

# An Interpretation of the Hammered Clavisimbalum of Henri-Arnaut de Zwolle c. 1440

Pierre Verbeek

Presented at the 45<sup>th</sup> *Clavichordtage* of the *Deutsche Clavichord Societät* in the *Hansestadt  
Stade*, 27–29 September 2019



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The treatise of Henri-Arnaut de Zwolle<sup>1</sup> c. 1440 has triggered much interest in the circles of Mediaeval and Renaissance organology since its publication by Le Cerf and Labande<sup>2</sup> in 1932 and its facsimile edition by Bärenreiter-Verlag<sup>3</sup> in 1972. This is hardly surprising, as the treatise of Arnaut provides most of the information we have today on the emergence of strung keyboard instruments between the Middle Ages and the Renaissance in the Duchy of Burgundy<sup>4</sup>.

A number of attempts have been made at reconstructing the strung keyboard instruments described by Henri-Arnaut de Zwolle in his treatise, including recently by Jack Peters, Philippe Humeau, Andreas Hermert, Paul Poletti, Carl Rennoldson, David Boinnard, Gregor Bergmann, and other makers.

During 2019, at the request of a Bavarian customer, I built a clavisimbalum based on the drawing in Arnaut's treatise<sup>5</sup>. The customer requested a clavisimbalum with the fourth type of action described by Arnaut, i.e. with hammer mechanism<sup>6</sup>. The purpose of this project was to build a clavisimbalum that will be used in actual musical practice rather than primarily advancing the corpus of organology knowledge regarding the original instrument.

The present paper is a companion to the instrument itself, presented at the 45<sup>th</sup> *Clavichordtage* of the *Deutsche Clavichord Societät* in Stade in September 2019. It provides technical details about the realisation of this project, started and completed in 2019.

I am grateful for their support, their assistance and their kind co-operation, to Dr. Andreas Defregger, Dr. Alfons Huber and Prof. Dr. Heiko Hansjosten.

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<sup>1</sup> MAYER BROWN, HOWARD, *Arnaut de Zwolle, Henri*, The New Grove Dictionary of Music and Musicians, 1980, reprint 1995, Vol. 1.

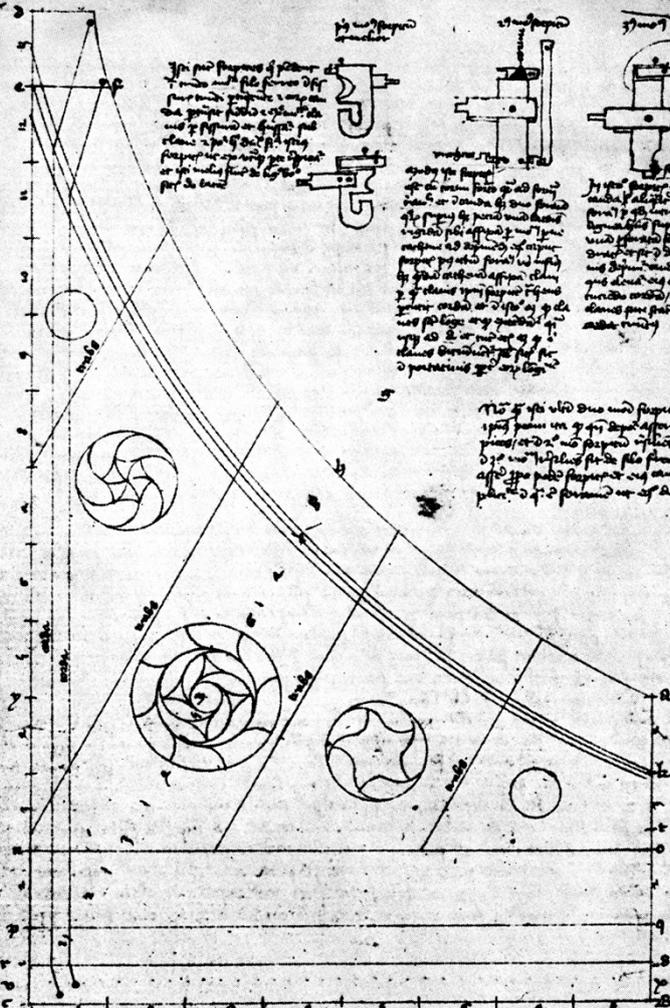
<sup>2</sup> LE CERF, GEORGES - LABANDE, EDMOND-RENÉ, *Les traités d'Henri-Arnaut de Zwolle et de divers anonymes* (ms B.N. Latin 7295), Paris, Auguste Picard, 1932.

