# The Bohlen-Pierce Clarinet

## Theoretical Aspects and Contemporary Applications

Dissertation

zur Erlangung des akademischen Grades

Doctor scientiae musicae

an der Hochschule für Musik und Theater Hamburg

vorgelegt von

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aus

Großburgwedel

Hamburg 2019

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Datum der Disputation: 13. Januar 2020

**Abstract**

Repertoire in Bohlen-Pierce (BP) tuning has grown significantly since the debut of BP clarinets in 2008. Literature specifically dedicated to the BP clarinet, on the other hand, is still rare. Practice-led research conducted by the author provides useful materials about the BP soprano and tenor clarinets, such as contemporary playing techniques or acoustical conditions. The current state of repertoire is shown; exemplary analyses of compositions featuring one or more BP clarinets are given. A new BP specific notation is introduced; it has been developed from a practical point of view and has gained great acceptance among musicians performing in BP. Beside using BP as the (only) tuning system in compositions, it is also possible to combine BP with other scales to achieve effects of extended tonalities or rich microtonal structures. Multiphonics as a very popular phenomenon in contemporary woodwind music are highlighted, providing fingering charts and notational suggestions for both BP soprano and BP tenor clarinets. The theoretical idea of a BP third-tone scale (39div3) is transferred into practice by providing fingering charts and practical advice to performers and composers. I hope that this thesis can give inspiration and advice to those motivated to compose for and perform on BP clarinets, and that BP clarinets will gain the popularity they deserve in contemporary music performance. The BP clarinet and its growing repertoire may widen the range of expression of dedicated clarinet players.

## Acknowledgments

I owe a lot to a large number of musicians, composers, theorists and woodwind makers, who have provided me with information, peppered me with well thought-out questions, instruments and software, and helped me recognise and correct errors or inconsistencies in what I have said or written regarding BP clarinets. There is space here to single out by name only those contributors whose influence has been of long duration and of particular intensity.

I am grateful to Stephen Fox who took on the challenge to design and build a whole family of clarinets in the BP system, and who has freely shared his expert knowledge of current practice (often including its scientific practice) in the making and adjusting of modern clarinets.

The debut concert of the BP clarinet project in Hamburg would not have been possible without my late friend Anna Bardeli, my first BP duo partner, whom I remember as an extraordinarily loving, warm and kind person. Her warmth and kindness will always be missed. Anna was followed by Ákos Hoffmann who performs with me today, and I would like to thank him not only for inspirational music making, but also for wine and friendship.

Other performing musicians whose interest, skills and dedication have been of inestimable value in the production of the CD *Beyond the Horizon* (Genuin 20695) are Melle Weijters, Julia Puls, Lin Chen, Tair Turganov, Julia Stegmann and Andrej Koroliov. The CD contains most of the compositions which are discussed in detail in Chapter 6. Benjamin Helmer put in a lot of work for the creation of the CD booklet, as well as the team with the label, Genuin. Janina Luckow contributed the striking cover design.

Todd Harrop is one of the earliest and most constant contributors to the BP clarinet project, providing a number of compositions, and always lending me an open ear to a clarinettist's needs and problems. His interest, patience, musical knowledge and sensitive musical ear have always provided me with a stimulus. Beyond this he has struggled along with me through several drafts of some chapters to make this book accurate and understandable for its intended readers.

A warm thank-you goes to Jason Alder who proofread the final version of this thesis for its grammar and orthographical consistency. His sharp eye and sense for details are greatly appreciated.

My two advisors have been supportive throughout the several years it took me to finish. The experience and scientific insight of Georg Hajdu have been of immense value to me. Even more so, I owe him for initiating the BP clarinet project and for maintaining his passion for it throughout more than a decade, and for the great deal of time and energy he put into performances, conferences and the production of the CD *Beyond the Horizon*. Manfred Stahnke, on the other hand, nourished my mind with his thoughts and musings while always encouraging me to follow my own path.

Last not least, all this - music, instruments, concerts and writings - would not have happened without the visions of Heinz Bohlen (1935-2016), whose sharp intellect, humour and life-long curiosity will always be an inspiration to me.

