substantial contribution is by Koster, 2008, pp. 8-9, but see also Koster, 2014, p. 175. The assistance of Lothar Bemann in searching for references is gratefully acknowledged.

⁶ Ripin, p. 526, note 15.

⁷ Mondino, pp. 59-62.

he inferred that some error in counting had been made.⁸ Thus, the number of keys which the instrument should have, has provided the most difficulty for commentators.

Arnaut's drawing of a *clavisimbalum* is on fol. 128r°, and its description is on the reverse of this sheet (128v°), then follow the instructions concerning Baude's clavichord at the bottom of this page (128v°). Fol. 129, which is the following sheet in *this* binding of the manuscript, but not necessarily the next sheet Arnaut wrote, contains the drawing of the *fimbria*, clavichord, and a description how to construct the *fimbria* (fol. 129r°), the string division diagram, which is the basis for Arnaut's own clavichord design. The proximity of Baude's clavichord on fol. 128v° and Arnaut's drawing on 129r° appears to have led to a conflation, or at least an omission by Ripin, to distinguish clearly between Baude's instructions and Arnaut's design.⁹

⁸ Koster, 2002, p. 16, but Koster 2008, p. 9, note 20 provided the explanation for this compass, that "either the beginning c was not counted or there was a miscounting (perhaps because the writer multiplied three octaves times twelve notes per octave, then mistakenly subtracted one because the actual span was a semitone less than three octaves)."

⁹ Ripin, p. 526, note 15, where he suggests that Arnaut could have made "a simple numerical slip" since the 35 keys of Baude's instructions do not agree with the 37 notes of his clavichord depicted on fol. 129r°. Ripin also expresses a competing idea, "that Arnaut's layout directions did not originate with him". Mondino, pp. 62 et seq. conflates the Baudecetus and Arnaut designs.

1. The string division

Le Cerf and Labande transcribed the latin of Arnaut's text, produced a French translation, and commented on some aspects of Baude's instructions, but it seems that an English translation has never been published.¹⁰

In order to understand the instructions it is convenient to present them in a step by step form, together with the graphical counterpart developed by Adkins, which helps clarify the *method* of the division of the string.¹¹ This is presented as Fig. 2, below.

Step	Name	Note	Instruction
	UT	c	determine a length you wish for the clavichord and place your bridge there
1	RE	d	starting from the key at ut divide the total length in 9; one of the nine parts gives re
2	MI	e	from re nearest the bridge divide in 9, a ninth gives mi
3	FA	f	divide the total length in 4 and the first part [from ut] gives fa
4	SOL	g	divide the length in 3 and you have sol [at the first part from ut]
5	LA	a	divide your length, starting from re, in 3 and you will have la
6	MI	b	starting from mi, divide your length in 3, and [at the first part from ut] you have the mi of b-fa-mi
7	FA	c ¹	divide the whole length in 2 and there will be the fa of c-sol-fa-ut
8	Si ^b	b ^b	to find the accidental [fictam] between a-la-mi-re and b-fa-b-mi, divide your string in 4 starting at fa of f-fa-ut and there will be your accidental [si ^b]
9	La ^b	a ^b	divide your string in 8 starting from the accidental of which we have just spoken and adding an eighth towards c-fa-ut [i.e towards the starting point, ut]: there will be the second accidental [la ^b] which is between a-la-mi-re and g-sol-re-ut
10	Sol ^b	g ^b	starting from this second accidental [i.e. la ^b] and going towards c-fa-ut, divide in 8 and adding an eighth and there will be the third accidental [sol ^b], and it is the one which is between g-sol-re-ut and f-fa-ut.
11	Mi ^b	e ^b	starting from the first of the accidentals [ficta primo = si ^b], divide the length in 2 adding one of the 2 parts towards c-fa-ut, and you will have the accidental [mi ^b] which is between d-sol-re and e-la-mi
12	Re ^b	d ^b	starting from the second of the of the accidentals determined [la ^b], divide your string in two, and adding one of the two parts towards c-fa-ut, you will have the accidental [re ^b] which is between c-fa-ut and d-sol-re
			Thus, you have all the notes and all of the accidentals as far as c-sol-fa-ut [c ¹].
13		d ¹	in order to have the following note, divide your string in two starting from d-sol-re, and you will have this note
14		e ¹	in order to have the following, divide the string in 2 starting from e-la-mi
15		f ¹	in order to have the following divide your string in 2 starting from f-fa-ut and continue thus until you will have 35 notes [35 tonos]
16		d ^{b,1}	in order to have the accidentals [fictas] situated above c-sol-fa-ut, you divide your string in two starting from the accidental [re ^b] which is between c-fa-ut and d-sol-re, and thus again for the other accidentals, and you find all the accidentals in dividing the strings always in 2

Fig. 1 Baudecetus' instructions for the string division

¹⁰ Le Cerf and Labande, pp. 11-12.

¹¹ Adkins, pp. 29-33.

Regarding the tuning: Baude's division results in a Pythagorean tuning with a "wolf" fifth between F \sharp and B (written as F \sharp x B), the same division as Arnaut uses for his *fimbria*, but he achieves the result by a different method since a monochord division is not obliged to follow a circle of fifths. Le Cerf appears to be the first to have recognised this Pythagorean tuning in Baude's instructions, and then Lindley gave the F \sharp x B designation.¹²

As regards the compass intended, the description is somewhat vague, The 35 notes, mentioned in step 15, are undoubtedly not intended to mean 35 *natural* keys, although it could be thought to be implied by the instructions for finding the *diatonic* notes.¹³ This ambiguity led Le Cerf and Labande to opine that the author had either made a mistake in the number of notes or was considering only a theoretical instrument.¹⁴ Mondino thought that the 35 diatonic notes might refer to another instrument, perhaps an organ.¹⁵

The key to understanding the bass note of Baude's compass comes from step 7: "divide the whole length in two and there will be the fa of c-sol-fa-ut". The instruction to divide the whole length [first tangent to bridge] into two, in order that the division produces the octave, is perfectly clear. Baude calls the first key "ut", but arrives at a "fa", in the octave c-sol-fa-ut. "fa" can only be an octave higher than "ut" in the system of the Guidonian hand. Thus, Baude applies two different designation systems: his division works its way through the *octave*, but the note names are designated according to the Guidonian hand, or hexachord system (as it was later called). See Figs. 4 and 5.

Although f is called f-fa-ut at its two occurrences in the Guidonian system (reading across the table in Fig. 5), c has three designations: C-fa-ut, C-sol-fa-ut, and C-sol. Thus, c-sol-fa-ut can be identified with c', and it follows that the starting note "ut" must be C-fa-ut, or c in our modern notation.

2. Clues from the manuscript

Unless the original manuscript of "librum Baudeceti" appears we will never have any other indications than those Arnaut has given us. However, there are two small clues that Arnaut was actually transcribing a text and not writing it himself.

One of these was noticed by Koster: Arnaut had written "stephanus" [referring to a "bridge"] above the word "hestal" from Baude's text, as if Arnaut needed to explain an unfamiliar term, to himself, or to others.¹⁶

The second clue is that when it comes to describing the accidental notes the text refers to "*ficta*". Even the b \flat is described as "*fictam*", which from theory is incorrect: the b \flat is not *musica ficta* but *musica vera*. Berger noticed this use of *ficta* in the manuscript and observed that "someone concerned with a keyboard instrument

¹² Le Cerf, 1931. Lindley, p. 13.

¹³ 35 naturals implies a compass such as GG-f \sharp , highly unlikely in a clavichord of the 14th century, and technically impossible in such a fretted instrument.

¹⁴ Le Cerf and Labande, p. 12, note 1..

¹⁵ Mondino, p. 60.

¹⁶ Koster, 2008, p. 11. There is an illuminating discussion of the word for "bridge" in different languages, as used in old manuscripts on clavichords.

would have to slip, sooner or later, into thinking of *b* [German *b*, i.e. *b_b*] as a feigned step by analogy with the other black-key steps."¹⁷ In what are presumably his own instructions (129r^o) for finding the notes on his *fimbria*, and thereby the tangent positions in the clavichord, Arnaut does not refer to *ficta*, but instead to a *semitonium*. It would seem that the instructions in 128v^o are those of Baude and not paraphrased by Arnaut.

Another circumstantial detail which could point in the direction of different authors is that Arnaut's *fimbria* design uses a different constructional method: Baude works his way up through the diatonic notes from *c* in the division, then back down through the monochord for the semitones; Fig. 2 in Adkins' style of presentation makes this clear. Arnaut describes a circle of fifths starting from *B* (*H* in Arnaut's notation).

Ripin observed that Arnaut's small drawing of tangent fretting on 129v^o yielded 34 notes, whereas his clavichord required 37, from which he concluded that Arnaut might have taken this fretting scheme from another author, possibly Baude.¹⁸

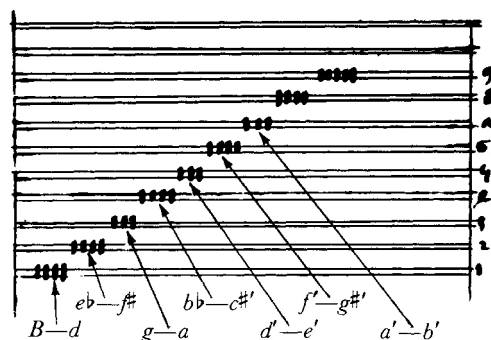


Fig. 2. Arnaut of Zwolle's Tangent Diagram (From Bibliothèque Nationale MS lat. 7295, fol. 129v.)