<sup>3</sup> *Les traités d'Henri-Arnaut de Zwolle et de divers anonymes* (Paris: Bibliothèque Nationale, ms. latin 7295). *Faksimile der Handschrift und kommentierte Übertragung mit einem Nachwort von François Lesure*. Documenta Musicologica, II/4. Kassel, 1972.

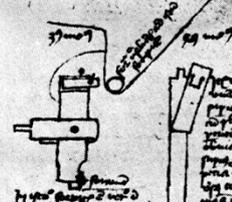
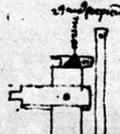
<sup>4</sup> The Duchy of Burgundy extended in the mid-1400ies from Chalon-sur-Saône to Friesland. As is well known, the Dukes, especially Philip the Good (1396-1419-1467), were important patrons of the arts, including painting, e.g. Jan van Eyck, Rogier van der Weyden, Hans Memling, and music, e.g. Gilles Binchois, Guillaume Dufay.

<sup>5</sup> See on page 4 below a reproduction of page 128 of Arnaut's treatise.

<sup>6</sup> See e.g. LESTER, JOHN, *The Musical Mechanisms of Arnaut de Zwolle*, The English Harpsichord Magazine, EHM Vol. 3, n°3, 1982, p. 35-41.



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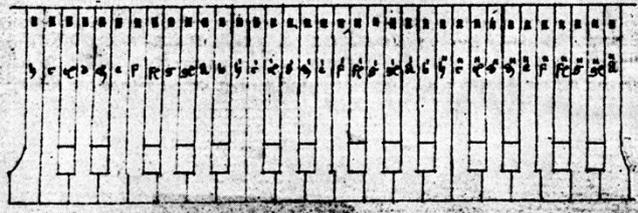


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## Main features and dimensions

	Features according to Arnaut's treatise	Features of the 2019 interpretation
Disposition	1 x 8'	2 x 8'
Span	H - a2 chromatic	H - a2 chromatic
Pitch	?	415 – 440 Hz
Overall length (without keyboard)	13 units $\cong$ 86.3 – 87.0 cm	102.0 cm
Overall length (with keyboard)	$\cong$ 14 units $\cong$ 93.0 – 93.7 cm	111.5 cm
Length of cheek	4 units $\cong$ 26.6 – 26.8 cm	37.0 cm
Width	8 units $\cong$ 53.2 – 53.6 cm, case walls not included	58.0 cm
Width of keyboard	8 units $\cong$ 53.2 – 53.6 cm	50.4 cm
Height	more than $\cong$ 15 cm	17.5 cm
Material of case	?	Cypress, poplar
Material of soundboard	?	Spruce
Material of wrestplank	?	Oak
Material of bridges	?	Wild cherry
Material of strings	Iron or brass	Brass 70% Cu, 30% Zn
Roses	5	3 – parchment

The “unit”, or “module”, used by Arnaut is not defined in his treatise. A value between 66.4 mm and 66.9 mm has been retained here<sup>7</sup>. It has been determined as follows, from the width of the naturals of the organ painted on the Altarpiece of Ghent (c. 1420-1430) and from the width of the naturals of the Urbino clavichord (c. 1470).