# Contents

# Glossary and List of Abbreviations

Several of the recurring terms and abbreviations may be new to some readers. Here are some short explanations that readers may find useful:

- *Tritave* means the interval of a perfect twelfth in Bohlen-Pierce context, as suggested by John R. Pierce.
- *12div2*, twelve divisions of the interval with the frequency ratio 1/2 (octave): this abbreviation applies to all temperaments and to the just and equal-tempered versions of the scale of 12 steps within an octave. *24div2* refers to a quarter-tone scale (step size: 50 cents)
- Also in use are the abbreviations *12-tET* for twelve-tone equal temperament, and *12-edo*, twelve equal divisions of the octave. Both expressions apply to the equal-tempered version of the scale, i.e. one scale step = 100 cents.
- The abbreviation *13div3* means 13 divisions of 1/3 (perfect twelfth; tritave) and describes the Bohlen-Pierce scale, in either just, tempered or equal-tempered versions. *39div3* refers to the BP triple scale, i.e. 39 steps within the tritave.
- Other microtonal scales can be described by similar abbreviations, e.g. 41-edo / 41div2 for the octave divided into 41 equal scale steps.
- The frequency ratio of an interval is the relation of one note (frequency in Hz) to the other.

  Example: a' = 440 Hz; e" = 660 Hz

  440/660 = 2/3 = frequency ratio of a perfect fifth

  The frequency ratio of an octave is 1/2 (e.g. 440 Hz and 880 Hz for a' and a"); that of a perfect twelfth (octave + fifth) is 1/3.

- Scale and mode

  The term *scale* refers to the entirety of the given tone material within a tone system, e.g. the octave-based twelve-tone scale (12div2) with its chromatic pitches, or the 13 steps of the Bohlen-Pierce scale. Within a scale usually a number of *modes* can be found, such as the major scale or Dorian in 12div2, or BP modes such as Lambda, for instance.

# Preface

Among non-standard tunings of contemporary microtonal music practice, the Bohlen-Pierce scale earns a particular position because it is in conflict with important properties of the Western standard system. Most notably, the octave and fifth play a smaller role, being signifiantly "out of tune", compared to the standard 12-tone system, and thus the most dissonant intervals of the scale.

The overwhelming effect of the Bohlen-Pierce scale can hardly be understood on the basis of descriptive words. It is the immediate aural impression that opens the doors to this alternate tonal world. Unlike the scales of our usual system, it is not the octave that forms the repeating frame but the perfect twelfth (octave plus fifth), dividing it into 13 steps, according to various mathematical and music theoretical considerations. The result is an alternative harmonic system that opens new possibilities to contemporary and future music, and that offers attractive new music experiences to audiences. The thesis at hand studies various aspects of the Bohlen-Pierce scale in order to gain a deeper understanding of its theory and offers an approach to music practice for composers and instrumentalists. The centre of the work is hereby the Bohlen-Pierce clarinet, the first acoustic wind instrument to play this extraordinary scale. For the first 35 years after its discovery, the Bohlen-Pierce scale has been a subject mainly for musicians and composers with computer programming skills. Due to the fact that the Bohlen-Pierce scale is not octave-based, but skips over the octave, it can hardly be played by wind instruments, most of which overblow to the octave. Additionally, the different step size of the Bohlen-Pierce scale creates pitches which hardly ever match the ones of the octave-based twelve tone scale and thus creates severe difficulties in finding suitable fingerings on standard instruments. Intonation, sound quality and the player's virtuosity would suffer to such a great extent that listening to and playing music in Bohlen-Pierce tuning would not be very enjoyable. The lack of professional instruments which are able to play the scale has likely been a reason why a very limited number of compositions in Bohlen-Pierce could be found in the past. Just a few composers who work in electronic music used the scale – until Canadian woodwind maker Stephen Fox created a Bohlen-Pierce clarinet, instigated by Georg Hajdu, professor of multimedia composition at Hochschule für Musik und Theater Hamburg. Since then the number of Bohlen-Pierce compositions using the new instrument has been increasing constantly, and the instruments of the Bohlen-Pierce clarinet family have begun to find their way into contemporary music life, providing new experiences to the concert audience by offering unfamiliar, yet harmonic, sounds.

The idea of building special instruments to play scales other than twelve divisions of the octave is not new. Attempts have been made to establish quarter-tone clarinets since the early 20th century, e.g. by instrument maker Kohlert (Graslitz, presently Czech Republic) in 1924, instigated by Alois Hába, or the double-tube quarter tone clarinet by Fritz Schüller, 1932 [Dullat 2001, pp.137-139]. Today, a wide range of microtonal wind instruments or instruments with special microtonal features are available, for example the 19-tone (per octave) trumpet [Altoft and Bousted 2012-2019, last accessed: 27th July 2019], as well as Dieter Gärtner's double bell trumpet [Gärtner and Thul website, last accessed on 27th Jul 2019], the Kingma system flute [Kingma 2011-2019, last accessed: 27th July 2019] which allows the easy use of quartertones, or the Howarth-Redgate oboe with enhanced microtonal, altissimo and multiphonic possibilities, made by Howarth of London and owned by oboist Christopher Redgate. Some of these instruments are currently used in concert life. The BP clarinet is still a young instrument, and the existence of these clarinets leads to questions about BP tonality and the overall compositional potential of the scale. It may even lead to research about BP microtonality or microtonal practice on a BP clarinet.