Source: Ripin, p. 525

It is impossible to determine whether Arnaut had made a mistake with the number of tangents, but Koster took this analysis a stage further when he re-assigned the tangent grouping, and inferred from the unusual fretting on the first string that the first tangent in the bass (*B*) had probably been added. Thus, the original range might have been *c-f²*, which was then modified to *B-f²* (31 notes).¹⁹ Koster's arguments give us the possibility of linking the fretting scheme Arnaut shows with Baude's string division, which would point to a 30-note compass for Baude's clavichord of *c-f²*. This is a tantalisingly plausible possibility, but it does not explain the 35 notes for which the division calls.

¹⁷ Berger, p. 419, who attributes the statement to Arnaut (c. 1440), whereas this study identifies the statement as earlier. I am grateful to Christopher Stenbridge for supplying a copy of Berger's article.

¹⁸ Ripin, pp. 524-526 and note 15.

¹⁹ Koster, 2008, p. 9 and Fig. 5c. *B-f²* was a possible range suggested by Ripin in note 15, but made merely on the basis that *B-f²* was a range we could expect in this period.

3. The place of Baude's instructions in Arnaut's manuscript

Before considering the various possible 35-note compasses which start on c, we should examine the context in which this tuning description is given.

Baude's instructions, or to be exact, what Arnaut gives us from them, are written around a row of 35 dots to be seen near the bottom of fol. 128v°, as can be seen in Plate 2 more clearly, in an enhanced version of the page. As Koster observed, this line of dots is from the balance pins of the *clavisimbalum* on the other side of the sheet (128r°).²⁰

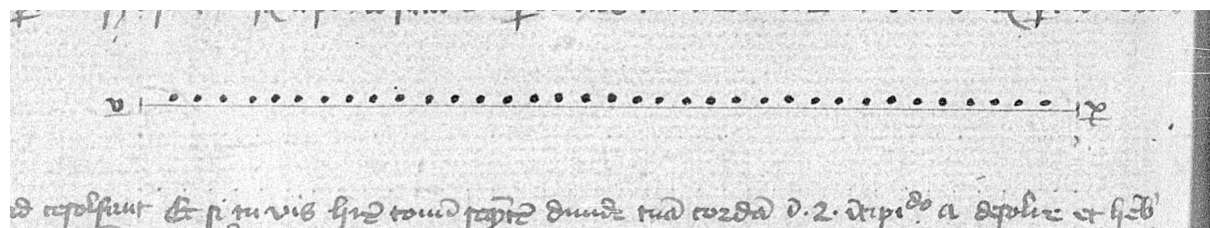


Plate 2. 35 dots along a line designated "v" and "x" fol. 128v°
(Source gallica.bnf.fr / BnF, enhanced jpeg)

There are also short vertical lines beside v and x which terminate the faint line below the dots. Koster had described elsewhere Arnaut's draughtmanship and mentioned marks, some of which he described as scribed lines and not visible in the facsimiles.²¹ Below v and x yet another small dot is to be seen, which is the mark of a divider point that has penetrated the paper from the other side, from the *clavisimbalum* drawing, where we also find a v and x, just above the front line of the case (C B in Plate 3).

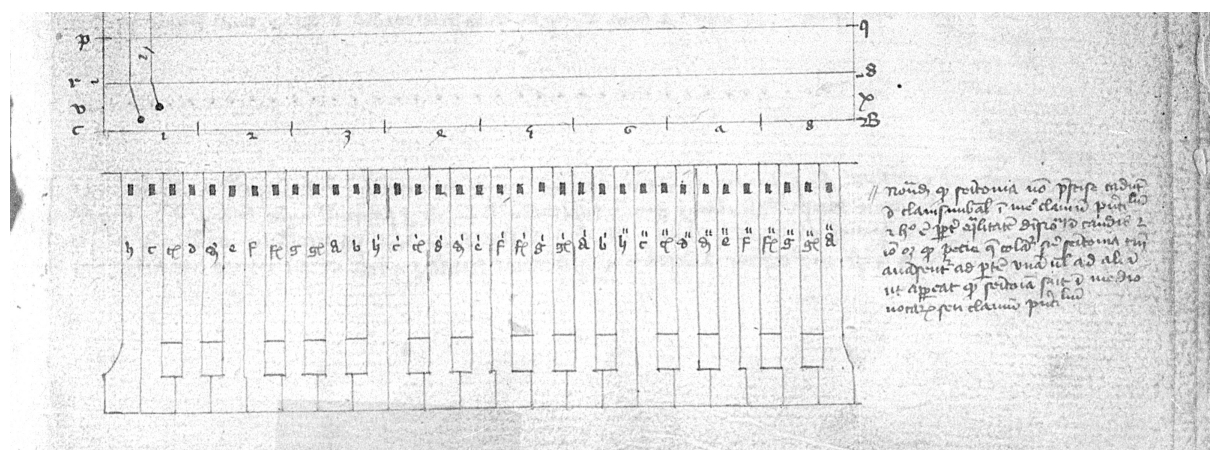


Plate 3. Part of the *clavisimbalum* drawing from fol. 128r° with v and x
(Source gallica.bnf.fr / BnF, enhanced jpeg)

If further magnification is used (Plate 4, below) then the point at v which penetrates the paper can be seen and also the point at C (the left hand corner of the instrument) which is visible below x on the *reverse* of the paper (128v°), i.e. below x in Plate 2 (above).²²

²⁰ Koster, 2008, pp. 8-9 and 2014, p. 175.

²¹ Koster, 2003, p. 13, note 6.

²² Such magnification is currently possible at the BnF website by selection of parts of the page. A software enhancement was performed later.

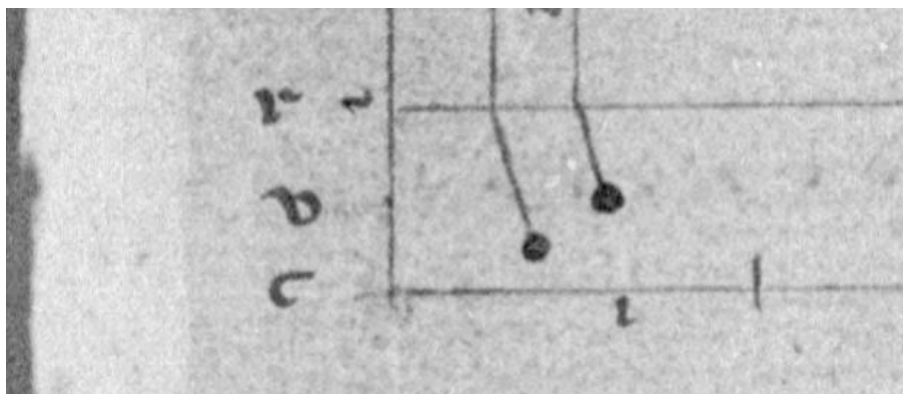


Plate 4. Magnification of v and C on fol. 128r°
(Source gallica.bnf.fr / BnF, enhanced jpeg)

We can also see in Plate 4 that the ink dots on 128v° have bled through slightly and many are visible on 128r°. It is thus clear that the v-x line of 128v° was produced by pricking through from the other side, from 128r°, and not in the reverse order. The ink dots themselves were made on 128v°, that is, on the side including Baude's instructions.²³

The purpose of this line v-x on 128r° is indicated in the *clavisimbalum* text (128v°), where it is described as the line of balance pins for the keyboard. Thus, we have a clear order of work in which the *clavisimbalum* (128r°) preceded 128v° and Baude's instructions.²⁴

Thus, it would appear that Arnaut had intended to produce another drawing on 128v° incorporating the same width of instrument as the *clavisimbalum*, with the same compass.²⁵ This could hardly have been the clavichord he drew on fol. 129v° since the keyboard must be in a different place on the paper in order to permit the full width of the instrument to be accommodated, and the clavichord compass was two notes larger. The most likely candidates are the keyboard instruments on 129v° and 130r°, the positions of which on the sheet are compatible with the line of dots on fol. 128v°. However, the fact that Arnaut went to the trouble of copying the v-x line from 128r° to 128v° suggests that he might even have intended to produce another version of the *clavisimbalum*. As is well known, Arnaut described four different actions for the *clavisimbalum*.²⁶ More speculation on Arnaut's purpose lies outside the scope of this study.

In the present binding of the manuscript, the drawing of the *fimbria*, clavichord and organ pipe (fol 129r°) occurs *after* the *clavisimbalum*. However, my previous analysis of these drawings has shown that the clavichord was developed first from the *fimbria*, then the *clavisimbalum* case from the clavichord, after which Arnaut was working on his clavichord and the *clavisimbalum* simultaneously. The *clavisimbalum* keyboard

²³ Koster, 2008, p. 9.