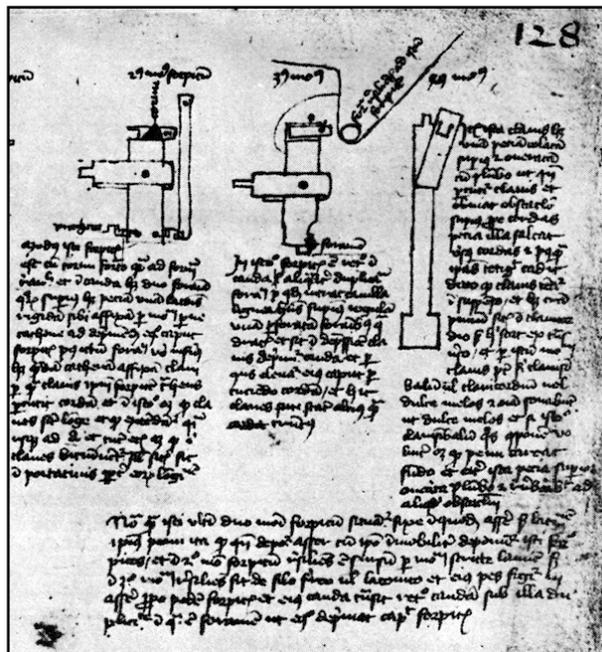
1. The width of the natural keys of the organ painted by the brothers van Eyck on the Altarpiece of Ghent, has been determined<sup>8</sup> to be 25.5 mm, inter-key included.
2. The *Stichmass* for the Urbino clavichord<sup>9</sup> is 532.0 mm, which yields a width of individual natural keys of 25.3 mm, inter-key included. This is in excellent agreement with the organ of the brothers van Eyck.
3. From now on, we will assume that such width might be transposed to the clavisimbalum drawing, which was drafted by Arnaut at a close date, in a similar cultural context and, for the van Eyck organ, in the same ducal court. This assumption seems reasonable.
4. One can now sum up the assumed widths of the 21 natural keys of the clavisimbalum. This gives a keyboard width between 531.3 mm and 535.5 mm for the clavisimbalum.
5. Dividing the keyboard width obtained so far by 8, for the eight modules, one gets, for each module, a measure between 66.4 and 66.9 mm<sup>10</sup>.

<sup>7</sup> It is worth noticing that such values are very close to 2.5 times the inch ( $\approx 2.5 \times 27.07$  mm) that was in use since the *Admonitio generalis* of Charlemagne of 789 in most of France and related areas. This inch was defined as one-twelfth of the *royal foot* (also called “Paris foot”), measuring  $\approx 32.48$  cm.

<sup>8</sup> KAUFMANN, MARTIN-KNUD, *Le clavier à balancier du clavisimbalum (XV<sup>e</sup> siècle)*, in *La Facture de Clavecin du XV<sup>e</sup> au XVIII<sup>e</sup> siècle*, (1976), Musicologica Neolovaniensia. Studia 1, Louvain-la-Neuve, 1980: 9-57.

<sup>9</sup> VERBEEK, PIERRE, *The Urbino clavichord revisited*, De Clavicordio X, Proc. of the VIII International Clavichord Symposium, Magnano, 6-10 September 2011, Ed. by Bernard Brauchli, Alberto Galazzo, Judith Wardman, ISBN 978-88-907625-1-3, p. 205-224.

<sup>10</sup> This value for the module is larger than that proposed by Stewart Pollens, 62.75 mm, quoted by RENNOLDSON, CARL, *The Clavisimbalum from the Manuscript of Henri Arnaut de Zwolle, c.1440* (July 2001, revised April 2013), FoMRHI Quarterly, Comm 1765, (Fellowship of Makers and Researchers of Historic Instruments FoMRHI). The module mentioned by Stewart Pollens is based upon the width of the keys of a late 16<sup>th</sup> c. virginal by Hans Ruckers.



