Jan Bouterse: Research as a basis for the reproduction of historical recorders

This a translation of my article ‘Wissenschaftliche Untersuchungen als Grundlage des Nachbaus historischer Blockflöten’ published in the proceedings of a symposium held in 2012 by the department Musikforschung der Hochschule der Künste Bern (Switzerland).
The title of the symposium was: ‘Exakte Kopie' in Bern 2012. The proceedings were published by Sebastian Werr and Lyndon Watts, with the editorial assistance of Daniel Allenbach.

About the illustrations: instead of the black and white photos from the proceedings, I have added the original color images here. Unless otherwise noted, all photographs are by the author.
Publication of this translation: July 10th 2022

1.1 Introduction

The announcement of the Bern symposium said: In the last few decades it has been observed that modern replicas of historical wind instruments are increasingly moving away from their models.
In my opinion a reason for this distance may be that for the maker the memory of the model instrument has faded over the years. Or one either did not perceive certain details of a historical instrument at the time or did not see through its function. My advice: it is advisable to orient yourself broadly and to include several instruments from the same maker in the investigations.
There are problems to be solved. How close can you get to the instruments? One often has to be content with drawings and measurements by other researchers. But then you don't always have a good overview of how complete and useful they are in terms of a replica. If you have the opportunity to examine historical instruments yourself, you have the problem that not all measurements are allowed. For example, the question arises as to whether the block of a recorder can be removed out of the head and, in general, whether the instrument can be played for a short or long time.
Once the measurement data are available, there are further problems of how to deal with it. It needs to be clarified whether the data can be used unchanged for making a copy or whether, for example, the dimensions of the original must first be reconstructed in order to determine what it might have looked like. The responsible woodwind maker would also like to know what technical means his historical predecessor worked with and what ideas he held about how his instrument should sound.

This article addresses the problems encountered when measuring and replicating historical recorders. The starting point for this article is my contribution to the three catalogs of Dutch woodwind instruments in the former Gemeentemuseum (now ‘Kunstmuseum’) The Hague*, including two instruments therein, of which I have made copies. These were a soprano recorder and an treble recorder by Engelbert Terton.

* - Rob van Acht, V. van den Ende & H. Schimmel: *Niederländische Blockflöten des 18.Jahrhunderts- Dutch recorders of the 18th century*, Celle 1991 (künftig als 'Blockflötenkatalog' bezeichnet)
- Rob van Acht, J. Bouterse & P. Dhont: *Niederländische Doppelrohrblattinstrumente des 17. und 18. Jahrhunderts - Dutch double reed instruments of the 17th and 18th centuries*, Laaber 1997 (im Text als 'Doppelrohrkatalog' bezeichnet).
- Rob van Acht, J. Bouterse & V. van den Ende: *Niederländische Traversos und Klarinetten des 18. Jahrhunderts - Dutch traversos and clarinets of the 18th century* (Frankfurt 2004).

Furthermore, this article refers to the English translation of my dissertation published in 2005 by the Koninklijke Vereniging voor Nederlandse Muziekgeschiedenis (KVNM) as Dutch woodwind instruments and their makers, 1660-1760.*

* In the references, the abbreviation 'Diss. Par. 5.2': Dissertation, Paragraph 5.2. See http://home.kpn.nl/mcjbouterse/Dissertation-Table -of-contents.pdf for the table of contents and www.kvnm.nl for more information about the dissertation.

Fig. 1.1: The Terton treble recorder from the Boers collection. The photo from 1981 was taken in the workshop of an instrument maker who had borrowed the instrument from the museum for his own studies. The recorder is made of boxwood, the brown paint layer is unevenly worn, the middle section is clearly warped, a continuous crack is visible at the top of the head. Right: Photo from the website of the Rijkmuseum Amsterdam (not in the original article).

Explanations

- In this article 'soprano recorder' refers to the soprano recorder by Engelbert Terton from the Gemeentemuseum collection with the inventory number Ea 374-1933 (new numbering 1933-0374) and 'treble recorder' to the instrument by Terton from the Boers collection in which Gemeentemuseum it had the number Ea 31-x-1952 (later 1952x0031), after returning to the Rijksmuseum in Amsterdam in 2010 the flute was given the inventory number BK-NM-11430-94. In the dissertation the soprano recorder is marked 'Terton-1' and the treble recorder 'Terton-2'.
- The notes on the instruments 'left', 'right', 'above' and 'below' refer to the player’s view when holding the recorder ready to play.
- The length and diameter dimensions in the tables and drawings are given in millimeters using the dimension point.
- All photos used in the article are taken by the author.

1.1 Alterations

Since the publication of the first catalog in 1991, there have been several alterations to the state of the instruments. In the discussion I shall confine myself here to the recorders. Rob van Acht had selected seventeen instruments for the recorder catalog at the time: by Abraham van Aardenberg, Willem Beukers, Thomas Boekhout, Van Heerde, Jan de Jager, I. Roosen, Engelbert Terton and Robbert Wijne. Eleven of these seventeen recorders come from the Boers collection, which was loaned to the Gemeentemuseum by the Rijksmuseum Amsterdam in 1952. In 1993 some more instrument parts were found in the Rijksmuseum. Included is the original foot of the treble recorder by Van Heerde (in the catalog this instrument has a foot by Boekhout), and a middle section of an alto by Boekhout, which was then in turn combined with the Boekhout foot that has since become vacant, while the head is still missing. Finally, the middle section of a recorder was discovered by Steenbergen.*

In addition, in 2010 the Boers Collection returned to the Rijksmuseum Amsterdam. Apart from the recorders mentioned above, 19 of the 38 double-reed instruments described and 6 of the 20 transverse flutes and clarinets also belong to the Boers collection. The three catalogs on the Dutch woodwind instruments have thus lost at least one function as inventory catalogs of the Hague Gemeentemuseum (Kunstmuseum).

* The data on the instrument parts mentioned here can be found in the dissertation, Appendix C

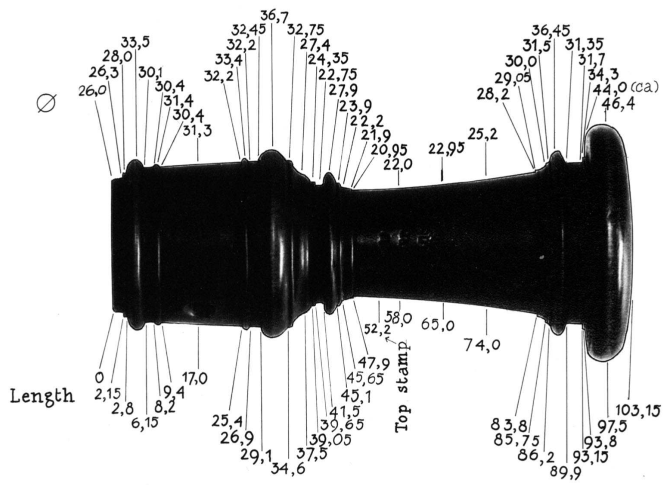


Fig. 1.2: For the catalogues, it was decided to draw the most important external dimensions such as length and diameter in black and white photos reproduced at a scale of 1:1. The black and white photo of the base of the Terton treble recorder turned out to be very dark , while on the other hand, details such as the stamp imprint can be seen more clearly in the color photograph of the complete instrument.

1.2 On the accuracy of measurements

Information about the surveying techniques is essential for the interpretation of the measurement results.*
With what accuracy were the measurements taken? It is also important to distinguish between measurement technology on the one hand and the presentation of results in drawings and tables on the other. An example: on the display of modern digital calipers you can see the result of a measurement with an accuracy of 0.01 mm. However, if each measurement process is repeated several times for a reliable result, it could turn out, for example, that the deviations between the measurement results are significantly more than 0.01 mm.

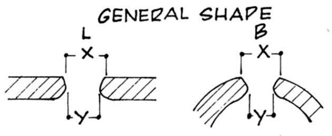
*While there is little on this aspect in the recorder catalogue, the double-reed instrument catalog proves to be much more informative.

In the recorder catalogue, all external length and diameter dimensions are recorded with an accuracy of 0.1 mm, the dimensions of the finger holes with an accuracy of 0.05 mm and those of the bores with an accuracy of 0.01 mm. This information suggests a very high level of accuracy, but this is open to doubt. Because the results are based on calculations as described below. A movable scanning arm is pushed through the whistle part, the deflection of this scanning arm being read as an angular deviation, in order to calculate the diameter of the bore using a mathematical formula. The formula contains a division, so that any number of decimal places could be specified in the result.*

* An advantage of the tracer survey technique is that expansions in a cylindrical or conical bore are accurately registered. A disadvantage is that working with these systems is quite time-consuming and, moreover, that there is a risk of less accurate measurements if the instrument parts are warped. In the other two catalogues, the bores were made with fixed measuring calibers, with the results on accurate to 0.1mm.

1.4 Researcher preferences

Which parameters are measured on an instrument sometimes depends on the preferences and opinions of the respective researcher. For example, Hans Schimmel not only noted the smallest opening Y in the schematic drawing for the table, both in length and width, but also marked the somewhat larger dimensions on the surface of the flute parts in the drawing with X (Fig. 1.3). This could also be referred to as an ‘overcutting’, but this is not a common term in instrument making practice.
However, there is no indication of the undercuttings of the tone holes in the tables and drawings. You can read about this in the introduction to the recorder catalog (p. 23): *The undercutting of the tone holes is not exactly indicated in the drawings. This can certainly be measured with modern material and modern equipment, but the result was always fairly imprecise. For this reason, and also because the undercutting of the tone holes can almost always be seen as a correction of the actual construction, we [Hans Schimmel and Rob van Acht] decided to give a more global indication and to use X-rays. [...] On the picture shown you can see the dimensions of the undercut of tone holes in the longitudinal direction of the recorder.*



Ø FINGERHOLES

	X L × B	Y L × B	CENTRE HOLE AT
0	4,9×5,0	4,9×4,9	30,8
1	4,65×4,55	4,6×4,5	43,4
2	4,8×4,75	4,65×4,7	64,4
3	4,85×4,85	4,7×4,8	87,6
4	4,7×4,8	4,6×4,75	112,5
5	4,7×4,8	4,6×4,75	132,8
6	4,15×4,1	4,0×4,1	153,2
7	4,75×4,6	4,35×4,45	173,2 (RIGHT HOLE)

Fig. 1.3: In the figure (finger hole table) The finger hole data of the Terton soprano recorder (measurement: Hans Schimmel, drawing: Vincent van den Ende). The seventh hole is double drilled left-right, the unused left hole is plugged with wax.
The seventh hole is drilled slightly (approx. 2 to 3 mm) obliquely downwards, but this is not indicated in the table and drawings.

Unfortunately, the quality of the X-rays is not good enough to get a clear picture of the undercuttings (see fig 1.3-b). And one could further argue about Hans Schimmel's view that the undercuttings are almost always corrections to the actual building. In my experience, undercuttings are often characteristic of certain flute makers and show how they worked on the tone holes. There is therefore reason enough to measure and describe them precisely, which is what happened in the two following catalogues.

Fig. 1.3-b X-ray of middle part and foot of the Terton alto recorder (from the 1991 catalog, not in the original article).