²⁴ This agrees with Koster's more limited description, but the aim of the analysis is to eliminate any doubt, and elucidate the *purpose* of the dots on 128v°.

²⁵ Here I depart from Koster's explanation: Koster, 2008, p. 9, explains the ink dots thus: "To show something of the three-dimensional design of the harpsichord..."

²⁶ See for example Koster, 2014 and Wraight, 2000.

formed the basis of the clavichord keyboard, in contradiction of his own instructions.²⁷ Since the *fimbria* formed the basis of both the clavichord and the organ pipe, this order of work is perfectly logical, therefore it is inferred that Arnaut's instructions for making his clavichord, together with the drawing of the groups of tangents, *preceded* the sheet containing the *clavisimbalum*.²⁸

Arnaut's order of working was different from the present binding and can be summarised as follows:

129r° [*fimbria*] > 129v° [clavichord] > 128r° [*clavisimbalum*] > 128v° [Baudecetus]

4. Baude's instructions considered in the 14th-century tradition

As a result of this analysis we have a clearer distinction between Arnaut's clavichord design (fol. 129r°) and the clavichord "according to the book of Baudecetus" (fol. 128v°). Ripin appears to have been partly influenced in his analysis of Arnaut's tangent layout by Baude's instructions *preceding* Arnaut's design in the order of the binding, and by the idea that Baude might have supplied more information than Arnaut communicated.

Koster also understood the Baude instructions as a separate and additional source, and found this practice of collecting together different, but related information to be normal in medieval manuscripts.²⁹

The description of a "clavichord" in the heading may have encouraged us to an incorrect expectation. When we examine Baude's text as an independent source, and not conflated with Arnaut's design, then there is remarkably little in it that it describes the *construction* of a clavichord. Only the instruction to choose a suitable string length and place the key (*clave*) at the *ut* distinguishes these instructions from a monochord division.

However, there are two characteristics which distinguish Baude's division from many earlier Medieval monochords: it has all chromatic degrees and the Guidonian notation (*ut*, *re*, *mi*, *fa*, etc.) is used. In these respects it is a parallel example to Hugo Spechtshart's full monochord, which first appeared in 1342.³⁰ This had a compass which exceeded the Guidonian hand (G-dd), with an extension to F in the bass, and *ee* in the treble.³¹ The instructions call for an F,G,A-e² compass, with a diatonic bass octave where B \flat is the first "raised" note, 34 keys in all.

The Medieval monochord was not a clavichord without keys, nor in the 14th century was the clavichord merely created by the addition of keys to a monochord. There is a

²⁷ Wraight, 2014, p. 507. There are discrepancies in the keyboard drawings which permitted this sequence of work to be established.

²⁸ Koster, 2008, p. 9, accepted the order of the binding as the order of work and argued on this basis.

²⁹ Koster, 2014, p. 175.

³⁰ See Adkins, pp. 170-174 and Diagram 47. For a modern edition of Hugo's text see Beck. A copy of a 1488 printing can be viewed in the internet. He is also referred to as Hugo von Reutlingen in many texts, for which reason I use his christian name. A valuable overview of manuscripts, texts, commentaries, and secondary works on the *Flores musicae* is Graf.

³¹ When referring to notes in the Guidonian hand I use the system which repeats A...a...aa, whereas our modern keyboard notation is based on a repetition at c: C...c...c¹...c². The Latin names for the hexachords have been retained since they accord better with manuscript texts in Latin.

long history of the transmission of music theory through the use of monochords, which, according to Adkins, fulfills three rôles:

- (i) pitch production for singers
- (ii) speculative discussions to explain and demonstrate intervals
- (iii) (less importantly) for instruments, such as organs, bells, organistri.³²

Hugo's division was clearly for a monochord, without any indication that it should be a keyed instrument. In fact, the range of notes in the bass (beyond G to F) exceeds that which could have been produced from a fully-fretted clavichord. Although Baude's division is clearly linked to a keyed mechanism, the range is restricted in the bass, starting on c. This is probably for the entirely practical reason that a fretted clavichord is impractical much below c, if all the (undamped) strings are tuned to the same pitch, even at the 4' level, since the tangent spacing requires a severe "cranking" of the keylevers.

Thus, Baude's design is clearly for a practical instrument (rôle iii), not for a monochord intended to explain and demonstrate intervals (rôle ii), since it lacks the notes below c (Γ A B, since Odo and Guido from c.1000). However, the division appears to fulfill mostly the second role of the monochord since its exposition is simple and didactic, rather than concise in the number of steps used.

This is where Adkins' diagrammatic presentation of monochord divisions shows a significant advantage in their analysis. Instead of a "linear" presentation, with all notes on a single line, he introduces a diagrammatic form with a separate line corresponding to each step of the instructions.³³ Although Adkins did not assert that the authors describing monochords worked in this way, his presentation is as useful as he claims. The comparison with the fretted clavichord is interesting since this instrument necessarily tends in the direction Adkins chose for presentation, although the string pair (with its 3-4 groups of tangents) cannot be directly compared with the lines of instruction in a division.

One of the advantages of Adkins' method is that one can quickly assess the "efficiency" of a division (as he calls it), that is, how many lines of instruction are required for a given number of notes. Guido of Arezzo's second (faster) method placed 11 notes with two lines of construction.³⁴ By comparison, Baude required 11 lines for 11 notes.

Economy of constructional method is also demonstrated by a specifically clavichord division, that of the Erlangen MS (c.1464), shown here in Adkins' Diagram 63 as Fig. 3.³⁵ Here we find that the 16-fold division of the first line yields 8 notes of the compass. However, it was not the practical requirements of instrument makers which brought about this economical approach: even Guido's first division (c. 1028) found 5 notes with a 9-fold division in the first line.³⁶

³² Adkins, p. 192.

³³ Adkins, pp. 29-33.

³⁴ Adkins, Diagram 43, p. 164. See also Huber, pp. 268-270, who discusses the tuning.

³⁵ Adkins, p. 240. This is a south German source, Ms. 554, University library, Erlangen. Watermarks in the paper permit a dating of in or before 1464, although the instructions could have been copied from an earlier source.

³⁶ See Adkins, Diagram 43, p. 164.

Although "efficiency" of construction is a criterion Adkins valued, the less efficient methods can be more easily memorised, as Guido himself recognised.³⁷ Thus, Baude's instructions come into this category, being inefficient, yet more easily memorised. That Baude thought in such terms is clear since the fourth line is redundant: the sol was already found with the 9-fold division of the first line. Of course, if the fourth line had been omitted then we would not have had the easily-memorised procedure, working through the Guidonian steps (ut re mi fa SOL...).

Neither would we have had the smooth visual line of the diatonic notes which Adkins' diagrammatic presentation uncovers (see Fig. 2).³⁸ Viewing Baude's division the reader will easily grasp the well-ordered structure, especially by comparison with Fig. 3 (Erlangen MS), with the diatonic notes presenting a diagonal line across the page and then the chromatic degrees forming a second line, returning to the origin.³⁹

In comparison with the many examples Adkins gives, Baude's division is remarkable for its clear order, which would have made it the more easily memorised. Since apparently none of the monochords discussed by Adkins were presented by their authors in visual form, it is difficult to know what significance we should attach to this visual elegance, but Yates' study of memory shows that it could have been useful to students, who would have been expected to assimilate and store information.⁴⁰

Baude's division is of the ascending type, that which was preferred by Boethius and which became the model for most Medieval monochord divisions following Odo (c.1000) and Guido (c.1028). "Ascending" means that the longest string is divided into ever smaller parts, which is logical for the construction of a fretted clavichord with strings of the same length. Predecessors of Baude who used a similar style of construction are Odo and Theoger, but these monochords had a wider compass than a clavichord, being intended for the rôles (i) and (ii).⁴¹ Thus, Baude probably extended the organistrum tradition with monochord divisions starting on c.⁴²

However, the clearly didactic character of the instructions is paralleled by the lack of practical information about making an instrument; there is merely the outline with the string division. We could imagine Baude's "book" to have been a conventional, and probably lengthy, treatise of music theory explaining all the intervals used in music, of which the instructions for a clavichord were only a minor part.

Since the main problem with Baude's instructions is to understand the quantity of 35 notes which was specified, it is profitable now to examine how the musical range developed in the 14th century.

³⁷ Adkins, p. 165, citing Guido, *Micrologus*, p.5

³⁸ In order to avoid any confusion: Adkins did not describe Baude's clavichord instructions since his remit was the study of the monochord, not the clavichord, but he did examine Arnaut's manuscript.

³⁹ In the Guidonian system the b flat (line 8) is not a chromatic degree, but it has been treated as such in the order of construction.

⁴⁰ Yates, pp. 85-87.

⁴¹ For Odo of Cluny see See Adkins Diagram 34, p. 145, and for Theoger of Metz, Diagram 36, p. 149a.

⁴² Meyer, pp. 270-273, gives several such divisions with ranges from c-b, with at the most two octaves. These divisions are discussed pp. LVI-LX.