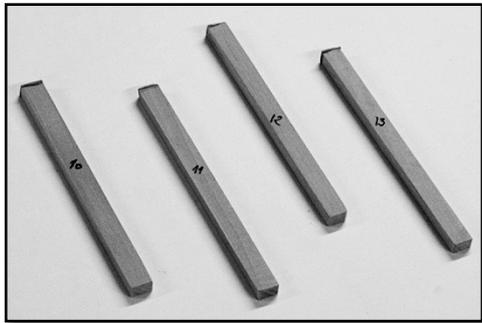
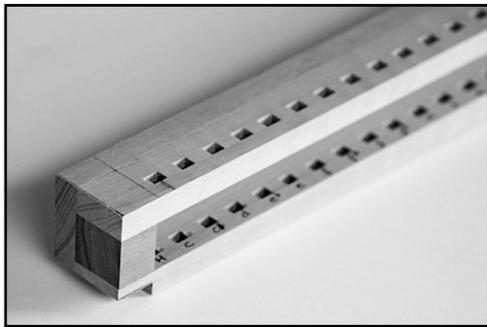
## Keyboard / keyframe

	Features according to Arnaut's treatise	Features of the 2019 interpretation
Width of naturals (inter-key included)	25.3 - 25.5 mm	24 mm
Front part of natural touchplates	≅ 25.9 – 26.1 mm	33 mm
Overall length of natural touchplates	?	101.5 mm
Length of sharps blocks	≅ 23.8 – 24.0 mm	67 mm
Length of natural keys = length of keyplank	≅ 166.0 – 167.5 mm	307 mm
Width of keyboard at the front	≅ 532 – 536 mm	504 mm
Width of keyboard at the rear	≅ 532 – 536 mm	495 mm
Material of keylevers	?	Lime
Thickness of keylevers	?	13 mm
Material of natural touchplates	?	Boxwood
Material of sharp blocks	?	Bog oak with bone tops
Keyframe	None ?	Poplar / cypress
Balance rail	Iron wire	Cypress, felt washers

For his clavisimbalum 2019, the customer has requested a keyboard that would be close to those of his other instruments, more modern, which is significantly different than a 15<sup>th</sup> c. design. Hence, the keyboard layout has been adapted to this request: the width of the naturals has been reduced to 24 mm (inter-key included), the sharps have been slightly chamfered, and the lengths of both naturals and sharps have been increased. A keyframe and a balance rail have been added. The outcome of those adjustments is that the keyboard eventually resembles closely to the Flemish / Ruckers “standard” keyboard of the early 17<sup>th</sup> c., as clearly suggested by the data on the table above and shown on the photograph on page 6 opposite.

## Hammered mechanism – Arnaut's text

Arnaut's text	Free translation
Item ista clavis habet unam peciam colatam superius et oneratam cum plumbo	In the same way this key has a piece glued on the upper part and weighted with lead.
ut quando percutitur clavis et obviat obstaculo superius prope cordas pecia illa saltat versus cordas	In this way, when it is struck by the key and meets an obstacle above, near the strings, that piece jumps against the strings.
et postquam ipsas tetigerit cadit, dato quod clavis teneatur in suspensio	After it has struck them, it falls down, the key is held suspended.
et habet crampinum sicut in clavicordio sed hic stat ex transverso	<The piece> has a crampinum like in the clavichord, but here it lies sideways.
et per istum modum clavis potest fieri clavisimbalum vel clavicordium vel dulce melos, et omnia sonabunt ut dulce melos	With this type of keys one can make a clavisimbalum or a clavichord or a dulce melos, and all will sound like a dulce melos.
et si isto modo clavisimbalum quis componere voluerit, oportet quod <peciam> careat fundo, et erit ista pecia superior onerata plumbo, et reverberabit ad aliquid obstaculum	If one wants to build a clavisimbalum of this type, it is important that the <piece> must be detached from the bottom, and that this upper piece must be weighted with lead, and will rebound against the obstacle.