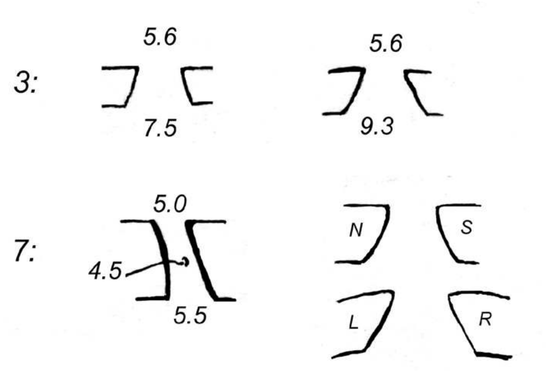


Fig. 1-4: Fingerhole undercuttings from an other Terton treble recorder (private collection Hazerswoude, The Netherlands). Top row: undercutting of hole 3 in longitudinal and transverse direction. Bottom left: hole 7 (on foot); bottom right: the general undercut shape from the finger holes of this recorder. The drawings are made from wax prints; this technique is not permitted in most museums but is very instructive.
On this recorder, the undercuttings from hole 0 to 6 are very similar, with almost the same angles of the tone hole walls.

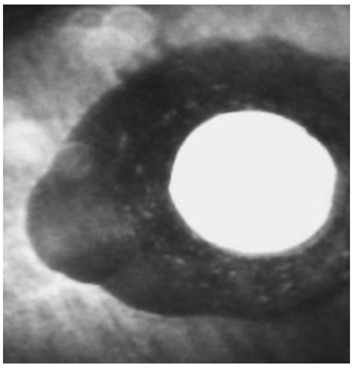


Fig. 1-5: Endoscopy image of one of the tone holes on the Terton treble recorder from the Boers collection. It can be clearly seen that on the left the undercutting is somewhat irregular. However, it is a clean job which leads me to believe that the holes are still in their original condition.

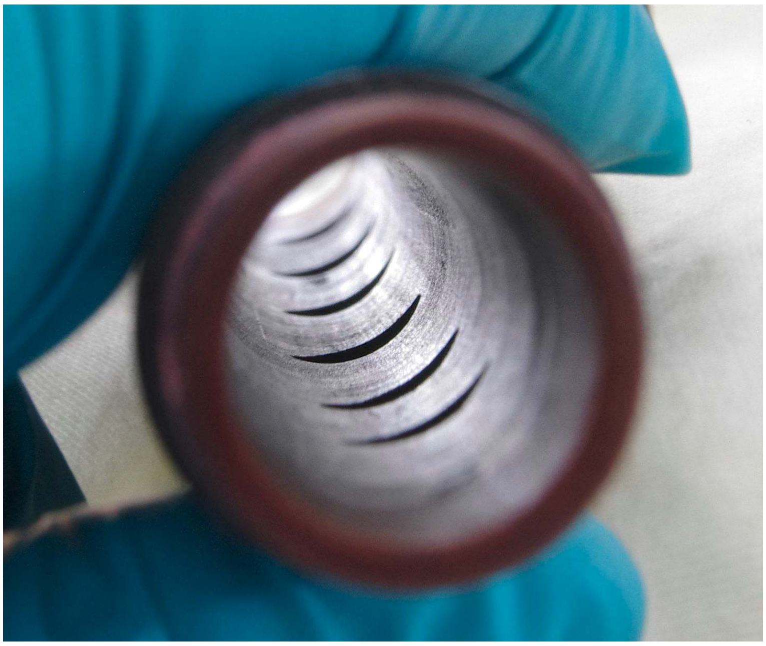


Fig. 1-6:
Photo of the bore of the same treble recorder with a regular arrangement of the openings of the tone hole undercuttings.

Figures 1-4 to 1-6 are very informative for instrument makers. They show details that are missing in most catalogues, including those of the Gemeentemuseum.
Finally, it should be pointed out that aspects without acoustic significance must not be ignored in a description. Examples are the shape of the sockets and tenons, details in the turning work or the exact position of the maker's marks.

2 Two Terton recorders: the descriptions

2.1 The instrument descriptions

In the instrument catalogues, the descriptions aim to add further aspects to the drawings, photos and tables that go beyond their possibilities.
It goes without saying that the aim is to be factual and objective, although the personality of the researcher has a decisive influence on the assessment. This applies not only to the illustration of the state of preservation, the processing and finishing of the instrument or the quality of the lathe work*, but above all the technical playing and tonal properties of the instruments.
In doing so, I have experienced that the information content regarding the musical quality and playing possibilities - which the reader of an instrument catalog usually has an increased interest in - sometimes suffers if the description turns out to be too factual and objective.

* In the catalog for the double-reed instruments I have qualified the turning work for certain instruments and explained the subjective terms used there such as 'elegant' and 'bold' in the introduction.

2.2 The soprano recorder

The catalog description of the soprano recorder begins as follows: The two-piece recorder is a beautifully finished instrument with silver fittings on the head and foot joint. The block is also lined with silver at the edge of the beak and at the entrance to the core fissure. The wood of the middle part is impressively grained. Unfortunately there is a long and partially glued tear on the left side of the head joint almost to the labium. The lip of the labium has broken off a bit, while a broken piece of wood at the base of the mouth has been restored. Otherwise, the instrument is remarkably well preserved.
Unfortunately, the wood species of the flute, which is boxwood (Buxus semper-virens L.), was not included in the description. Terton positioned the radial face of the wood on the front of the flute components. In his notes, Hans Schimmel referred to the wood of the block as cedar. But it is not known which cedar species it is and it is also difficult to determine. For reasons of age, it is often hardly possible to identify the wood of the block with the help of colour, smell and macroscopic features. The only reliable method is to examine the wood under a microscope. This means that the wood would have to be damaged, which is usually neither possible nor necessary.
The detail drawing in the catalog shows that the block path lies between the radial and tangential surfaces of the wood.

The instrument is not only known for its luxurious features, but also for its good playability and beautiful sound. Two sound recordings bear witness to this, one by Frans Brüggen and the other by Saskia Coolen. In the course of his recordings, the first of which dates from 1972, Frans Brüggen played seventeen original baroque recorders from various collections (Telefunken, Das Alte Werk, SMA 25073-T/1-3; these recordings were also published on audio CD in 1995, Frans Brüggen Edition, Teldec 745099747527). The recording by Saskia Coolen was released as an audio CD in 2004 entitled 'Recorders recorded' (Globe GLO 52090).

Fig. 2.1: The Terton soprano recorder. The instrument was formerly lacquered or stained dark brown, with the layer of paint largely missing and some suggesting that it was deliberately scratched away. As a result, the stamps are a bit vague. Traces of the original paint layer can still be seen in the narrow grooves of the turned parts. The instrument is recently in the Rijksmuseum, the inventory nummer is BK-2016-98-19 (photo from the website of the museum).

Fig. 2.2: The silver fittings on the foot ring and head baluster of the soprano recorder

It's no secret, because Frans Brüggen himself reports in the accompanying text of the recordings that several of the recorders he played that came from museums ripped under his hands, while this did not happen with the privately owned instruments.* The reason for this lies in the fact that the latter were played continuously by their owners, while the museum instruments could no longer cope with the sudden changes in humidity and temperature. Terton's soprano recorder was also among the victims, suffering a crack in her head.

* Frans Brüggen played 17 recorders for the recordings, 8 of which came from private collections. He writes: This phenomenon 17 (indivisible) and 8 (divisible) later proved very interesting when I realized that 17 is indeed divisible, because some wonderful museum pieces broke in my hands, and because the 8 flutes private collectors played almost daily by the owners, despite the terrible central heating in my house, didn't break.

In addition to the damage already mentioned, the soprano recorder has a number of special features and irregularities that cannot be properly identified from the illustrations and tables and have therefore been included in the description section of the catalogue. For example, the windwayis slightly off centered (to the left). The side walls of the labium are also slightly asymmetrical, with the right side wall being directed somewhat more to the right than the left wall to the left. As a result, the side walls of the labium are not of the same height at the edge of the labium. In the detailed drawing, these dimensions are given as 4.4 and 4.75 mm.
In addition to the small and inconsequential restoration at the windway opening, there was probably another intervention that is more serious and questionable. These are the undercuttings of the finger holes. Hans Schimmel had already noticed that some holes, especially holes 5 and 7, are wider and less regular than the other holes. It remains to be surmised that these changes to the undercuttings, which are almost imperceptible to the instrument from the outside, were made in the twentieth century to improve the intonation of the low notes. Such irreversible interventions are now considered a professional mortal sin, but this may not have been a general opinion fifty years ago.

2.3 The treble recorder

The description of the Terton treble recorder in the catalog begins with a list of the instrument's short-comings: This Terton recorder stands out due to its particularly warped middle joint. There is a deep crack in the upper part on the right side of the headjoint; the small upper ring has been filed away*. The block has various cracks in the area of windway opening; Otherwise, the entire instrument (especially the headjoint) has scratches and signs of impact.

*Once the centerpiece has been examined more closely, the description 'particularly severely warped' can be more appropriately characterized as 'clearly warped'. The 'small upper ring' is marked 'small ring' in the drawing of the recorder head on page 26 of the catalogue; the turning work as part of woodwind instruments raises considerable problems in the description when naming and especially when translating into another language. There is no standard terminology, especially for smaller details.

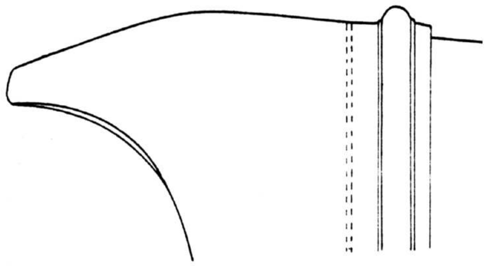


Fig. 2.3: Side view of the upper part of the treble recorder head. Fig. 2.4: The filed ring is indicated on a drawing by Vincent van den Ende (this drawing is not published in the 1991 catalogue).

It seems more appropriate to precede the description of an instrument with a summary of the most important aspects (and not with the shortcomings). The brief description in Appendix C of my dissertation reads in translation: Alto recorder in brown-stained boxwood, formerly played intensively, now relatively warped and crooked and with a continuous crack at the top of the head. The beautifully designed windway with block and labium is in good condition. The playing characteristics of the instrument are also of high quality. The stamps: E:TERTON with crown and standing lion.

Also on this treble recorder, Terton has positioned the radial face of the wood at the front, while on the block it is on the side of the block track, as in the detailed drawing of the catalogue. As with the soprano recorder, the side walls are asymmetrically cut and the windway is clearly off-centered.*

* This course of the windway is not described in the catalog or derived from the drawings and measurements. Only during a recent inspection of the instrument during a visit to the depot of the Rijksmuseum did I notice the extent of this asymmetry of the windway and labium. And basically, from this point of view, it makes sense to examine Terton's other recorders again.

Fig. 2.5: Terton's treble recorder photographed from above. The black line is drawn vertically down from the center of the windway opening. The asymmetry of windway and labium is clearly visible.

3 The pitches and tuning of the recorders

3.1 Assessing the pitch

A woodwind maker who wants to replicate an instrument has the greatest interest in knowing the tuning of the original instrument as precisely as possible. At first glance, it would appear that recorder pitches are easier to determine than transverse flutes or oboes, where embouchure and choice of reed and stylus greatly affect pitch. But it is questionable whether this assumption is justified.
The pitches of the playable instruments are given in tables in the 1991 recorder catalogue. My own measurements sometimes show strong deviations from those data, recorded by Hans Schimmel. In discussing this issue with Rob van Acht, we first came to the conclusion that differences could be due to conversion errors. But there was no evidence of this, so in 1992 I suggested playing the treble recorder again.*
The result was pitches that were twenty to thirty or even more cents higher than those found by Hans Schimmel. Table 3.1 gives an overview of the comparison. The discrepancies raised the question of whether Hans Schimmel might have played the flute differently.