Hugo specified a monochord with the range F-ee.⁴³ For Hugo the ee was already *extra manum* (outside the hand), as he clearly states, but the first printing of his text (in 1488) shows a "hand" with ee as the highest note (Fig. 4), which by then was the conventional range.⁴⁴ The "Guidonian hand" hexachord system is often described now in reference sources with the range of G-ee, even though Guido only developed the system as far as dd, i.e. with 6 hexachords (Fig. 5).⁴⁵ The ee is reached with a *durum* hexachord from g (Fig. 6, col. 7)

Hugo also gives us a hint of the older practice regarding chromatic degrees where the range was still limited to dd, since his instruction for adding the dd_b includes the option: "if it pleases you" [si placet], which would not be required in a range restricted to dd.⁴⁶

Sources usually ascribed to the contemporary Philipp de Vitry (c.1318) give instructions for a further extension of the range to ff, despite the fact that the chart following the division text gives only G-ee.⁴⁷ This highlights an essential difficulty in dealing with early sources, that copying produced errors; included in this process is the possibility that the subject matter was dictated, leading to misunderstanding. In fact, in one manuscript the scribe obviously did not understand (or think about) that which he was copying.⁴⁸ Fuller argues that Vitry's 'Ars Nova' manuscript, of which there are several versions, is a compilation by later copyists, not a complete work written down by Vitry.⁴⁹ Given these circumstances it is less surprising that there should be a lack of concordance in the ranges G-ff and G-ee.

Already apparent in the first, 1332, version is Hugo's other extension to the Guidonian hand, which occurs at the lower end, where he observed that players used an F below the Gamma, in order that the lower B_b should be available. This note was traditionally missing from Guido's hand, but Hugo's explanation implies the *molle* hexachord with ut on F (Fig. 6 col. 8) in order that the mi-fa interval falls on the B_b.⁵⁰

Thus, we have 14th-century texts which testify to the use of F (below Gamma) and suggest the use of an ff. This latter note is of interest for us since it coincides with the

⁴³ Spechtshart, 1488. According to Gümpel, pp. 89-90, there were two printings in 1488. He also relates, p. 68, that Chapter II, De Monochordo was added to Spechtshart's work in the revision of 1342.

⁴⁴ Beck, p. 79: "10) Sic etiam ab E La Mi acuto duas fac partes et in medio pone E E La extra manum." This detail is not contained in Adkins' translation, p.173. The "hand" is shown in the Bayerische Staatsbibliothek copy as p.21 of the PDF file; the printed copy has no page numbers. The *extra manum* therefore refers to the older Guidonian scheme (G-dd, see Fig. 5), not that which the printer added in 1488.

⁴⁵ For example, Apel, p. 384 and Berger p. 412. The term "hexachord" was not applied by Guido to this system.

⁴⁶ Beck edition, p. 78: "...et in septima, si placet, B semintonium inter C C Sol Fa et D D La Sol."

⁴⁷ Adkins, Diagram 39. p.155, correctly shows the construction of the third f (ff) at line 8. Adkins' source is given only in the bibliography as CS III (Coussemaker, vol. 3), pp. 15-22.

⁴⁸ See Plantinga, p. 222, note 18. The scribe wrote "semitonium" where a whole tone was required.

⁴⁹ Fuller, especially p. 27.

⁵⁰ See Beck, p. 68, line [48], or Gümpel, p. 120, line 229.

"Per formatores monochordorum juniores
infa G graecum reperitur Ut F sociatum
Dictis servatis mensuris nec variatis
Ut sine defectu vocum Bmollis haberi

Inferius valeat cantus pleneque doceri," (Beck, lines 231-234,; Gümpel, lines 229-232)

instruction in Baude's "book" where f^1 is the last diatonic note determined (an octave below ff), and could therefore be the compass limit envisaged for the clavichord.

The problem which still remains is how to understand the "35 *tonos*" which Baude's instructions call for, since these would not match a c - f^2 range (30 notes), which the clavichord design *appears* to yield. However, when we consider the history of Vitry's text (6 surviving manuscripts) and and Hugo's (with 14 manuscripts before the printed version of 1488), then it would not be surprising if the repeated copying of an original source, or copies, had introduced errors.⁵¹ We should not naively imagine that Arnaut necessarily saw an original work; even Baude's "book" may have been a copy, or compilation from earlier manuscripts. The use of "*fictas*", instead of the correct "*semitonium*", could be interpreted as an indication of the level of understanding of a copyist. In this sense it would be easy to imagine that a scribe could refer to 35 *tonos* as the entire "hand" which was practised in the 14th century (i.e. F, G, A - ff , 35 notes) and that this was clumsily or unthinkingly combined, (as in the Vitry manuscript), with the clavichord instructions.

The last diatonic note named by Baude (in step 15) is f^1 (f - fa - ut) which Ripin interpreted as a hint that the compass might end on f , i.e. on f^2 , which led in turn to his speculation of a compass of B - f^2 .⁵² When we review this division in its 14th-century context then we can understand better Baude's instructions. We are told (step 15) that the procedure of halving the string lengths should continue until 35 tones are found. This type of procedure is also found in Jean de Muris' division (c.1290-1351): "Then divide by octaves until the instrument contains nineteen chords."⁵³ The result is a Guidonian G - dd hand with 19 positions (Fig. 5), thus, it may be the *number* of notes of the entire hand which has more significance than the last named note.

After considering Hugo's and Vitry's divisions, we could infer that the 35 notes Baude mentioned are from F to f^2 , specifically F, G, A - f^2 . This inference presupposes that a clumsy conflation of sources took place, as described for Vitry above. This range contains 35 notes, with 22 naturals and 13 raised notes, that is, that Baude (or even an author preceding him) is referring to the *entire* complement of notes of the musical space known to them, and even this included notes *extra manum*, outside the later 14th-century Guidonian hand of G - ee (Fig. 6).

How the F and f^2 would have been incorporated into the Guidonian system is not difficult to envisage, and is shown in Fig. 6. At the lower end the addition of a *molle* hexachord (col. 8) would have created the extension from G [Gamma] to F . The addition of a *naturale* hexachord (col. 8) at the upper end of the scale would place the mi - fa at e^2 - f^2 .

The implication of this interpretation is that a clavichord with a range c - f^2 was using only a part of the (new, 14th-century) Guidonian range, since we have records of instruments around 1400 with a range reaching to g^2, a^2 (i.e. lacking $g\sharp^2$), which

⁵¹ Fuller lists the six manuscripts and Graf the fourteen.

⁵² Ripin, p. 526, note 15.

⁵³ Cited and translated by Adkins, p. 152. He explains that by "chords" we should understand "notes", and not the number of strings; it is a monochord, not a polychord.

accords exactly with the *naturale* hexachord of col. 8.⁵⁴ The Norrlanda organ is even chromatic to a^2 .

On this interpretation, Baude's clavichord could have had the compass $c-f^2$ (30 notes), which is easily realisable as a fully-fretted design, and 35 notes would have referred to the entire range of the Guidonian hand.

5. 35-note compasses

A 35-note compass could have the range $c-b^2$, *without* b_b^2 , but initially this seems so strange that we might interpret the string division as $c-b^2$, *including* b_b^2 , which was Koster's suggestion, who explained the 35 notes as an error for the 36 notes of the $c-b^2$ range.⁵⁵

However, a compass *without* b_b^1 was given by Bormann (BB- b^1), as Arnaut's third, 36-note organ disposition (fol. 131v°).⁵⁶ Although this interpretation was not explained, there was thought to be a precedent in organ building at that time, which Bormann probably knew: Tagliavini described the original compass of the 1471-1475 Lorenzo da Prato organ in San Petronio, Bologna, as AA- c^4 , without BB $_b$ and b_b^3 (50 notes).⁵⁷ By 1979 Tagliavini had corrected this reading of the original compass to a more conventional, 51-note FF,GG,AA- a^2 range.⁵⁸

The omission of $g\sharp$ in the top octave of a keyboard is better known, and a portative organ described by Arnaut, with a drawing of the pipe positions (fol. 130v°), gives an unmistakable B- g^2 , a^2 compass. Given this documentation of compasses lacking raised "black" notes, $c-a^2$, b^2 (without b_b^2) could *appear* to be a solution for Baude's instructions, when they are interpreted literally.

Since the criteria for Baude's compass were a *chromatic* bass, and 35 notes, there are other hypothetical solutions which fit, providing we permit the omission of certain notes. The evidence of compasses - g^2 , a^2 (considered above) suggests a hypothetical three-octave compass $c-g^2$, a^2 , b^2 c^3 , (without $g\sharp^2$ and b_b^2). An intarsia of a table organ in the Gubbio *studiolo* appears to confirm this sort of practice, showing a compass ending in the treble on f^2 , g^2 , a^2 , that is, without $f\sharp^2$ and $g\sharp^2$.⁵⁹ However, further examination of this intarsia shows that it was a modified version of another compass (F,G,A- f^2), which disqualifies its evidential value.⁶⁰ An intarsia of a virginals in S.Lorenzo, Genua, appears to show a compass extending to g^3 , a^3 , b^3 , but closer examination shows this information to be unreliable.⁶¹

⁵⁴ For example, the Faber organ in Halberstadt might have been built in 1361 with a manual compass of B- g^2 , a^2 , the compass recorded by Praetorius in 1619.