## Hammer mechanism – 2019 interpretation

The text of Arnaut on the fourth *modus*, the striking mechanism, is not very explicit; it is therefore open to speculation and interpretation. However it is possible to find very simple mechanisms that would comply with the description of Arnaut and his drawing, the simplest being a free vertical tangent at the end of each key on the keyboard. When the key is depressed, the tangent rises towards the string and strike it. The escapement is obtained simply by the conjunction of two design features: (a) an obstacle stopping the movement of the key upwards; and (b) the length of the tangent adjusted in such a way that the tangent loses contact with the string by gravity, just after having struck it.

It is that basic mechanism that has been retained for our interpretation, albeit with the addition of an intermediate lever. We tested the simplest mechanism without an intermediate lever, and its poor kinematics lead to an extremely direct keyboard touch and to a rather weak sound. The reflections lead us to add this intermediate lever.

The photographs on page 8 show the solution developed for our reconstruction. It is very similar to the Tangentenflügel mechanism developed 350 years later by Franz Jacob Späth and Christoph Friedrich Schmahl<sup>11</sup>.

## Tangents

In our reconstruction, the tangents – hammers, really – are small sized sticks (approx. 5 mm x 5 mm x 78 mm) made in pear wood. They are guided by an upper and a lower register, made in a way similar to those of the Ruckers registers for harpsichords<sup>12</sup>. See the photographs of tangents and registers on page 8 opposite.

## Dampers

The instrument has no dampers, in compliance with Arnaut's drawing and with Denzil Wraight's remark "*Bei allen Mechaniken ist es wahrscheinlich, dass eine Dämpfung der Saite nicht vorgesehen war.*"<sup>13</sup>: This ensures the production of long, lasting tones when the strings are struck by the hammers or by the tangents.

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<sup>11</sup> DI STEFANO, GIOVANNI PAOLO, *Tangentenflügel e altri pianoforte con martelletti non imperniati*, Università degli Studi di Roma 'La Sapienza', Dottorato di ricerca in storia ed analisi delle culture musicali XIX Ciclo, 2006. DI STEFANO, GIOVANNI PAOLO, *The Tangentenflügel and Other Pianos with Non-Pivoting Hammers*, The Galpin Society Journal, LXI, April 2008, p. 79-104, 242-244.

<sup>12</sup> O'BRIEN, GRANT, *Harpsichord registers*, in Ruckers, *A harpsichord and virginal building tradition*, Cambridge University Press, 1990, p.110.

<sup>13</sup> WRAIGHT, DENZIL, *Überlegungen zu Mechanik und Messurentwicklung im Cembalobau des 15. Jahrhunderts*, Das Österreichische Cembalo, Ed. Alfons Huber (Tutzing 2001), p. 79-88.



## Scaling

The scaling is as follows, measured on our reconstruction:

H	867 mm
c	839 mm
f	699 mm
c1	519 mm
f1	381 mm
c2	255 mm
f2	191 mm
a2	152 mm

## Stringing / tension

In accordance with the practice on dulcimers, clavichords, etc. since the early days of stringed instruments, we have decided to select a double-strung design for this reconstruction. Furthermore, as the strings of each choir must be capable of resisting to the hammer impulsion, we have increased their diameter compared to the usual thinner strings of plucked instruments. Therefore, we have applied the following stringing pattern for brass strings (70% Cu, 30% Zn – Malcolm Rose English brass).

H-d	0.56 mm
<i>eb</i> - b	0.52 mm
h – d1	0.48 mm
<i>eb1</i> – <i>f#1</i>	0.45 mm
g1 – b1	0.44 mm
h1 – d2	0.40 mm
<i>eb2</i> – <i>f#2</i>	0.38 mm
g2 – a2	0.36 mm

This yields a total longitudinal stress on the instrument of approx. 6000 N.

## Internal bracing and framing

In order to withstand a total load of approx.. 6000 N, we have added to the case sides a system of internal bracing and framing. The photographs of page 10 show the internal framing in poplar before and after the assembly of the external case in cypress.