* The results of this recording are published in the dissertation in paragraph 8.7.

Ton	Schimmel 1991	Charles Stroom 1985	Jan Bouterse 1992
f1	-35	+5	-5/+5
g1	-52	nm	-20/-10 (-5 possible)
a1	-56	nm	-20/-10 (-5 possible)
b-flat1 (0 1 2 3 4 . 6 7)	-52	-5	-15/-10
b1 (0 1 2 3 . 5 6)	-22	+15	+15/+20
c2	-48	0	-10/0
d2	-48	-5	-15/-5
e2	-39	0	-5/+5
f2	-31	0	-10/0
f#2 (. 1 2)	-69	-5	nm
g2	-26	+15	0/+10
a2	-31	0	-15/-5 (0 possible)
b-flat2 (0h 1 2 3 4 . 6)	-48	-20	-15/- 5
b2 (0h 1 2 3 . 5)	-14	+10/+15	+15/+20
c3	-10	0	+5/+15
c#3 (0h 1 2 . 4)	-48	-25	-15/-5
d3	-18	-10	-10/-5
e3	-48	-25/-30	-20/-10
f3	-31	-30	-20/-10

Table 3.1 Pitches from the treble recorder Ea 31-x-1952 by Engelbert Terton (in the Boers collection in the Rijksmuseum, this recorder has the inventory number BK-NM-11430-94).
Explanation: the pitches are given in cents as deviations from the tuning a'=415 Hz for an even voice. Missing measurements are marked with 'nm'. The English notes are given in italics. In the recording from 1992, the measured difference in tuning is given for each note, rounded to the nearest 5 cents.

Table 3.1 shows clear differences between the measurement series. If air pressure measurements had also been carried out at the same time, they could possibly provide information about the causes of these deviations. The catalog of Renaissance recorders in the Kunsthistorisches Museum in Vienna provides an example of such parallel measurements.* The instruments were blown on mechanically using a wind machine. It turned out that the air pressure build-up between the registers is quite different. Some specimens require significantly more pressure than others for the highest playable notes. The Terton treble recorder is an instrument with great stability. Because until the sound breaks, the air pressure can be increased relatively strongly. Even if the pitch rises, it should hardly be 30 cents.

* Beatrix Darmstädter: The Renaissance recorders from the collection of old musical instruments in the Kunsthistorisches Museum, Vienna, 2006.

On the audio CD 'Recorders recorded' from 2004, the tuning of the instruments played is also given in the accompanying booklet. The tuning a'=417 Hz was attributed to Terton's treble recorder, which presumably refers to the warm recorded flute. A'=409 Hz was measured for the Terton soprano recorder, which is 35 cents below a'=415 Hz. This value deviates much less from my own measurements. For c'', c''' and c'''' I found values of 40, 30 and 40 cents below a'=415 Hz, while Hans Schimmel measured only slightly lower values for these tones, namely 48, 48 and 61 cents below a'=415 Hz.* These findings make the relatively low pitches of the treble recorder measured by Hans Schimmel appear even more puzzling.

*In the catalog there is an error in the bottom line of the list for the soprano recorder, because the finger grip Ø 1 . 3rd 4th 6 7 it is d'''' instead of c''''.

3.2 Comparing the pitches of Terton's recorders

In order to assess the tuning of both the soprano and treble recorders, it seemed interesting to include Terton's other treble recorders in this comparison. Of the eight Terton treble recorders I know of, two are significantly longer than all the others. These two instruments - as far as they were accessible to my investigation - also have a lower pitch, which is comparable to that of the soprano recorder in The Hague.*

* The only reliable method of tuning comparison is to play the instruments in the same place under the same conditions. Unfortunately, this is practically impossible for eight recorders belonging to eight different collections.

The tuning of the recorders and transverse flutes of the other Amsterdam instrument makers shows a relatively wide range. For example, a group of instruments is tuned in a'=405 to 410 Hz, while the tuning of a'= 415 Hz is also regularly represented.* From this it can be concluded that the tunings of Terton for both the soprano and the treble recorder are in of the Dutch tradition.

* See Diss. Par. 7.8 3 on the tuning of Dutch recorders, and Par. 8.8.2 for the traversos.

3.3 The temperament of the tuning

Another important consideration with recorders is their tuning temperament. Is this to be assessed as well-tempered or more than mean-tone and purely tuned in the most important thirds? In the table with the measurements in the recorder catalogue, the first major third (c''-e'') on the soprano recorder is 13 cents too small and on the alto recorder (f'-a') 21 cents too small to be considered well-tempered be able. In the recording from 1992, however, a value of minus 15 cents was measured for the alto flute. These results indicate a meantone intonation.*

* A pure major third is 14 cents smaller than a well-tempered one.

But what about the other third intervals on the recorder? To do this, a remark must first be made. Because with instruments where the octave intervals - for whatever reason - are not pure, it is often not possible to determine the tuning temperatures from the smaller intervals. Furthermore, if there are several thirds in the first or lower register, a fork fingering is required for one of the two notes of the interval, for example for the interval d''-f'' or d''-f sharp''(f#' ') on the soprano recorder. For f'' and fis''(f#''), the player can add or subtract the finger at the bottom of the fork, or half-close a tone hole, to affect the intonation. The upper tone in the lower register shows a different problem. Because many finger holes are open, notes on the soprano recorder such as b'', b-flat'', c''' and d''' are significantly more sensitive to fluctuations in breathing pressure than the lower one tone is in the first register. And because of this, it can only be measured less accurately. In addition, historical woodwind instruments often show a contraction in the bore at the top tenon because the wood is thinner there. Such a contraction often raises the pitch of certain notes, such as c''' and d''' on the soprano recorder.*

* The intonation of affected instruments often improves when the middle joint is pulled out a little. So one could come to the wrong assumption that the center piece was shortened at the top. Also in conversation I had with Frans Brüggen, it turned out that he assumed that the soprano recorder he played was shortened by Richard Haka. However, after examining his instrument and comparing it with other Haka soprano recorders, I was able to assure him that a reduction in length is extremely unlikely.

On the treble recorder, the g'', where only the 2nd tone hole is closed, sounds a little too high due to the contraction of the hole at the upper tenon of the middle piece. There is also a bore contraction in the soprano recorder, but in contrast to the treble recorder, no major tuning imperfections are detectable. So does this instrument have a special quality that allows a good player to achieve good intonation with minimal correction? However, when I made my first copy of this soprano recorder, it became apparent that it was necessary to reconstruct what was assumed to be the original course of the bore. Fig. 5.1. offers the bore graphic. The antinodes of the air vibrations from the overblown tones e''' to a''' are located in the bore between the edge of the tenon and the thumb hole marked "0". If the bore is too narrow in this area, the octave intervals will be too small and the c'''' will be more difficult to respond.

The question arises whether the mean tone temperemant of the two recorders is special. Table 7.11 in the dissertation gives an overview of the character of the lower third on a selection of well-playable Dutch baroque recorders. In about half of the instruments the lower third was purely intoned, in the other instruments it was more well-tempered. It is noticeable that some instrument makers also have both types. It should also be noted that this comparison is only a general overview and most of the instruments could only be played briefly.

3.4 The fingerings

Of course, in order to determine the purity of tuning and the tuning temperature of a flute, one must use the correct fingerings. For my 1992 recording, I opted for Dolmetsch fingerings, also known as English baroque fingerings, which are used on almost all modern recorders. Although these fingerings are not ideal for the Terton alto or soprano, they can be used quite well*, which is not the case for many historical recorders, which is why other fingerings have to be used for some tones. The flute player can either take these from the historical tables, for example from the book of 1707 *Principes de la Flûte* by Hotteterre, or he has to look for suitable fingerings himself.

* With Dolmetsch fingerings, the b'/b-flat' is played on the alto flute with 0 1 2 3 4 . 6 7 and the b'' (b-flat'') with Ø 1 2 3 4 . 6 (0 is the thumb hole again, a dot means the hole is opened at that point). For my copy of the alto flute, I had previously provided these fingerings without any major problems. For this, only hole 4 has to be a little smaller and hole 5 a little bigger than on the original. It was also no problem to build the copy in a well-tempered mood. This means that the a' and a'' are slightly increased. The 6th hole must then be positioned a little more upwards on the center piece. With recorders in meantone intonation, the c#''' is often a bit low, while the b'' is a bit too high. The advantage of Dolmetsch fingerings is that - because the 4th hole is smaller and the 6th hole is slightly larger - these tones fit better into a well-tempered mood. On the other hand, with the recorder in the second register you can hardly adjust the fork fingerings with these tones, which in turn behaves completely differently than with the same tones, but one octave lower.

4 About the sound of recorders

4.1 To describe timbres

Is it possible to objectively assess the sound and playing characteristics of woodwind instruments and to express them in words or numbers? Anyone who undertakes this task inevitably exposes himself to the danger of creating confusion as well as the desired clarity. In his book 'Flöten', Herbert Heyde (1978) formulated sound descriptions for various instruments. He used terms such as *Volumen, Ton-volumen, Tonkraft, Klangstärke, Klangfrische und Tragfähigkeit oder wie Helligkeit, Schärfe, ange-nehme Rauhigkeit.* Instruments were alsso *grundtönig, obertönig,* or with *gedecktem* or *Näselklang* (volume, tonal volume, tonal power, sound strength, sound freshness and carrying capacity or such as brightness, sharpness, pleasant roughness. Instruments are described as having fundamental, overtones, or a muted or nasal sound). For an experienced player or instrument maker, such descriptions can be very helpful, although misunderstandings cannot be ruled out. A large volume of sound, for example, does not mean that the instrument sound also has great carrying capacity. Without definitions, there is not only the danger of misunderstandings but also the further danger that at the same time purely sub-jective evaluations of the person making the judgment flow in unnoticed. I noticed this, for example, with the treble recorder by Van Heerde from the Leipzig Musical Instrument Collection, where I came

to different conclusions than Heyde. However, such a sound description, even if it has to remain partly subjective, is ultimately an enrichment that one would not want to do without.
This requires a musical instrument researcher to define the sound and playing characteristics that he has studied so that memories of it cannot fade. Not only a finely trained ear is desirable, but also experience as an instrument maker, if possible, in order to grasp the connection between the various playing characteristics.

4.2 Terton's recorders and their sound

I have also described the playing qualities for the recorder catalogue, trying to limit myself to those that can best be determined objectively. These were the response of the tones in the different registers, which were characterized as light or heavy, the resistance to blowing and the presence of certain background noises, which I described as rustling, wolf sounds or ‘spucking’. Regarding the treble recorder, I noted in the catalog: the recorder responds well in the low range with stable tones and little background noise; from the middle register on it rustles a bit and in the high register (cis''' and f''') it sometimes responds poorly. In his notes to the catalogue, Hans Schimmel had said: beautiful, concentrated sound, highs responding well, but tending towards hissing, full, moderately stable lows. In Appendix C of my dissertation I added the assumption that some background noises in the second register as well as the poorer response of cis''' and f''' could possibly be traced back to the slightly too high block.
The 1991 catalog says about Terton's soprano recorder: The instrument is extremely playable, stable in the low range, easily responding in all registers and only has a few imperfections. I also included the opinions of two flute players in the dissertation *

* Disc. Table 7.14.