⁵⁵ Koster, 2002, p.16, suggested a chromatic compass of $c-b^2$. See my footnote 8 above for his explanation of the discrepancy in the number of notes.

⁵⁶ Bormann, p.166, in the German notation as HH- h^1 , and "ohne b^1 ". Bormann's reproduction of Arnaut's table renders the data more legibly than fol. 131v°.

⁵⁷ Lunelli, (published in 1956), p. 11, citing Tagliavini's examination of the organ.

⁵⁸ Tagliavini, 1979, p. 31.

⁵⁹ For example the small organ in the studiolo of Gubbio, now in the Metropolitan Museum of Art, New York. See Raggio p. 138.

⁶⁰ Wraight, "The Gubbio organ..." .

⁶¹ The instrument is illustrated at

<https://www.beweb.chiesacattolica.it/benistorici/bene/1225241/De+Fornari+A.+>

Thus, we can return to the fact that the only possible *chromatic* 35-note compass starting on c (without omitted notes) is c-b \flat ², but a *manual* compass which ends on b \flat is barely known in the literature. Eberlein interpreted the third of Arnaut's 36-note organ dispositions (fol. 131v^o) literally, as containing the compass B-b \flat ² and thereby differed from Bormann.⁶² What Arnaut gives us is a densely-packed table listing the numbers of pipes in three organs (fol. 131v^o): the groupings are preceded with the column of note names: h f h f h f h [the notation is German whereby H = B]. Against the penultimate f in this list Arnaut has written "6", indicating 6 notes in the compass, i.e. f²-b \flat ², apparently confirming Eberlein's reading. Had Arnaut intended f²-a²,b² (without b \flat ²) then he should have entered 5 after f and 1 after h.

If we have to imagine a compass ending on a b \flat , would this have been a raised, "black" note? There is an intarsia by Antonio Barili of a small table organ apparently with "sharps" as the first and last notes, beyond the F,G,A-f² compass.⁶³ Liuwe Tamminga has suggested that these are not accidental notes, but register stops for effects such as crickets (*grilli*) or nightingales (*rossingnoli*).⁶⁴

Given what we know of the development of the keyboard it seems *prima facie* unlikely around 1390 that a keyboard could end on a "black" note. A 14th-century instrument in which b \flat occurs as a "white" note is the Norrlanda organ.⁶⁵ The paper label above the *manual* keyboard indicates that it starts on a c and is chromatic to a¹ with b \flat as a "white note": there are four "white" notes in succession between g \sharp and c \sharp ¹.⁶⁶ The Norrlanda organ was constructed with the 8-note, diatonic pedal keyboard C-B, with B \flat as a "white note", and the manual keyboard, also with B \flat as a "white note".

The following photos clarify this arrangement. Plate 5 shows the manual keyboard alone, at greater scale, for better visibility, then Plate 6 shows the two keyboards as they are mounted in the organ. (The "key" in the middle of the paper strip, above the manual keyboard, is a stop, and not part of the keyboard).

[+De+Pantaleoni+G.M.+281514-1529%29%2C+Tarsia+con+clavicembalo+aperto](#) As made, the intarsia shows a virginal with the treble strings at the left hand side, and only appears to have this g³,a³,b³ compass if the intarsia is reversed to show a normal instrument. Regardless of how one views the keyboard, a plausible compass does not result. Maurizio Tarrini kindly provided information which made this assessment possible.

⁶² Eberlein, 'Neue Rekonstruktionen...', p.4, H-b² in the original German notation. He kindly confirmed that no other examples of this compass are known to him (personal communication 19.08.2021). We need not examine whether Arnaut's first listing of a 43-note instrument is to be understood as revealing the full compass of the Salins organ or merely reflect the distribution of pipes in the pedal and manual keyboards. The present discussion is limited to finding solutions for a compass with 6 notes from f².

⁶³ This intarsia (c.1490-1500) was made for the chapel of San Giovanni, in the Duomo of Siena, but is now in the church of San Quirico d'Orcia, under which name it is usually described. For further details see Wraight, 'The Gubbio organ...', Appendix 2,1.

⁶⁴ Winold van der Putten kindly communicated Tamminga's email written in 2018. Liuwe Tamminga died in April 2021, before my own investigations into this matter started. A reproduction of this intarsia as a working organ was made by van der Putten: <https://www.orgelmakerij.nl/2018san-quirico/> See Wraight, 'The Gubbio organ...', Appendix, 1.

⁶⁵ Various dates are to be found in the literature, often c.1370-1430. Bormann, p.35, who drew his information from studies in Swedish (Wester) and Danish (Andersen) gives 1370-1400 as the date when the organ was installed. Elsewhere in his book he refers to the date as "before 1400" [vor 1400].

⁶⁶ The manual keyboard range is also discussed and clearly illustrated with a drawing (Fig. 6b) in Lindley, op. cit., pp. 28-30. More detail is given by Bormann, esp. pp. 65-67.



Plate 5, Source: internet⁶⁷, unknown copyright holder, probably Statens historiska museum Stockholm.



Plate 6, Source: : <http://mis.historiska.se/mis/sok/fid.asp?fid=116311&q=1>
copyright: Statens historiska museum, Stockholm.

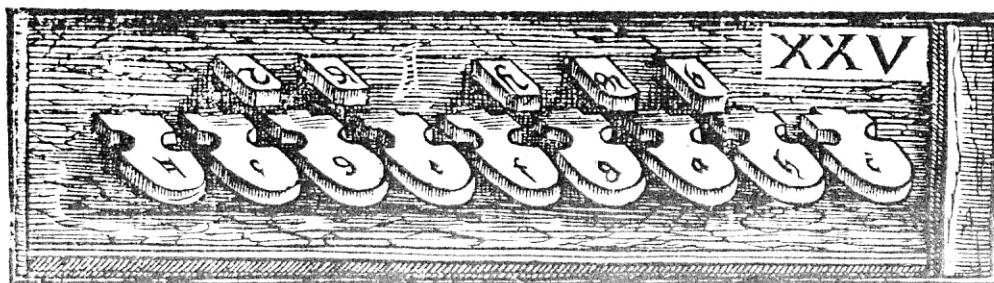
Thus, an *instrument* from the period we are considering (c.1390) establishes that b_b as a "white note" was indeed possible. Whether this principle can be extended to explain the treble end of Baude's clavichord will now be examined.

That an organ pedal keyboard in the first half of the 15th century could end on b_b is established by a South German manuscript examined by Göllner, with the range $h-b$ [$B-b_b$], to which Witkowska-Zaremba has drawn attention.⁶⁸

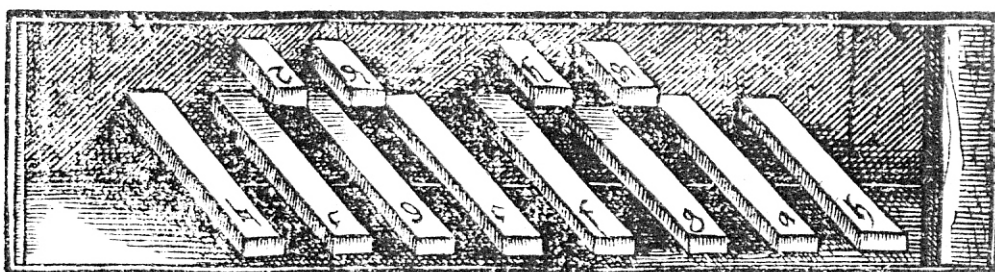
⁶⁷ <https://i.pinimg.com/originals/65/45/7f/65457f3af53567872f819f550985de40.jpg>
(download 16.05.2021)

The pedal keyboard from the Halberstadt organ of 1363 is well known through Praetorius's publication: the highest note of Das III. Clavier (Plate 7) is labelled "h" [i.e. b], as if the b_b were missing; the pedal keyboard has the same layout, but is not labelled. It will be argued below that this "h" was a b_b.

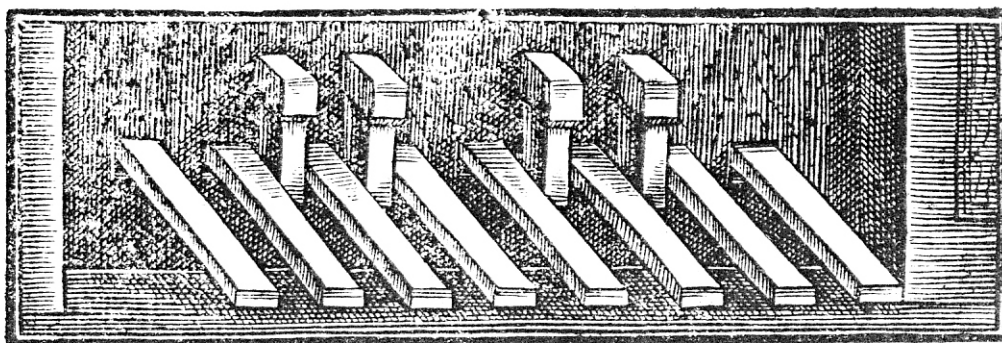
Das I. vnd II. Discant-clavier.