Chapter 1 of this dissertation explains basic theoretical questions and the history of the Bohlen-Pierce scale. Chapter 2, about Bohlen-Pierce notation, is the footbridge to the practical section: Chapter 3 studies practical aspects of work in Bohlen-Pierce with a strong focus on the instruments of the Bohlen-Pierce clarinet family and their repertoire, composed since their "birth" in 2007. Finally, chapters 5-7 give a valuable helping hand to composers and Bohlen-Pierce clarinettists, and to a great part consist of tables and fingering charts for contemporary playing technique.

## State of Research

A significant number of treatises about the BP scale has been published since Heinz Bohlen's first manuscript in 1972 and its publication in 1978. BP has become increasingly popular, especially in the past decade, so this general overview of literature can in no means be called complete. Generally, it can be said that theoretical treatises on the BP scale outnumber practical approaches by far. With regard to the focus of my own work and to the needs of clarinettists, I am pointing out some works published to this date.

Heinz Bohlen‘s groundbreaking research can be read about in a manuscript publicly accessible on the webpage of Stichting Huygens Fokker in Amsterdam, The Netherlands [Bohlen 1972]. In this paper, which is the basis for his first publication about his scale in 1978 [Bohlen 1978], he highlights aspects of auditory perception in connection with the development of the BP scale. Even today, Bohlen's extensive work of many years, which he published in form of a website currently maintained by Stichting Huygens-Fokker in Amsterdam (NL), is still one of the most popular resources regarding the Bohlen-Pierce scale. In the early 1970s Bohlen imagined BP tonality and specific instruments, e.g. guitar and metallophone in BP, and he constructed the first BP instrument ever, an electronic home organ that he had planned and built with great effort. A BP clarinet was, of course, not available to Bohlen; the realization of this instrument was to happen decades later.

In their early publications [Max V Mathews, John R Pierce, and Roberts 1987, pp. 59-84, for instance] John R. Pierce and Max Mathews also explain fundamental aspects of the scale, starting with Mathews's experiment on intonation hearing. With the works of Pierce, Mathews and Roberts a small but continuous line of musicians with an interest in the BP scale began in North America, e.g. Richard Boulanger and Elaine Walker. They were in direct or indirect contact with Pierce and Mathews, so that one can speak of a tradition here.

Elaine Walker [Walker (2001)] published her student research on BP chord progressions in 2001, which also includes a field study on perception. Walker's research is based on her practical experience in some of her microtonal pop songs, which she has performed with her band ZIA since 1991. Walker is mainly interested in electronic instruments, especially keyboards, which she designs and builds herself.

William Sethares contributes fascinating thoughts about artificial spectra and consonance. In chapter 6 of *Tuning, Timbre, Spectrum, Scale* he explains this topic in particular, using the BP scale as an example, for which he suggests stretched spectra which allow the overtones to match the pitches of the scale [Sethares 2005, pp. 110-112]. In doing so, he continues Pierce's earlier work on consonance in arbitrary scales [John R. Pierce 1966]. Georg Hajdu also draws on Pierce's work in *Beyond the Horizon*, one of the first compositions featuring BP clarinets: for the sound of the keyboard he synthesises such a stretched spectrum. This is a good example about how systematic musicological research finds artistic application in contemporary chamber music.

Dave Benson dedicates a section in his profound book *Music. A mathematical offering* to the BP scale [Benson 2007, pp.224-227]. The brilliant mathematician offers fascinating insights into the numeric world of BP. However, practical aspects of repertoire, notation etc. are not discussed in Benson's work which is thus of high interest only for the math lover.

Krantz and Douthett [Krantz and Douthett 2011] offer alternatives to equal temperament in BP. Although an inspired work of high quality from a music theory point of view, it remains of rather little importance for music-making practice on the BP clarinet. On the other hand, the practical value of the article should not be underestimated. It may be inspirational when searching for equal-tempered tunings on electronic keyboard instruments and other synthesizers.

Georg Hajdu, Konstantina Orlandatou and Nora-Louise Müller offer an overview of theoretical and practical aspects of music making in BP in *Starting Over - Chances Afforded by a New Scale* [Müller, Orlandatou, and Hajdu 2015, pp. 127-173]. This includes aspects of BP tonality, ear training, notation and instruments, which allows musicians a practical approach to the BP scale.