Heiko ter Schegget: rich in resonance, clear tone with some noise around the core, not sharp, with direct articulation, breathing resistance light but in excellent balance with the tonal and dynamic possibilities of the instrument. Hans Schimmel about the same instrument: a pleasant, clear and rich sound, lowest tones stable, speaks easily in the highest register.
Heiko ter Schegget and Hans Schimmel are (or were) professional players with experience in recorder making, so that their descriptions - albeit occasionally subjectively colored - were more detailed. However, here too the question arises as to which specific phenomena are involved in 'rich sound' or 'light noise around the core'. Those who have played this soprano recorder themselves can certainly understand such assessments. But to outsiders, they're likely to remain rather vague.

4.3 Different ways of examining the sound

From what has been said above, it becomes clear how subjective the perception of the playing characteristics remains, even with an instrument that is easy to blow, such as a recorder.*

* In the case of the Terton soprano recorder, the assessments of the sound of the three researchers are not very far apart. In contrast, the three judgments on a soprano flute by Abraham van Aardenberg differ significantly from each other (Diss. Par. 7.8.6).

In addition to the acoustics of the surrounding space, the experience and skills of the player are also important for a good judgement. Every instrument maker also knows the importance of a certain adaptation of the player to the instrument. One can certainly have the depressing experience that a player does not adapt to the instrument, produces an ugly whooshing sound on a top instrument and yet sometimes finds this flute wonderful.
So you can't avoid looking at a player's individual assessment with critical restraint. The existence of several judgments by different players for the same instrument is more meaningful. A larger number of opinions that still need to be read critically tends to provide a more reliable picture.*

*In an opposite approach, Piet Dhont was the only but very experienced player to play several instruments for the oboes in the double reed catalogue, which also led to interesting results.

Another but more technical method is the Fourier analysis of the sound structure. Rob van Acht has obtained sound spectra from various woodwind instruments, including Terton's soprano and treble recorder from the Gemeentemuseum collection. The instruments were played by professional players. The overtone graphs show differences in sound both between instruments and between different tones of the same instrument.*

* The results of his investigations can be found in the Proceedings of the Conference on Musical Instruments, organized by the Galpin Society, 9-11. July 1999 in Edinburgh.

However, it is not always easy to interpret the results of a Fourier analysis. And I even consider it dangerous to make overly broad statements about the sound character of the instruments of a certain flute maker based on such graphics.
Good players in particular adapt to an instrument and can still get a decent sound out of a bad recorder. One should therefore blow on the recorders with a wind machine, although this method can only cover a part of the instrument's playing possibilities.

4.4 The recordings by Saskia Coolen

The researcher must assess which characteristics of woodwind instruments are specific or incidental. He also has to reckon with the fact that some properties are initially hidden and only emerge when the instrument is carefully cared for and played in. Because with historical instruments from a museum there is almost always a problem that they cannot be played optimally immediately. Poorly fitting tenons, cracks and dried out wooden surfaces have a strong influence on both the sound and the playing characteristics. This was made clear to me when I heard Saskia Coolen's recordings for the 2004 CD 'Recorders recorded', Globe 5209. Because several of the nineteen recorders from the Haags Gemeentemuseum that she played were already known to me as being problematic.
In contrast to my personal experiences with the soprano recorder, when I could play it personally but only for a very short time, Saskia’s recording by Willem Beukers* sounded wonderfully clear and without the annoying background noises I noticed.
The two Terton instruments can also be heard on the CD with a very nice sound.

* In the recorder catalogue, this recorder from the Boers collection has the inventory number Ea 25-x-1952.

Conversely, however, it also happens that historical woodwind instruments begin to lose their sound after a period of playing in. The causes can be, for example, cracks that have occurred or a swelling block. Every recorder maker knows that even very small changes to the block or windwaycan have a significant impact on the playing characteristics of the instrument. Then the response, especially of the higher tones, can decrease, the approach can change, unwanted background noise can become noticeable and much more. Sometimes these changes to the block or bevels are so small that they are not even measurable.
In this context we must realize that for many historical recorders the changes that have occurred over a long period of time are not small but significant. The labium may be slightly sunken, the chamfers recut, the wood from the block may be roughened, etc. The Terton soprano and alto recorders appear to suffer little or no such problems. However, it is still possible that they also had a different sound in the past. In addition, there is something that Saskia Coolen writes about in the accompanying booklet of the CD 'Recorders recorded': It turned out that the old instruments are generally quieter and require a different way of blowing than the modern copies. Are they from a less noisy environment?
Have amplifiers and bigger orchestras changed our ears? Have the instruments shrunk and dried out so much that they sound different? Who changes more during the game, the instrument or the musician?

5 The bore profiles of the Terton recorders

5.1 The profiles of the bores

Woodwind instrument bores must be reamed with great care because the profiles largely determine the intonation and other acoustic properties. That is why it is important for historical instruments that you want to replicate to measure the bores precisely and to analyze the results.* It can be seen that while the outer profiles were made freely by hand, the bore profiles, which were mostly made with reamers with a solid profile, are more characteristic for the instruments of a particular woodwind maker.

* For a comprehensive introduction to this area, see Thomas Lerch's dissertation: Vergleichende Untersuchung von Bohrungsprofilen historischer Blockflöten des Barock (Comparative investigation of bore profiles of historical Baroque recorders), Berlin 1996.

As already mentioned, in the 1991 recorder catalogue, the bore dimensions are somewhat misleadingly specified at 0.01 mm. However, an accuracy of 0.1 mm is sufficient for an analysis or the production of reamers. When drawing graphs on graph paper, it is a good idea to always use the same scale.* It is then easy to compare the bore profiles of two instruments by superimposing the charts with the graphs and holding them up to the light. You can then see at a glance whether bores or only certain parts of them are identical. If you then move the reeds horizontally or vertically, you can see where a flute maker inserted the broaching tools deeper into the bore.

* The bore graphics I created for this article are sketched to provide a quicker view of bore profiles.

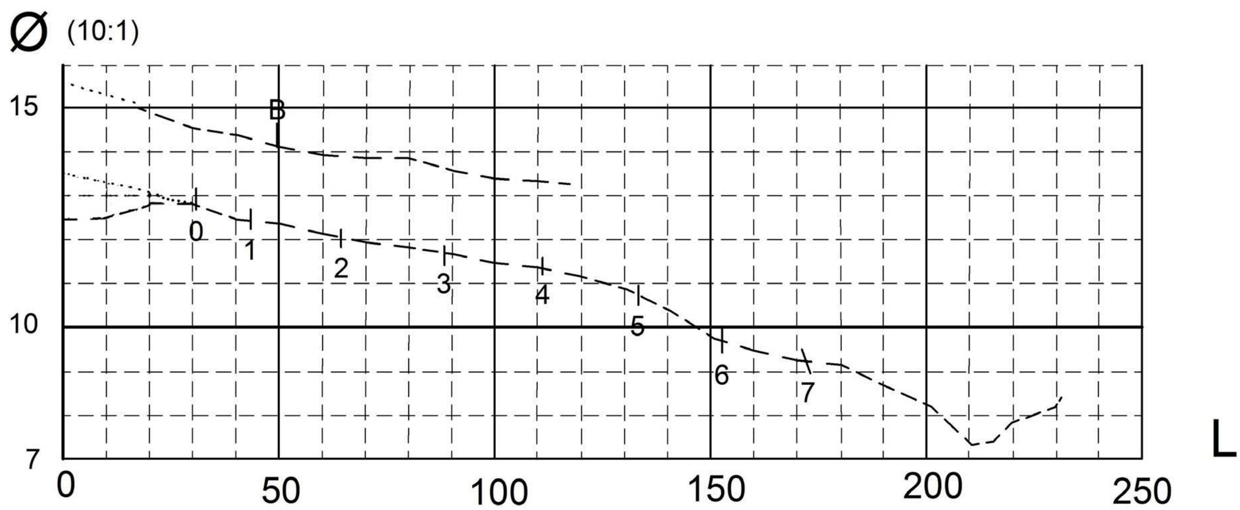


Figure 5.1: Bore diagram of the Terton soprano recorder. The upper dotted line of the head bore (B= block line) shows the assumed course of the bore in the area of windway. The bottom line indicates the bore profile from the base of the two-piece instrument. The numbers 0 to 7 denote the finger hole positions; Hole 7 is drilled slightly obliquely downwards. A tenon contraction of the lower joints is clearly visible between L 0 and L 25. The reconstructed course of the bore is shown in dotted lines.

In the head, the bore tapers from 14.1 mm at the block line to 13.1 mm at the lower end of the socket (which is not shown in the graphic). In the lower part, the bore in the area of tenon contraction widens from 12.5 to 12.9 mm and then becomes narrower. After hole 5 the taper is stronger while the bore widens again on the last 20 mm. At the narrowest point, the hole diameter is 7.2 mm.

No other soprano recorders by Terton are known. It is therefore not possible to determine whether this instrument is a special design. In comparison to other Dutch soprano recorders from Terton's time, however, there are no noticeable differences.*

* The closest agreement is found with a three-piece soprano recorder with a very beautiful sound by Philip Borkens (Dr. Iino collection, Tokyo, Japan). However, this has a slightly wider bore towards the bottom. See Diss. Table 7.16 for an overview of the most important dimensions of fourteen Dutch baroque soprano recorders from eight different recorders. Of these instruments, ten are in two parts, the other four are in three parts.

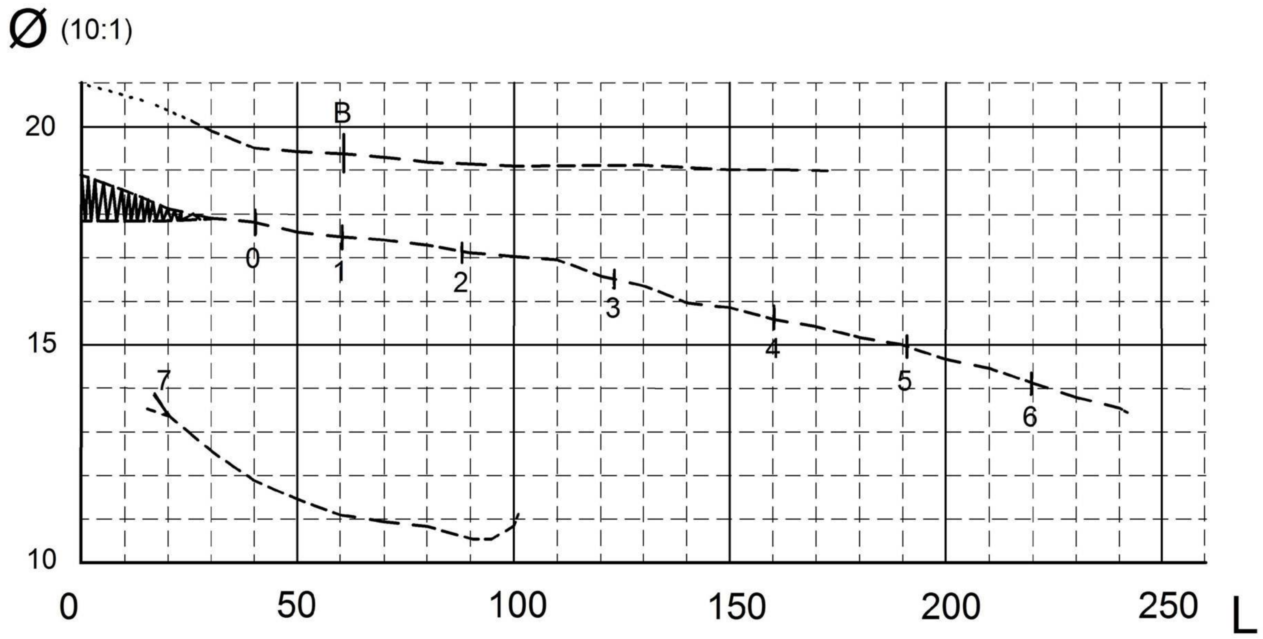


Figure 5.2: Graphic showing the bore of the Terton treble recorder (see Figure 5.1 for explanation). The three lines of head, middle piece and foot are recognizable. Hole 7 is also drilled downwards. The bore at the top of the middle piece has no actual tenon contraction, but is drawn strongly oval. The line above the hatching represents the wider bore, the lower line the narrower one. In the center piece, the bore gradually becomes narrower over the first 110 mm, after which the conicity becomes somewhat stronger. In the foot you can see that the bore graphic is a little steeper at first, and then gradually flattens out. At the lower end, the bore is only slightly cleared.