Das III. Clavier.



Das IV. Pedal-Clavier,



Dies sind die Manual-vnnd Pedal-Clavier, wie die in der gar grossen Orgel im
Thumb zu Halberstadt vber einander liegen.
D I.

Plate 7. Source: Praetorius, *Syntagma Musicum II*, Tafel XXV, Bärenreiter 1980.

A further example is the pedal clavichord in a pen and ink drawing dating from 1464 (Plate 8), (and probably 15th century), which is usually linked with the name of Hugo von Reutlingen, although it is only in a handwritten compilation of his *Flores musicae* by a student, Ägidius von Bulach, 122 years later.⁶⁸ The clavichord has a compass of B-f², but the pedalboard has an *apparent* BB-B, without B_b.

⁶⁸ München, Bayerische Staatsbibliothek, Cod. lat. 7755: Göllner, p. 177, referred to by Witkowska-Zaremba, 2001, p. 378. "h-b" is the original designation, although the pitch level is not specified.

⁶⁹ MS Cod.poet.et phil.qt.52, Württembergische Landesbibliothek,

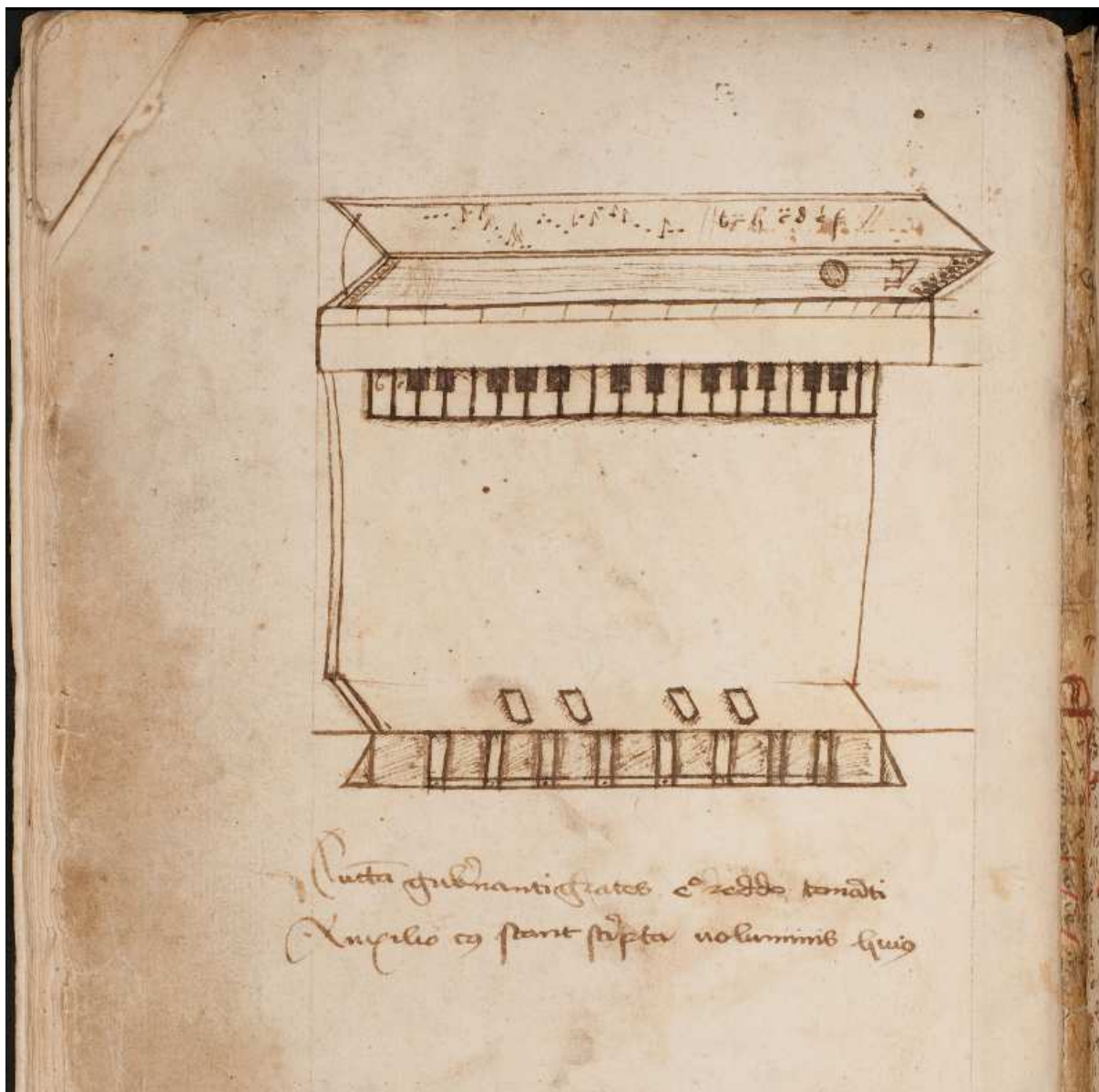


Plate 8. Source: MS Cod.poet.et phil.qt.52, Württembergische Landesbibliothek

This pedalboard compass has presented something of a mystery to generations of clavichord scholarship, although the situation regarding Praetorius' example was correctly analysed by Bormann as long ago as 1966, who, with commonsense, refused to believe that the B \flat could have been omitted, and identified the "B" as a B \flat .⁷⁰ Eberlein provided the explanation for this practice when he linked the BB-B \flat pedalboard as a *downward* continuation of the B-g²,a² manual keyboard of the Halberstadt organ.⁷¹

http://digital.wlb-stuttgart.de/sammlungen/sammlungsliste/werksansicht/?no_cache=1&tx_dlf%5Bid%5D=2079&tx_dlf%5Bpage%5D=1 The errors in Ägidius' Latin found by Gümpel and Sachs, p. 65, note 2, led them to infer that this manuscript was an aural record of his instruction from the *Flores musicae*.

⁷⁰ Bormann, p. 43: "Es ist kein musikalischer Grund denkbar, den Ton H zweimal anzulegen und so die chromatische Folge zu brechen". Those suggesting a missing B \flat , or not identifying the compass in the pedal clavichord are chronologically: Handschin, Jeans, Ford, Potvlieghe, and Brauchli.

⁷¹ Eberlein, "Die Entwicklung ...", p. 1, although he repeats Praetorius' printed -A,H ranges for the Halberstadt organ. Meeüs' extensive list of 15th century organ compasses lists only (p.7, no. 30) the

Documentary confirmation of these interpretations was provided by Witkowska-Zaremba who found a section in a Prague manuscript (1427-1436) which drew this arrangement of the pedal keys and named the notes.⁷²

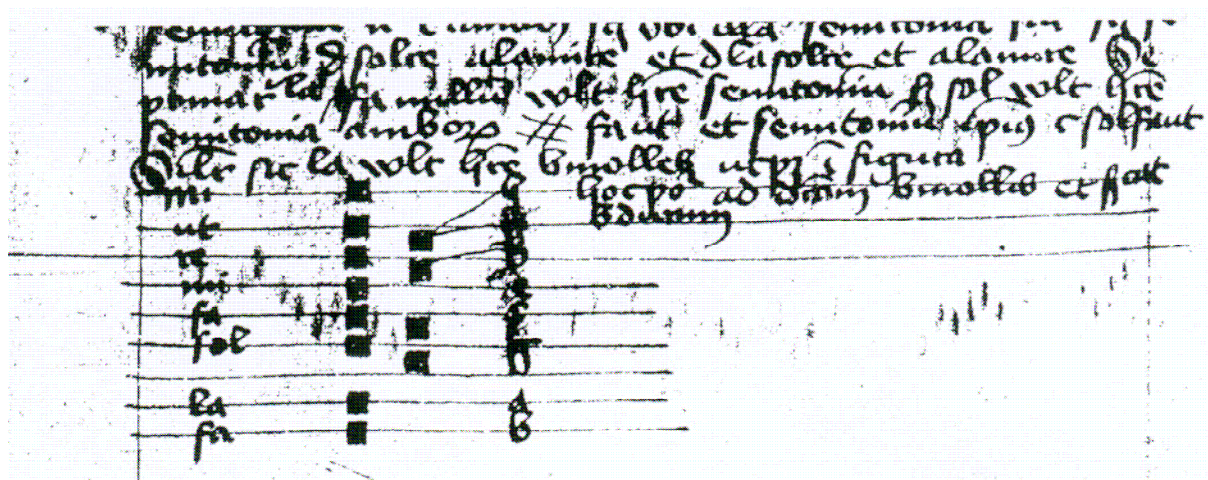


Plate 9. Source: Witkowska-Zaremba, p. 378.

For clarification, with the key names (rotated into the horizontal plane):

B C D E F G A B_b (English)
H C D E F G A B (German)

mi ut re mi fa sol la fa

We can see that of this range, the part C-B_b is in effect the overlapping of the *naturale* and *molle* hexachords (see Fig. 6, cols 9 and 8), that is, the combination of two tetrachords. In a Pythagorean F_# x B tuning, these tetrachords are also identically tuned.