In the head of the treble recorder, the bore at the top where the block sits has a relatively strong conicity. After the labium, the bore becomes almost cylindrical.
The bore profile of this treble recorder bears a close resemblance to an ivory instrument by Terton in a private collection in the Netherlands, inscribed 'Terton-6' in the dissertation. The profile of the center joint bore is comparable to a boxwood alto flute from another private collection (Terton-7). However, if you compare the precisely drawn bore graphics, you can see that the reamer of the Terton-7 has pierced 10 mm further. The foot bore on this instrument also has a completely different profile. I believe that Terton only used two or maybe three different reamers for the middle sections of his treble recorders. As for the feet, I have also found in treble recorders from other makers that while their head and body bores are often very uniform in length and bore, the length and bore profile of the feet vary much more. Examples are provided by the treble recorders by Thomas Boekhout (Diss. Table 7.17) and by Peter Bressan*

* Jan Bouterse: 'Alto recorders by Bressan', FoMRHI Quarterly No. 118, (2011), p. 5-16

5.2 The walls of the bores

The German instrument restorer Rainer Weber has carefully examined many historical woodwind instruments over the course of his long career and also inspected the bores. In the article ' Insights into original recorders from the 16th to 18th centuries' * he discusses the surface structures of bores. He finds that not only are they rarely really smooth, but also that they are of great importance for the sound of the instruments: ... because in wind instruments the vibrations of the material are less important than the vibrations of the air column, which are strongly influenced by the structure of the surface.' Weber quotes a remark by Justus Johannes Ribock about an ebony flute made by Friedrich Gabriel August Kirst (1750-1806) in which the bore was polished smooth. As a result, the resonance was lost due to the presence of inelastic abrasives in the wood surfaces. On the other hand, a flute on which you could still clearly see the clearing marks in the bore had a much more pleasant sound. Weber goes on to say that oiling too much softens the flute walls and can destroy the sound. On the other hand, in my experience, on instruments where the wood is very dry, even a tiny bit of oil can make a dramatic improvement in tone. There is some debate among instrument makers about how and with what oil boxwood flutes should be oiled, namely only on the surface or through and through.

* Rainer Weber: 'Insights into original recorders from the 16th to 18th centuries', in: New Musicological Yearbook, Volume 15 2007, pp. 21-66.

It is not known how Terton treated the wood of his recorders. We also do not know whether the instruments have been oiled on the inside in the past fifty years. Both recorders discussed here have smooth bore walls, which is common for most boxwood instruments.

6 The windways, blocks and labia

6.1 The measurement data in the recorder catalog and the longitudinal profile of the windways

Historical recorders often have a complicated shaped windway. This enables experienced players to influence the sound of these instruments and to expand their dynamic possibilities. A flute maker who builds a copy would therefore like to have the most accurate information possible about the windways. Hans Schimmel measured the windways for the catalog in great detail, which means that we have exact knowledge of the longitudinal curvatures of the core gap roof and block track, for example. The results can be found as numbers in the tables and additional information can be found in the detailed drawings. But it's not so easy to combine all this data. The beautifully shaped windway of the Terton treble recorder should serve as an example for the interpretation of the measurement data.

The recorder catalog contains the following information for each instrument:
a- the table with horizontal and vertical bore diameters of the recorder head; b- two tables with the depths of the longitudinal curves of the block track and upper track ('windwayroof');
c- Detailed drawings with indications of dimensions of the curvatures in the transverse direction, of the upper course and block course as well as the labium edge.

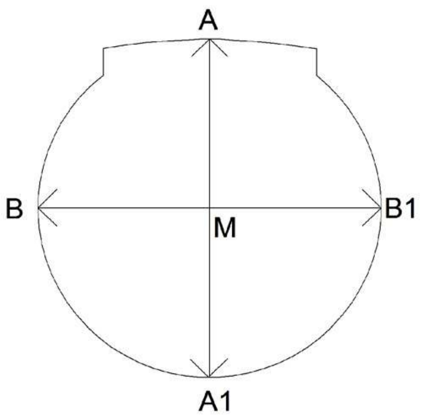


Fig. 6.1: Cross section through the recorder head in the windway area
A-A1: the vertical bore diameter (Ø-ver)
B-B1: the horizontal bore diameter (Ø-hor)

In the windway area, Schimmel took a horizontal and a vertical measurement every second millimeter. The profile of the broaching tools used by Terton can be derived from the horizontal bore dimensions. The course of the windwaycan be reconstructed from the vertical measurements.

Table 6.1 contains a summary of these measurements. L = length, Ø = diameter.
The last row, which is not in the catalogue, gives the calculations of the distance A-M (see Fig. 6.1). However, because of the cut-out beak curve, the measurements only start at L24 (horizontal) and L26 (vertical).
From the series of vertical measurement data (Ø-ver) one could conclude that the windwaydrops slightly between L38 and L60. That's not the case. Because the bore in this area becomes conically narrower in the direction of the window, for a correct assessment of the course we have to consider the distance from the fissure roof to the imaginary axis of the recorder head, i.e. the distance A-M in

Figure 6.1. To do this, you have to subtract half the horizontal value from the vertical value. The corrected image: the windwayroof rising to L50, then sloping down slightly to the window. From these calculations we also learn the important value of the step, which is the effective height difference between the windwayroof and the edge of the labium.

Table 6-1			
L	Ø-hor (B-B1)	Ø-ver (A-A1)	A-M
24	20.08		
26	20.00	20.18	10.18
30	19.89	20.19	10.24
34	19.77	20.16	10.27
38	19.66	20.18	10.35
42	19.57	20.17	10.38
46	19.51	20.16	10.40
50	19.47	20.16	10.42
54	19.45	20.15	10.42
58	19.42	20.11	10.40
60	19.41	20.09	10.38 (a) (Block line is at L 61.2)
62	19.38		
66	19.35	19.24	9.56 (b) (Labium edge = L 65.5)
72	19.29	19.22	(a) - (b) = step = 0.82 mm

What is not clear from this data is the course of the ‘beak section’ of the windway. This is to be calculated from the tables with the values for the longitudinal curvatures of the windway.
You have to imagine that a ruler is placed over the highest points at the beginning and end of the curve, with the distance from the upper web to the ruler being measured every second millimeter.*

* This measuring technique with the ruler is well suited for the longitudinal curvature of the block track. However, it is not clear how Hans Schimmel solved the problem with the windway roof.

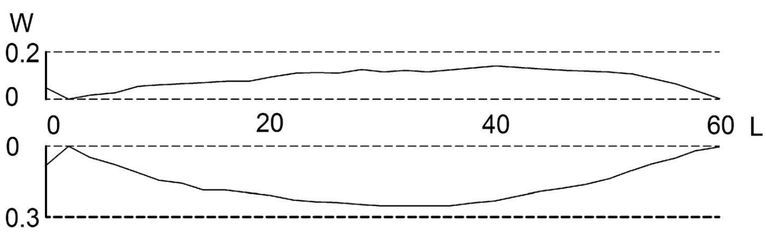


Fig. 6.2: Explanation of the graphic: the upper line shows the curvature of the upper track of the treble recorder, the lower one of the block track. The values are taken from the table with longitudinal curves in the catalogue.

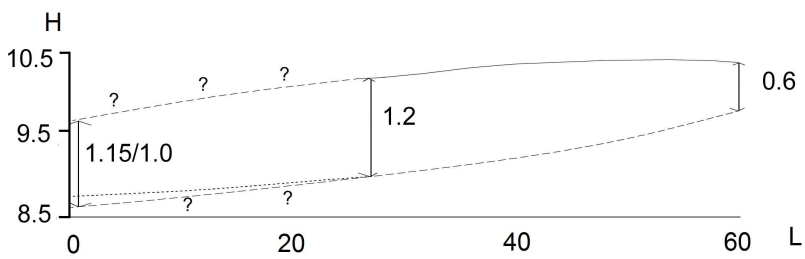


Fig. 6.3: Here the profiles of the curvatures of the top track and block track are given as the distance to the axis of the recorder head. The presumed course is marked with question marks. The values listed between the two lines refer to the distance between the upper track and the block track. The value of 0.6 mm is significantly smaller than the increment, because this is measured between the roof of the windway and the underside of the labium edge.

The graph in Fig. 6.2 is somewhat misleading because the windwayappears to have a much greater height in the middle than at the ends. Also, only the chamfers at the entrance of the windwayare drawn. Values for the chamfers - which are so important for the sound quality - were not given in the table with longitudinal curves.
In the graph of Figure 6.3, the top line relates to the calculations in Table 6.1 (the series of A-M values) and the bottom line relates to the dimensions of the block as they appear on the detail drawings in the catalogue.
The graphic in Fig. 6.3 shows that the largest core gap height of 1.2 mm is around L25. The windway and both the upper track and the block track run upwards.*
Even if it seems as if the differences are very small, experience teaches that in the windwaythey sometimes have a very strong effect on the properties of the recorder. Problems like the ones described here are quite common when reading instrument drawings.

* Because the Y-axis has a different scale than the X-axis in the graph of Fig. 6.3, the notion of the slope is somewhat exaggerated. The calculations assumed that the wood of the recorder head has not shrunk irregularly, which could lead to different results. It is also important to remember that there is a margin of error with any measurement. In the case of calculations with several measured values, the errors can then increase as a result of rounding. There is still an uncertainty. Hans Schimmel gives a value of 1.15 mm as the height of the opening of the windway. However, it is not clear whether this value was measured right at the beginning, at L0, or a little further, at L2, where the windwayis somewhat narrower. This uncertainty has a relatively strong effect on Figure 6.3. So that's why the question marks are drawn.

Terton made a similar, slightly curved top track in the windway in the soprano recorder. However, the maximum curvature is more in front. Corrected with the horizontal bore values, it turns out that the top track rises slightly over the first half and runs axially, parallel to the axis of the flute, over the second half of the length. The longitudinal profile of the block track is almost flat. The silver plate covers the block for the first 15 mm (Fig. 6.7a and b).

6.2 The windways in cross section

If a recorder company's brochure states that instruments are offered with a curved windway, this means that this canal has a convex cross-section. Many, but not all, historical recorders have such curved windways . More information about these profiles can be found in the recorder catalog on the pages with the detailed drawings. Fig. 6.4 shows some examples of Terton's alto flute.

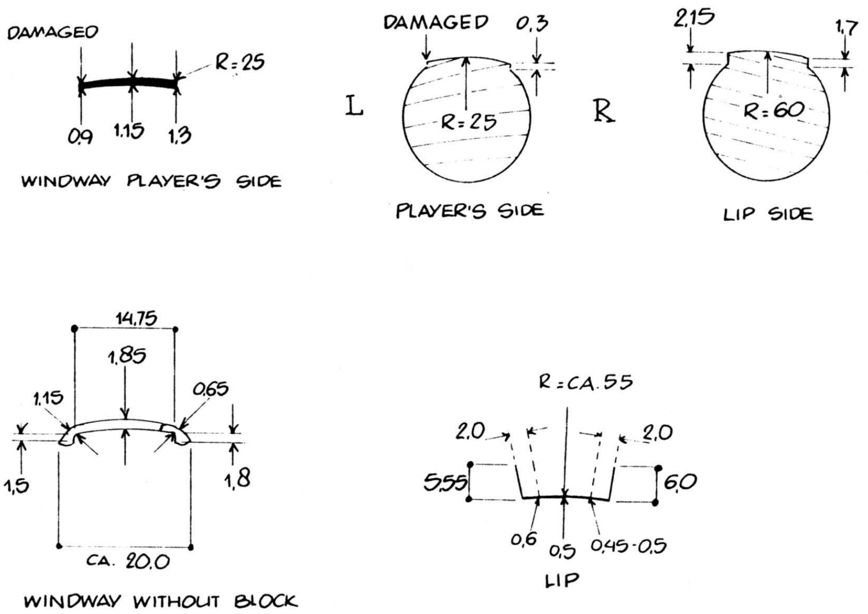


Fig. 6.4: Detailed drawings of the Terton alto recorder from the recorder catalog
Top left: windway entrance; top right: cross-sections through the block (R =25: radius of curvature) at the top and bottom.
Bottom left: Windway entrance without a block; right: cross-section at the edge of the labium.

In the catalogue, the curvature of the labium edge and the block cross-sections is specified as the radius of an imaginary circle. The block on the Terton treble recorder is more curved at the front with R= 25 mm than on the window with R = 60 mm. The radius of the edge of the labium is also given, with 55 mm.
The curves of the labium ridge and the top panel of the windwayrun completely parallel as can also be seen in Photo 6.6a. At 14.5 mm, the windwayis wider at the entrance than with
12.5 mm at the exit at the window. However, the taper is not uniformly conical. In the upper half, it is slightly thicker at 14.5 to 13.2 mm than in the lower half, where it is 13.2 to 13.2 mm
is 12.5 mm. A condition known among recorder makers as the 'Venturi core gap'. In summary, it can be said that this treble recorder is a windwaywith a very complicated shape, in which everything is curved and the curvatures in the course of the canal also change.

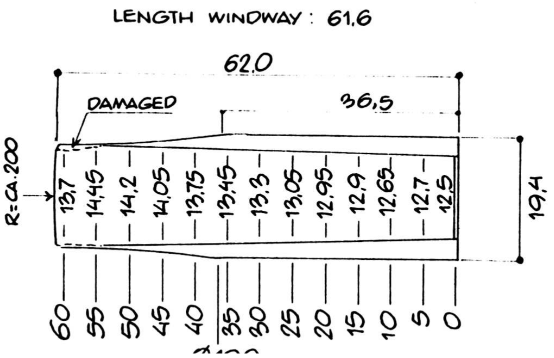


Fig. 6.5: From the catalogue: dimensions of the block of the Terton alto recorder

Fig. 6.6a, 6.6b and 6.6c The Terton treble recorder. The left image from 1981 is focused on the lip of the labium after removal of the block. However, it cannot be seen here how thick this lip is. Also the lower labium (English: candleflame) is not visible. The picture in the middle shows the opening of the windway. Damage can be seen on the left. The tear on the right goes through to the right lateral wall of the labium. On the right, the beak is photographed from below and the damage to the block at the entrance to the windway is clearly visible.

In cross-section, the soprano recorder shows a different picture than the alto recorder: in front, the recorder is very flat, but the top track is clearly curved, as can be seen in Fig. 6.7a. In the direction of the window, Fig. 6.7b shows the block track and the edge of the labium being regularly curved.

Fig. 6.7a and 6.7b. The Terton soprano recorder. The photo left is focused on the opening of the windway, right on the lip of the labium. The damage to the labium edge is not visible in this photo.

From the data in the catalog it is possible to calculate the surface area of the entrances and exits of the windways. The opening of the windway is irregularly shaped on the soprano recorder. It is 1.6 mm in the middle and 0.9 and 1.1 mm high on both sides. On average, that's about 1.3 mm and with a width of 12.5, the surface is 15.6 mm2. At the exit, the height above the block is 0.8mm and the width is 9.8 mm, so the surface area is 7.8 mm2. This causes the air speed when it flows out of the windway to be approximately doubled when playing. For the treble recorder, with its wider windway and because the block is higher, almost approximate sizes for the openings are shown, namely about 15 and 7.3 mm2 respectively.

5.3 Modern measurement techniques such as X-rays and computed tomography

The recorder catalog also contains X-ray photos of the instruments. The longitudinal curvatures of the windways should also be visible in the longitudinal sections. However, the recordings are rather indistinct and are reproduced on a reduced scale. They are only of limited use for assessing the tone hole undercuttings. Computed tomography, i.e. the production of CT scans, offers a much better solution. Klaus Martius and Markus Raquet showed scans of various recorders at a symposium in Michaelstein (Germany) in 2006.* The longitudinal curvature of the windwaycan be clearly seen on an early baroque instrument by Hieronymus Kinsecker. As a bonus, we can see the course of the wood grain on the scan. From this it can be concluded that the windwaywas made with the help of wiindway cutter (as in Fig. 6.8).

* Klaus Martius & Markus Raquet Measuring? 3D computed tomography as a solution for the documentation of woodwind instruments. In: History, construction and playing technique of the flute. Michaelsteiner Conference Reports Volume 74 (Augsburg - Michaelstein 2008).

Fig. 6.8: Windway cutter from the famous Encyclopédie by Diderot and d'Alembert (1751-1772); This tool is used to push and not pull.

5.4 The step measure

The step size and the dimensions as well as the state of preservation of the recorder and upper track bevels also determine the characteristics of a recorder to a large extent. Hans Schimmel was able to measure these parameters in detail for the recorder catalogue.

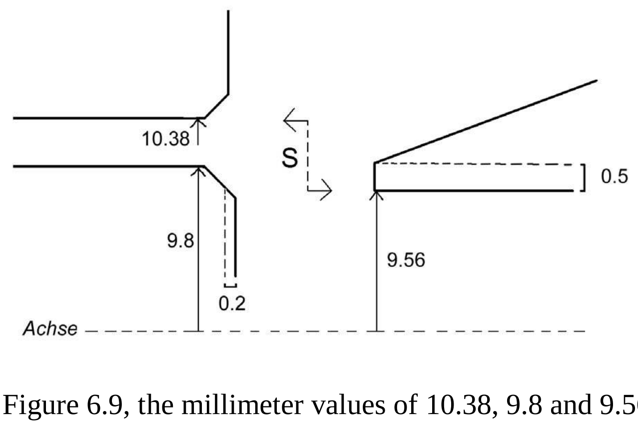


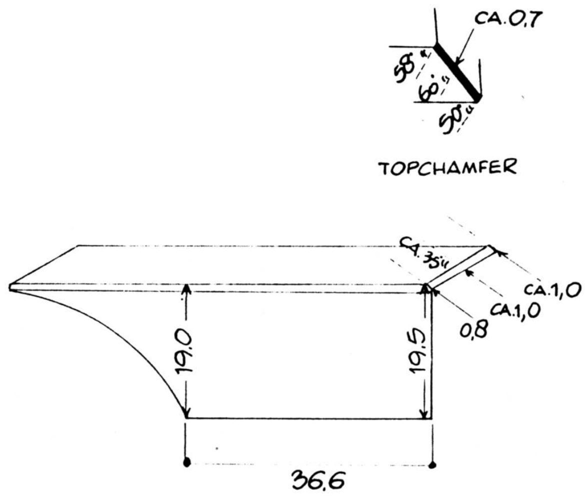
Fig. 6.9: Schematic drawing of window and surroundings for Terton's treble recorder. The value of 0.2 indicates the block protruding by 0.2 mm from the block line, shown here as a hatched vertical line.

In Figure 6.9, the millimeter values of 10.38, 9.8 and 9.56 refer to the head axis distances calculated from the data in Table 6.1. The increment is therefore 10.38 minus 9.56, which is 0.82 mm.
If you round the numbers to 0.05 mm, you get values of 10.40 minus 9.55, which are then 0.85 mm and thus significantly more than the distance of 0.6 mm rounded off between the upper track and the block

track. This is an indication that the wood of the block has shrunk a little less over the years than the boxwood of the flute, also because it protrudes a little too far into the window space.

The question arises whether in a copy you have to make the block just as high and sticking out a little far. Heiko ter Schegget, the main lecturer in recorder at the University of Applied Sciences in Utrecht, is of the opinion that the recorder sound is at its best when the recorder is at a high level, so that the underside of the lip of the labium cannot be seen through the windway. A disadvantage is the danger that a critical note like f''' on an alto flute responds a little less, especially if the block gets wet and swells up a bit while playing.

When measuring the step size in recorder heads, the possibility must always be taken into account that a relatively high value will be measured as a result of a sunken lip of the labium. This is often not easy to see with the naked eye, even after the block has been removed from the flute. You have to compare the horizontal and vertical bore dimensions with each other. If these deviate significantly in the area of the labium, this is a sign that the wood has worked hard there. This is not the case with the Terton treble and soprano recorders. The differences between the two measured values are at most 0.2 and usually no more than 0.1 mm over the entire length of the head bore. On the Van Heerde treble recorder from the Boers collection (no. Ea 33-x-1952, in the Rijksmuseum: - BK-NM-11430-95) we see a difference of up to 0.8 mm. In order to replicate this instrument, one must carefully reconstruct the original dimensions and also take precise measurements on the outside of the head.



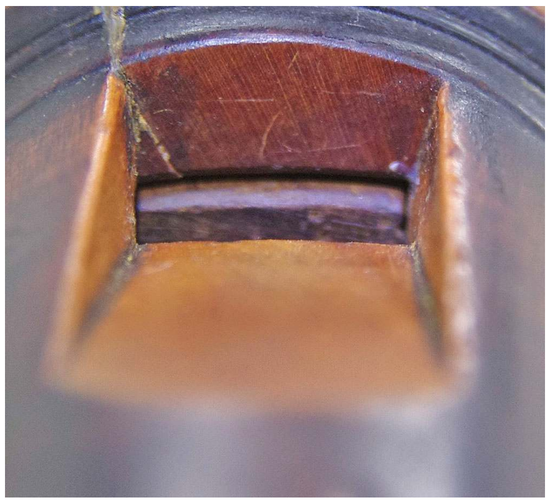


Fig. 6.10: From the catalogue: drawing with dimensions of the chamfers on the block and upper track on the treble recorder
Fig. 6.11: Photo of the 'north face' and the chamfers at the windwayexit of the treble recorder. The beautifully cut bevels may no longer be perfectly smooth, but they are still in excellent condition.