It is interesting to note that music practice has changed so much in the intervening (nearly 600) years that we now have difficulty in understanding the logic behind such a pedalboard. However, merely 80 years after this manuscript was written, Arnolt Schlick (in 1511) reported a type of pedalboard he had seen, our modern version, with B_b as a raised (black) note and B_n as a "white" note, and warned that it "would almost be unusual for the organist and cause confusion". He recommended therefore that the "usual" type would be best, which by implication included a B_b as a "white" note.⁷³

1493 Rotenburger organ in Bamberg (Praetorius, p. 111) with FGA-b_b in the pedal, and an unclear example (p. 9, no.56) from 1516, Saint Mathieu in Perpignan as C-B_b or C-B in the pedal.

⁷² Witkowska-Zaremba, 2001, p. 378, citing fol. 99v, claves pedales, of the Praha, Archiv Prazskeho hradu, Knihovna Metropolitni kapituly M.CIII manuscript. Witkowska-Zaremba, 2003, p. 5 drew attention to the relevance of this MS to Praetorius's pedal board in Tafel XXV.

⁷³ Schlick, Das drit capitell, Das vij blat, The text reads from "Item das bdür..." to "die gemeyn form des stücks die best.", in Eitner. The Flade and Smets renderings into modern German are unsatisfactory, and the best version (although not faultless) is Berry's English translation, p. 94. See also Wraight, 'Schlick...', for a new translation and fuller discussion.

Confusion appears to have taken hold by Praetorius's time (1619) since one of his reports included a B \flat as the highest note in the pedal, but in another this was a B \natural .⁷⁴

It is the Guidonian hand itself which assigns an equal position to B \flat and B \natural in the diatonic series of 19 positions (Fig. 5). These positions are the numbering of the places at which the names occur on the drawing of the hand (Fig. 4). B \flat and B \natural occur at positions 3, 10 and 17 so at each position the mi-fa interval can be set, as the hexachord requires, producing either the \flat or the \natural . It is therefore perfectly logical for this way of thinking that both notes be white, which is exactly what we find in the Norrlanda organ; if the range would have been extended beyond a¹ then we can imagine that a "white" note for b \flat ¹ would have been used.

The Norrlanda organ is merely a smaller version of the hypothetical c-b \flat ² compass we are considering for Baude's clavichord, but the question arises how the Baude instrument would have been conceived if the b \flat notes had been implemented as "black" notes, as we find in Arnaut's manuscript, c.1440? Is it possible to have b \flat as a black note in the middle range, yet end on b \flat ² with a "white" note? This might seem strange, but the pedal keyboard Schlick described in 1511 with its C-B \flat range is directly comparable with the treble c²-b \flat ² of Baude's clavichord, and the organist's thinking regarding B \flat could have applied to b \flat ². We can see that in 1511 organists still played the B \flat from a "white" note in the pedal, even though the range above this (throughout the 15th century) was provided with b \flat on a "black" note. Why this should not have caused the confusion of Schlick's foreboding is something we cannot answer, but it appears possible to conceive of a clavichord compass around 1390 with a c-b \flat ² compass with b \flat ² as a "white" note.

One detail which appears to speak against this interpretation is the description in Baude's string division (step 8) where the b \flat is described as *fictam*. Furthermore in the series of the construction b \flat is placed on the "black" notes. Of course, we can consider that merely the b \flat ² was made as a "white" note, which is compatible with the instructions, but the idea of b \flat as *ficta* is of course incorrect. Berger observed that "At the same time, the acceptance of a sharp promoted the tendency to think of b [b \flat] as yet another dividing the whole tones of the gamut, identical in status with other "black-key" steps, and to think of the whole gamut in terms of the monochord or keyboard, rather than in terms of the hand."⁷⁵ As has been observed above, use of "*fictas*", instead of the correct "*semitonium*", could be interpreted as an indication of the level of understanding of a copyist, and Baude's "book" may have been copied or compiled from several sources. We can observe an occasional lack of congruence of ideas in these early manuscripts.

This hypothetical compass to b \flat ² represents an *extension* by a fourth of the probable normal compass around 1400 (i.e. reaching to f²), and might reflect the practice we

⁷⁴ Praetorius, p. 110, for the pedal compass of A-b \flat , and p. 111 for the range FGA-b \flat , but p. 99 gives a pedal range of \natural to h. The pedal for the San Salvador church, p. 110, has a final note, which is somewhere in appearance between b and h. One wonders whether the printer had created this problem.

⁷⁵ Berger, p. 417.

find in 16th-century Italian harpsichords and virginals, with their c^3 or f^3 top notes.⁷⁶ However, even if we understood this practice better, it would not enable us to decide if Baude's instrument was designed for a $c-b_b^2$ compass. The testimony of Arnaut's record of an organ (from fol. 131v^o) with the compass $B-b_b$, the argument above regarding the use of B_b in the pedal keyboard, and above all the Norrlanda organ, show that Baude's clavichord could have been designed for a $c-b_b^2$ compass with b_b^2 as a "white" note, 35 notes in total.

Conclusions

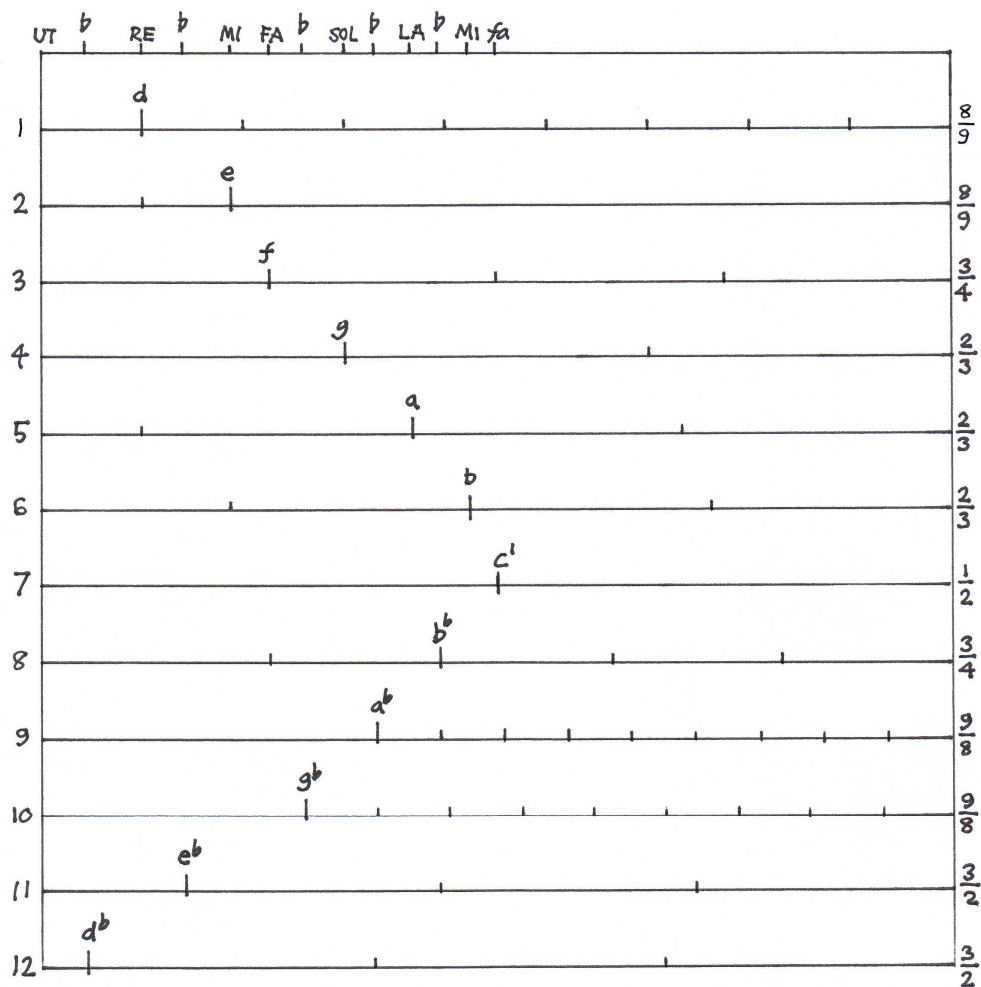
1. Commentators before Koster have tended to conflate Baude's design with Arnaut's clavichord. They are distinct designs.
2. Arnaut's working order is not that of the present binding of the manuscript. The clavichord was designed before the *clavisimbalum*, then follow Baude's instructions.
3. Baude's instructions for the string division of a clavichord are unusually well ordered and might have been aimed at demonstrating general principles of design rather than giving details for constructing an instrument.
4. The problem is to explain a range starting on c which contains 35 notes. If a miscounting is assumed in the number of notes specified by Baude, then $c-b^2$, as suggested by Koster is possible. If Arnaut introduced "35" as an error, from his *clavisimbalum* range, then any plausible compass is possible.
5. A review of 14th-century evidence for the monochord range indicates that the highest note of the clavichord could have been f^2 . Thus Baude's clavichord could have been intended for a range of $c-f^2$. Following Koster, Arnaut's drawing of tangent groupings could be taken as confirmation of this range, if we assume that they were supplied by Baude's instructions. The interpretation also requires us to explain a more substantial error in the number of keys, 30 versus 35, which might have come from copying or compilation errors in Baude's text.
6. From the string division starting on c , and the instruction for 35 tones, the only possible chromatic compass is $c-b_b^2$. The Guidonian hand provides the theoretical basis for understanding the Norrlanda organ where b_b is a "white" note. Even in 1511 Schlick reported pedal keyboards with B_b as a "white" note, which also explains the drawing of the pedal keyboard of a clavichord associated with Hugo Spechtshart. Thus, the compass of Baude's clavichord could have been $c-b_b^2$ with 35 notes, and b_b^2 as a "white" note.