The chamfers at the end of the block and the upper course, for which many recorder makers use the English term chamfers, regulate the wind coming out of the windwayand have a great influence on the quality of the recorder sound. Hans Schimmel measured the chamfers precisely, but this is not easy. The results can be seen in the detail drawings in Fig. 6.10. The condition of the chamfers is then explained in the descriptions, namely whether they are clean, dirty, rounded or sharp-edged.
As with the chamfers the exact measurement of the thickness of the labium edge is not easy. For the Terton treble recorder, Hans Schimmel has stated that the thickness is 0.6 mm on the left, 0.5 mm in the middle and 0.45 mm on the right. Charles Stroom has slightly lower values, namely between 0.35 and 0.4 mm, measured. My personal impression is that the labium edge is a bit thinner. Who is right here? Also in Figure 6.9 it is striking (and unlikely) how thick the labium ridge is (0.5mm) compared to the distance from the block to the roof of the windway(0.6mm).

In May 2005, on the occasion of the 5th anniversary of the death of the Australian flute maker Fred Morgan, two interviews were published in the magazine 'Tibia', published by the German company

Moeck. One included a conversation between Ines Müller-Busch and Fred Meyer, an instrument maker based in Switzerland.*

*Tibia, Year 30, No. 1. Fred Morgan is best known for his work on the drawings of the recorders from the collection of Frans Brüggen (Frans Brüggen und Fred Morgan: The recorder collection of Frans Brüggen, ZenOn, Tokyo), highly regarded by experts , 1981)

Meyer claimed that Fred Morgan built recorders with a relatively high step and large chamfers. For Mayer it was a negative surprise at first, because then you need a lot of air when playing. But he said the starting point for him is a recorder that still works well after some playing time, after the block is wet and a little swollen. The step size should therefore be 0.95 to 1.30 mm when dry, which is significantly more than the value for Terton recorders. But Mayer added that those who don't play more than an hour a day can get along well with recorders with a narrow bore.
Fred Meyer further stated that Fred Morgan incorporated noticeably thin labium edges into his recorders. He claimed that in certain registers a thick labium edge provides a beautiful sound, but that the disadvantages for him are so great that the third register responds less well and the sound volume is also smaller. In the light of these remarks, it can only be pointed out that Terton's treble recorder in particular does not correspond to Fred Morgan's views. However, Terton may not have expected that his recorders would be played for hours a day.

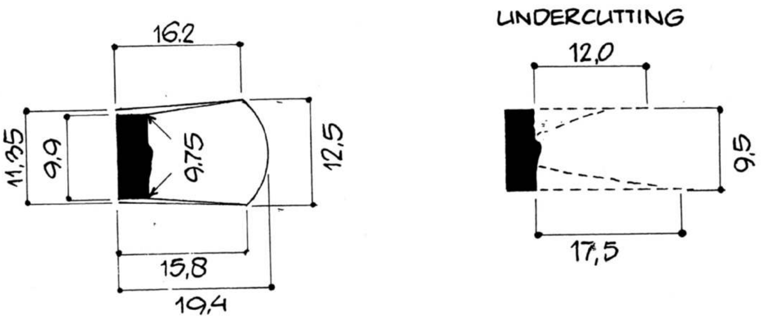


Fig. 6.12: From the recorder catalogue, the detailed drawing of the labium on the left and the lower labium on the right of the Terton soprano recorder. The hatched line indicates the 'candle flame', the transition from the curvature of the labium rim to the curvature of the bore.

The lower labium is located in the head bore, so it is not visible on the outside of the instrument. The tip of the candle flame usually reaches the edge of the labium, but there are exceptions to this rule.
In the recorder catalogue, the lower labia are indicated in the drawings under the somewhat confusing designation undercutting and marked with a hatched line, see also Fig. 6.12.

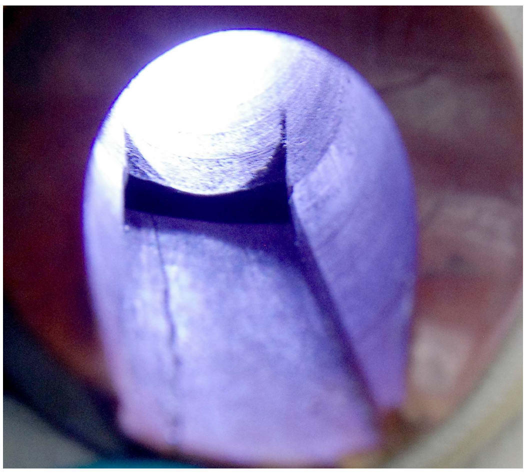


Fig. 6.13: With the treble recorder, after removing the block, you can see the lower labium with the so-called candle flame.

6.6 Why such complicated shaped windways?

With a maximum of 0.14 mm, the waindway roof of the Terton treble recorder has a relatively small longitudinal curvature. For the treble recorder by Van Heerde (Boers collection the maximum is 0.37

mm and for the treble recorder by W. Beukers (Boers Collection) even 0.70 mm. If you remove the block, such curves are usually easy to see with the naked eye. However, they cannot be measured precisely without special equipment. Why did the windways become like this made, curved crosswise and provided with longitudinal curves? I already mentioned that this can expand the dynamic possibilities of the recorder.*

* See also Rainer Weber in his article 'Insights into original recorders from the 16th to 18th centuries', in: New Musicological Yearbook, 15th year 2007, p. 21-66).

It also plays a role that - in contrast to an organ pipe, where only one tone sounds, on baroque recorders two octaves and a few more tones must be produced. In addition, the air that is blown in is moist and warm and then condenses on the walls of the instrument. Higher tones require more breathing pressure than the lower register and it can be assumed that the air flows onto the labium edge at a different angle. As with transverse flutes, the player has to adjust the wind slightly differently for overblown notes. Quantz writes about this in detail in chapter 4 in his *Versuch einer Anweisung die Flöte traversière zu spielen* (An attempt at an instruction to play the flute traversière, from 1752, reprint 1997). With the recorder you also want to blow the lower notes with a little more pressure without them sounding high. My impression is that Terton has realized these properties very well on the recorders discussed here.
How does the wind flow through the arched windway? Perhaps it would be possible for a trial setup or computer simulation to mimic and analyze the movement of air from such a complicated windway as that of Terton's treble recorder. Many flute makers would be interested in the results.

7 Engelbert Terton

Who was Engelbert Terton? When he registered his marriage to the thirty-four-year-old Jannetje Cornelis in Amsterdam in 1709, he gave his age as thirty-three, a profession as an instrument maker, and his place of origin as Rijssen, a small town of Rijssen in the province of Overijssel. However, the family name Terton does not appear in the archives there. This prompted Rob van Acht to consider whether it might also have been "Rijssel". Because "Rijssel" is the Dutch name for the northern French city of Lille. This would suggest that he might have been a member of the Huguenots who emigrated to the Netherlands. But these assumptions remain speculative as long as no evidence is found. In 1710 Terton was registerd as an independent woodwind maker. A year later he lived in the Warmoesstraat ‘bij de koffermaker in de middelste bijbel', ('at the trunk maker in the middle Bible'). This address is documented because his son, who was named Engelbert after him, had to be buried. Dudok van Heel and Marieke Teutscher* give the same apartment (today Warmoesstraat 8) for Albertus van Heerde and claim that Terton had been apprenticed to Van Heerde.

* S.A.C. Dudok van Heel and Marieke Teutscher: 'Amsterdam as a center of 'fluytenmakers' in de 17e en 18e eeuw', in: (exhibition catalogue), historical wind instruments, The Hague/Kerkrade, 1974.

Later, two more addresses are occupied for Terton. Because after the death of his first wife in 1748 he married Catherina van Halteren from Nijmegen for a second time. This marriage also left no descendants. At his death in 1752, Terton was known to be a wealthy man. The value of his house is given as 1750 guilders. It is also known that he and his wife owned bonds worth 9,000 guilders.*

* See Diss. Par. 2.30

The fact that Terton became known as woodwind maker is also due to the fact that he stamped his name on his instruments. Stamps similarly to his maker’s mark, with a name without a scroll, a crown above the name and a lion rampant (a rampant lion) below the name, are also found on instruments by Boekhout, Van Heerde and Borkens.

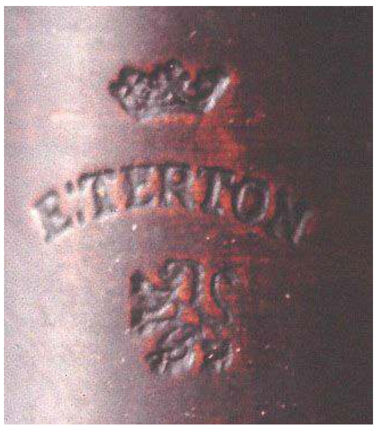


Fig. 7.1: Terton's stamp on the foot of his treble recorder (Boers Collection, Rijksmuseum Amsterdam)

Thirteen instruments by Engelbert Terton are known. Ten of them are, as of 2001, in musical instrument museums in both Europe and the United States, and the remaining three are privately owned. In all, there is one soprano recorder, seven treble recorders, one transverse flute, three complete oboes and the middle section of one oboe.* These instruments are made of boxwood and come with or without ivory or silver rings. One of the alto flutes is made of ivory and two of the oboes are made of ebony.

*Further instruments by Terton, such as a flageolet, some treble recorders, a transverse flute, a shawm and two bassoons, are known from 18th-century household auction sales catalogs (see diss. par. 4.26).

What can be concluded from this? Perhaps that Engelbert Terton, like most of his colleagues, was a versatile ‘fluytenmaker’ who could build various types of woodwind instruments. But neither this fact nor the knowledge that some of the instruments are luxuriously designed provide an outstanding feature for this time. It also remains unclear whether Terton owed his wealth to the sale of his musical instruments or whether he became wealthy through his marriages.

With 13 preserved instruments, Terton is in a middle group, comparable to Abraham van Aardenberg (17), father and son Willem Beukers (16), and Albert and his son Jan van Heerde (13 instruments). By contrast, 20 instruments by Jan Steenbergen and about 40 each by Richard Haka and the brothers Hendrik and Fredrik Richters have survived. However, these figures cannot provide any indication of the quality of the instruments. For example, Richard Haka is known to have trained several students who were involved in the production of woodwind instruments (Diss. Par. 2.12). The fact that a large number of oboes by Hendrik and Fredrik Richters survived may also be due to their particularly luxurious furnishings (Diss. Par. 9.8).

7.1 How good are Terton recorders?

How good are Terton's treble and soprano recorders? Why are both so interesting? Their state of preservation is certainly not perfect. The alto flute doesn't have a special charisma, because the outer profiles are more beautifully turned on other instruments, including those made by Terton himself. This also applies to a certain extent to the soprano recorder, although the beautiful silver fittings draw attention away from the woodwork. Above all, the instruments are so good and interesting because they have very good playing characteristics.
And another question follows: What is the cause for the so good sound? I am convinced that the well thought-out concept is the main reason for the good quality of these recorders. In addition, it is of course also important that the parts that are so important for the formation of the sound, such as the windway, block and labium - despite various irregularities and the broken labium edge on the soprano - are not only very well matched to each other on closer inspection, but are also in good condition .