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⁷⁶ This subject is too complicated for discussion here, but the reader is referred to Meeùs, 1977 and Wraight, 1997, Part 1, especially pp. 296-298.

Fig 2. Baude's clavichord division



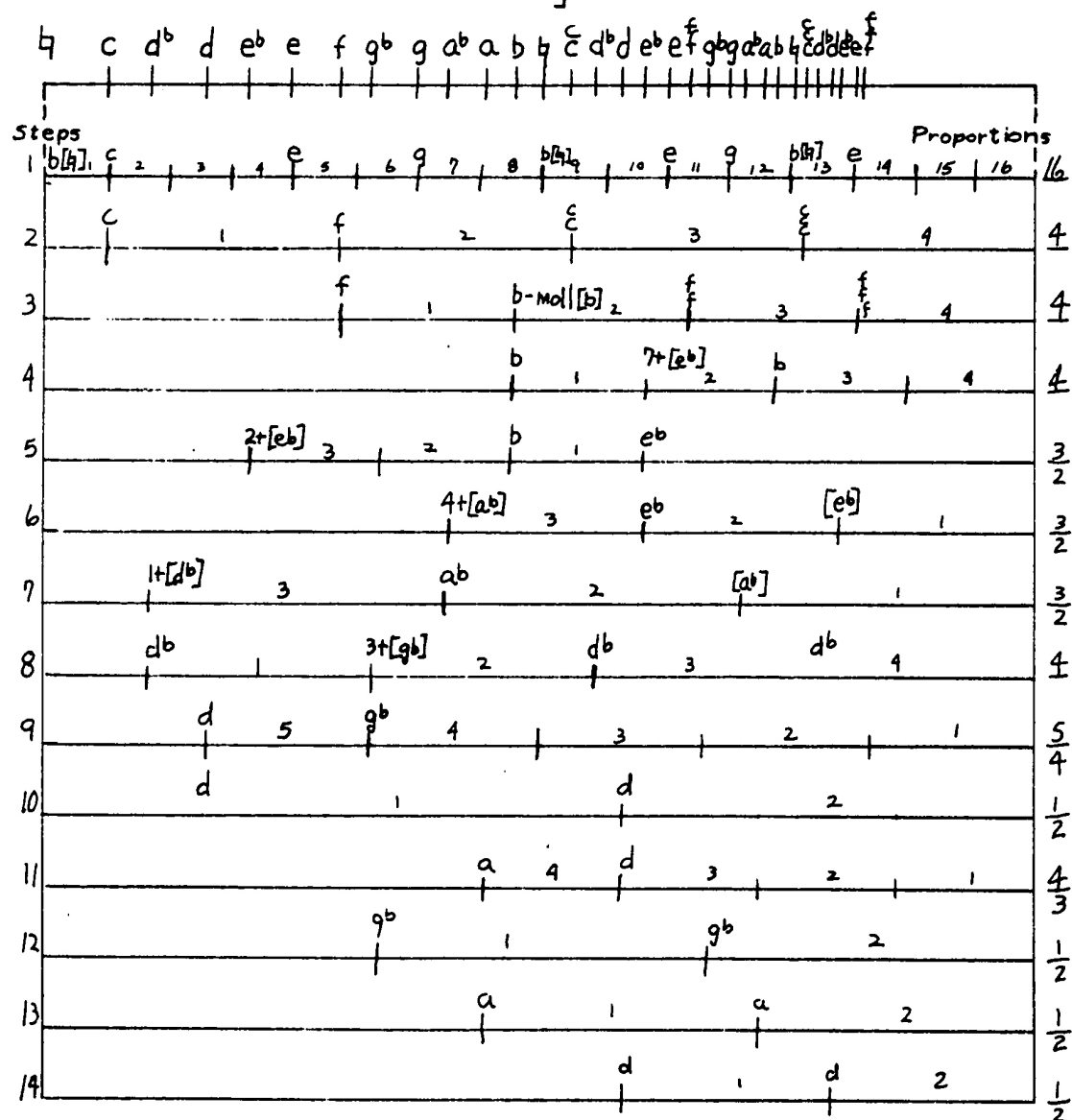
Steps 1-12; 13-16 are merely octave repetitions

Fig. 3. Erlangen manuscript, clavichord instructions, in or before 1464

Diagram 63. Anon. Dupont, Pro clavicordis faciendis (2nd half / 5th C.).

Direction: Ascending. Measurements: 2, 3, 4, 16. Notes: 31.

Completed Monochord: Just Tuning.



Source. Adkins, p.240

The dating is my own estimation, based on watermarks of the paper (see note 34).

Fig. 4. The Guidonian hand from Hugo Spechtshart (von Reutlingen), 1488 printing



Source: Universitätsbibliothek, Basel
https://www.e-rara.ch/bau_1/content/titleinfo/20880738

Fig. 5. The Guidonian hand and the Hexachord System until c. 1330

Guidonian "hand" = G-d² [Γ-dd]

P	M	G	1	2	3	4	5	6	
19	d ²	dd						la	D la
18	c ²	cc						sol	C sol
17	b _q ¹	q q							B mi
	b _b ¹	bb _b						fa	B fa
16	a ¹	aa					la	mi	A la mi
15	g ¹	g					sol	re	G sol re
14	f ¹	f					fa	ut	F fa ut
13	e ¹	e				la	mi	M	E la mi
12	d ¹	d			la	sol	re		D la sol re
11	c ¹	c			sol	fa	ut		C sol fa ut
10	b _q	q				mi	N		B mi
	b _b	b _b			fa				B fa
9	a	a		la	mi	re			A la mi re
8	g	G		sol	re	ut			G sol re ut
7	f	F		fa	ut	D			F fa ut
6	e	E	la	mi	M				E la mi
5	d	D	sol	re					D sol re
4	c	C	fa	ut					C fa ut
3	B _q	B _q	mi	N					B mi
	[B _b]								
2	A	A	re						A re
1	G	Γ	ut						G ut
			D						

D = hexchordum durum

N = hexachordum naturale

M = hexachordum molle

Column G: the form of note designation after Guido, the octave repetition occurs at a

Column M: our modern note designation with the octave repetition occurring at c

Column P: the numbering of the places on the hand

Fig. 6. The Guidonian hand and the Hexachord System from c.1330

Guidonian "hand" = G-e² [Γ-ee, columns 1-7]

9	8	P	M	G	1	2	3	4	5	6	7	
la			[d ³]									
sol			[c ³]									
			[b ²]									
fa			[b _b ²]									
mi	la		[a ²]									
re	sol		[g ²]									
ut	fa		[f ²]									
M	mi	20	e ²	ee							la	E la
	re	19	d ²	dd						la	sol	D la sol
	ut	18	c ²	cc						sol	fa	C sol fa
	N	17	b _h ¹	h _h							mi	B mi
			b _b ¹	bb _b						fa		B fa
		16	a ¹	aa					la	mi	re	A la mi re
		15	g ¹	g					sol	re	ut	G sol re ut
		14	f ¹	f					fa	ut	D	F fa ut
		13	e ¹	e				la	mi	M		E la mi
		12	d ¹	d			la	sol	re			D la sol re
		11	c ¹	c			sol	fa	ut			C sol fa ut
		10	b _h	h				mi	N			B mi
			b _b	b _b			fa					B fa
		9	a	a		la	mi	re				A la mi re
		8	g	G		sol	re	ut				G sol re ut
		7	f	F		fa	ut	D				F fa ut
		6	e	E	la	mi	M					E la mi
	la	5	d	D	sol	re						D sol re
	sol	4	c	C	fa	ut						C fa ut
		3	B _h	B _h	mi	N						B mi
	fa		[B _b]									
la	mi	2	A	A	re							A re
sol	re	1	G	Γ	ut							G ut
fa	ut		[F]		D							[F ut]
mi	M		[E]									
re			[D]									
ut			[C]									
N												

D = hexchordum durum

N = hexachordum naturale

M = hexachordum molle

Column G: the form of note designation after Guido, the octave repetition occurring at a
Column M: our modern note designation with the octave repetition occurring at c

Column P: the numbering of the places on the hand

Columns 8 and 9 represent the theoretical extensions of the system

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