It is clearly perceptible that both instruments were played a lot in earlier times. But we don't have any precise knowledge of how long and how intense it actually was and what the quality of the players was. But it is clear to me that both recorders were of excellent quality from the start. The question arises as to whether the sound could have changed over time. The wood of woodwind instruments is under the influence of microorganisms such as bacteria or fungi. These are favored on the one hand by the condensation from the player's breath and on the other hand by the wood itself in its capacity as a breeding ground. The edges of the chamfer and the edges of the tone holes are often smooth and sharp in new modern copies, which sometimes leads to a sound that is too bright and sharp, especially with instruments made of very hard wood, often with hissing background noises. These recorders look perfect, the wood used is of exceptional quality, the finish is impeccable. And yet something seems to be missing. The New Zealand recorder maker Alec Loretto once said of such an instrument: She is not sexy.
On old recorders, the rims and edges are sometimes barely visibly eroded, instead of being perfectly smooth. In addition, there are small irregularities as already described above with the Terton flutes. Is that all together maybe the the reason why these instruments often have such a 'mild' (i.e. not sharp) sound? In addition, there is also the question of whether they had this quality from the start. And in order to pursue this thought even further, the question arises as to whether the modern flute maker needs to incorporate a bit of aging into his copies or, on the other hand, is there a risk that these

instruments will be worn out too quickly? In a nutshell, the question is: How can a flute maker give an instrument sexy qualities? In this context, however, it should also be pointed out that there are also players who expressly do not appreciate recorders with too much character. They prefer a neutral instrument that gives them more opportunities to influence the sound itself.

7.2 Copying or reconstructing?

In connection with the above questions, the question arises for today's flute maker as to what condition he should assume when making a copy. Either of the instrument as it is now, or as it used to be, or more aptly, as the flute maker thinks it once was when it left the workshop many years ago. Be that as it may, the shrinkage of the wood over the years must be taken into account when copying. Both recorders are made of European boxwood (Buxus sempervirens L.). It is known that this type of wood shrinks relatively strongly when drying from freshly felled to completely dry wood, namely 11% in the radial direction and even 15% in the tangential direction. That's about twice the shrinkage of other types of wood used in flute making at the time.*

> * See Vademecum houtsoorten (4th edition, no year, publication by the Stichting Houtvoorlichtings-instituut Amsterdam). See also the wood database of the Professorship for Wood and Fiber Materials Technology at the Technical University of Dresden (http://mhph58.mw.tu-dresden.de/dbholz/).

The result of this process is that the flute bores no longer become circular on average over time, but oval. The question here is also how dry was the wood at the moment when Terton used it for his instruments and then whether he reamed the flutes after a while at an overhaul. We don't know that either. However, we can see from the tables that, apart from the upper tenons of the risers, the bores of both recorders have remained almost circular in cross-section. With the soprano flute, the deviations are usually less than 0.1 mm. Although the silver ring at the bottom of the foot is loose at the moment, it can be moved up about 2 mm. But that doesn't mean that the wood under the ring has shrunk that much. A recent check revealed that the ovalities on the outside of both Terton recorders were also very slight, with deviations of less than 1% from the circular shape.*

> * When measuring turned parts, Hans Schimmel always gave only one diameter, probably the maximum diameter. For the Dutch woodwind instruments in the other two catalogues, however, the maximum and minimum diameters were always noted at each measuring point.

From these results and the finding that both Terton recorders have a beautiful sound and play cleanly, taking into account the intonation temperature, it follows that the current state of preservation can be used without major problems as a starting point for making copies. It is probably correct to observe the bore contractions mentioned earlier. When I made a copy of the soprano recorder, it was necessary to widen the bore at the tenon in order to get a clean tuning of the octave intervals between the first and second register. The fact that I left the undercuttings of holes 5 and 7 smaller also has to do with the fact that I tuned the flute with Hotteterre fingerings. It remains strange, however, that the contraction in the bore clearly affects the tuning of the copy, although it hardly seems disturbing in the original.

7.3 The crooked windway and the asymmetrically cut labia as special features of Terton recorders

The asymmetrically engraved labia of Terton's recorders have been quite familiar to me for a long time. However, it was only recently that I became aware of how crooked their windways are. Does that mean that a copy of the Terton soprano or treble recorder, for example, must also have these features? After noticing crooked canals on a few other historical recorders, I can only imagine that the instrument maker worked a bit quickly and then noticed that the recorder didn't suffer any disadvantages from this executing of the windway. In any case, there are no obvious advantages. The same applies to the asymmetrically cut labium wall.
Or should these walls even represent a certain correction for the off-set windways? Further considerations must also remain speculative as to whether Terton may have just not looked properly while working on the windway and labium or whether it was due to the tools he used. Or does the recorder perhaps sound different if you blow at an angle through the windway, more or less like Frans Brüggen once used to play recorders?

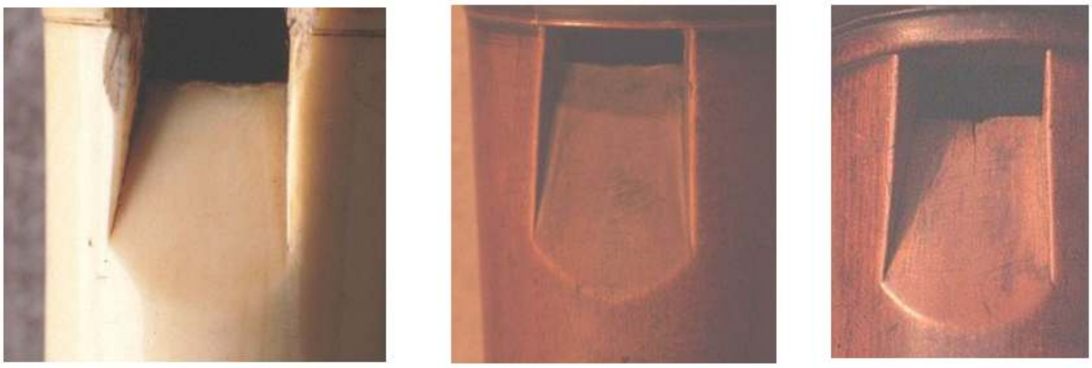


Figure 8.1: Three labia with asymmetrically cut sidewalls on Terton treble recorders. As can be seen in the photo on the left, the right wall (left on the photes) is always more slanted than the other.
Left: The badly damaged ivory alto flute from a private collection, Holland; Center: alto flute in the Dayton C. Miller Collection, Library of Congress, Washington DC, USA (inv. no. 871); right: alto flute in the Brussel Museum of Musical Instruments (inv. no. 1038).

7.4 About flute makers and musical instrument collections

When I started building woodwind instruments in 1980, initially as a hobby, later also professionally and today again primarily for my personal, primarily scientific interest, there were only very few good drawings with measurement data from historical instruments. The only possible solution was to visit the collections yourself and, initially as an inexperienced amateur, to take the measurements yourself. However, that was still permitted at that time.
The situation has changed significantly since then. Not only do many instrument museums now lack the money and employees to conduct their own research and publish, but they have also become much more reluctant to allow playing and measuring of the instruments because these activities could cause damage. Lending flutes to any player or instrument maker, as happened with the Terton treble recorder in 1981 (see photo 1.1), is now probably gone forever.

Because of these restrictive measures, the distance between flute makers and original instruments has become almost unbridgeable. A situation has arisen in which not only a new generation of players but also of instrument makers has grown up who have never held a historical recorder in their hands or heard its sound live. Is it even possible for them to make a true copy and also judge it for the players?
I am all too aware of this problem. In the past thirty years I have been able to examine three or four original old recorders and transverse flutes in detail in my own workshop. Although these instruments were mostly of limited playability, I learned a great deal from the process, much more than is possible from most detailed drawings or descriptions of other flutes. For me these were essential experiences to better understand the instruments and to build copies that came as close as possible to the spirit of the old fluytenmakers. In doing so, I realized how difficult it is to capture these experiences, to remember the sound and the playing feel.
It is therefore advisable to make a copy in close temporal relation to the measurement. It is very valuable to be able to see instruments that are being copied again from time to time, as I was able to do on the occasion of this article. The flute maker, a good copy has succeeded, it is to be wished because of her high ideal value that he never has to part with her.

What can museums do? The minimal option, such as displaying musical instruments in a display case with labeling that reveals little more than the maker's name and year, is unsatisfactory for either a museum or visitors. The need for information about the instruments is certainly strong among flute makers and players. I therefore hope that the people responsible for the collections will see it as their task, even more than before, to describe and measure the musical instruments in detail and to publish these results. Instrument makers, even amateurs, can help and should freely share the results of previous research.
For advanced research, however, a museum needs up-to-date expertise and state-of-the-art equipment. Close ties between collections and a university or research institute are therefore essential. This is the

case, for example, in Leipzig and Edinburgh. However, the Gemeentemuseum (now Kunstmuseum) The Hague is a general art museum. For this reason, music and musical instruments are not a priority for the management. Since 2011 there has been no staff for the collection of instruments.*

* The depot in the basement of the museum can still be visited to a limited extent by telephone agreement. The instruments can be measured there, but playing them is not permitted.

7.5 Ambitions and criticism

Having repeatedly criticized certain aspects of musical instrument catalogs in this article, although I was involved in a corresponding publication myself, I would like to emphasize at this point how important I consider the three catalogs of Dutch baroque woodwind instruments to be. With such an ambitious catalog project, one must always be very critical of both the selected research methods and the presentation procedures of the measurement results. You only get to know the problems fully during the work and then you would like to use other techniques. Which is then neither financially nor organizationally possible. A clear example of this is the fact that all the photos and drawings in the catalogs were created without digital technology.

In this context I would like to mention the paradoxical consequences of catalogs of musical instruments. Because they stimulate interest in seeing these instruments in person, either to hear their sound or even to be able to play them oneself if possible, and also lead to the desire of a flute maker to carry out a few additional measurements. But the catalogs were also created with the aim of preventing just such activities. They thus unfold their effect on instrument makers and flute players almost as a protective wall.

And who buys such books? I would like to highlight the catalog of the Kunsthistorisches Museum Wien on the recorders of the Renaissance.*

* Beatrix Darmstädter: The Renaissance recorders from the collection of early musical instruments in the Kunsthistorisches Museum, with contributions by Adrian Brown. ed. by Wilfried Seipel, Kunsthistorisches Museum Vienna, 2006).

It is a most important publication on a very important collection. All renaissance recorder players should read the book to learn more about their instruments. But six years after its release, you could buy it in the museum at a greatly reduced price. The same thing happened to the three catalogs of the Gemeentemuseum. An antiquarian bookseller finally acquired the last copies.

As already stated, music and musical instruments are no longer a priority for the museum in The Hague. It also didn't help that the catalogs were highly praised and won important prizes.* The musical instruments now lie dormant like many Sleeping Beauty on soft white beds in the museum's depot. Who is the prince with a suitably large purse who can awaken them and bring them back to light?

* In 1991 the recorder catalog won the German Music Edition Prize in the music book category.

9 About the author

Jan Bouterse, born in 1949, studied ecology and nature conservation at Wageningen University. In 1980 he discovered historical instruments through his hobby of building recorders and transverse flutes. This resulted in contacts with the Haags Gemeentemuseum, which at that time still had an active music department. While he was an author at the curator Rob van Acht accompanied production of three catalogs of Dutch baroque woodwind instruments, he decided to continue research on these instruments. Thanks to two scholarships, he was also able to visit instrument collections in other Euroepan countries, Japan and the USA. He received support for this project from the University of Utrecht, where he received his doctorate in 2001. The English translation was published in 2005 under the title Dutch wood wind instruments and their makers, 1660-1760.

Jan Bouterse is editor of Bouwbrief, a magazine for musical instrument making. He also organizes courses and workshops on flute making and is still actively looking for historical instruments and their iconography. He has published various articles on historical instruments and instrument making in international magazines.