Todd Harrop published his article *Just Chromatic BP Scales and Beyond* in the same book [Harrop 2015, pp. 181-201]. He, on the other hand, like Krantz & Douthett above, accentuates aspects of microtonal theory which is a theoretical discipline unto itself and quite apart from clarinet playing. However, in *On Mixing Scales: three compositions with 19 and 13 equal steps per twelfth* [Harrop 2017, pp. 139-176] Harrop offers analyses of three compositions by Roger Feria, Fredrik Schwenk and Sascha Lino Lemke featuring a combination of traditional and BP clarinets, thereby proving his own dedication to the practical understanding of BP clarinet music from a composer's perspective.

As one of the motivational forces in the BP clarinet project, Hajdu shows in *Die Transkription des Poème Vers la flamme op. 72 von Alexander Skrjabin für Bohlen-Pierce-Ensemble* [Hajdu 2015] his approach to the said work with regard to the BP scale. In his elaborate transcription *Burning Petrol* Hajdu uses a trio of BP clarinets.

As for BP the triple scale (39div3), no other literature has been found except Paul Erlich's proposal on huygens-fokker.org [Bohlen 1996-2013], and Manfred Stahnke's unpublished musings about the same or a similar scale. Both proposals date to 2010 or a little earlier. The idea has probably not been taken into practice yet, and so I dare say that in this book you will find for the first time some practical advice about playing BP clarinet in BP third tones. This, on the other hand, might inspire further investigation into the theory and practice of music in 39div3. (NB: Benjamin Helmer makes use of BP fifth tones in his composition *Preludio e Passacaglia*, 2015.)

Plenty of publications are available containing fingering charts for multiphonics on traditional clarinets of all sizes: Krassnitzer, Rehfeldt, Bok, Watts, just to name a few [Krassnitzer 2002; Rehfeldt 1994; Bok 2010; Watts 2015]. Yet it is surprising to see that the theoretical aspect of the generation of multiphonics is ignored by most authors. None of these books gives a satisfactory answer to the question of why and how multiphonics on woodwind instruments happen. Benade's research [Benade 1976/1990] led me in my attempt to give an understandable explanation of the physical phenomenon.

Jack Liang investigates an important practical aspect in multiphonic production, the non-articulatory tongue motion in his dissertation *Clarinet Multiphonics: A Catalog and Analysis of Their Production Strategies* [Liang 2018]. His work is of great practical value to all clarinettists, and can be referred to when generating multiphonics on BP clarinets, too.

From this overview it becomes clear that research in the field of the BP scale is by no means a musicological wasteland and that the BP clarinet, in recent years, has increasingly moved into the focus of attention, although monographical literature on the BP clarinet and its repertoire is almost completely lacking. Subjects of further investigation in this book will be the repertoire for BP soprano and tenor clarinet composed between 2008 and 2018, contemporary playing techniques specifically on these instruments, and aspects of BP microtonality. I hope to contribute relevant knowledge to help close the gap between theory and practice of BP clarinet music.

# 1 Taking Big Steps into the Bohlen-Pierce Scale

When I first got a Bohlen-Pierce (BP) clarinet to play in 2007, I was irritated. There seemed to be a curse on the instrument: whatever I was trying to play, be it Mozart or Brahms or *Stranger on the Shore*, turned out wrong. This instrument gave me something completely different from what I expected. The pitches differed largely from those on a normal clarinet, and everything I played seemed a surprise to me.

The instrument uses an alternative harmonic system which is called the Bohlen-Pierce scale – or BP scale.

The different step size of the scale results in intervals and harmonies which are not existent in the traditional 12-tone scale. These novel, yet harmonic triads are the basis of a new musical horizon. Compared to 12div2, consonance and dissonance seem to be upside down: the BP fifth and eighth are dissonant, while other intervals, such as the BP 4th or 7th, are much more consonant in comparison to 12div2 tritone and minor seventh. Although it is tempting to constantly compare BP intervals to their close 12div2 relatives, it makes more sense in the long run to see the BP system for what it is in itself. When playing in BP, we have to think upside down. We have to think outside the box and leave our hearing habits behind in order to open our ears to this new tonal world, which may be uncomfortable in the beginning. And if we do so and treat the BP clarinet for what it is, it gives us otherworldly music, or just pleasantly strange music, whichever you prefer. The Bohlen-Pierce clarinet needs new repertoire; it needs special compositions and a specific approach to tonality.

In our usual tuning system, the octave forms the interval of equivalency of the scale. The BP scale has a perfect twelfth (octave plus fifth) as its frame. And in BP terms, this interval is called a tritave, and henceforth will be referred to as such. The tritave is achieved with 13 tone steps, according to various mathematical considerations which will be outlined further down in this chapter. Every single step is sized about a three-quarter tone, in equal temperament exactly 146.3 cents. Simplified, this can be imagined as an elastic band: instead of achieving the octave after twelve semi-tone steps, the elastic band is stretched in order to choose the tritave as the arrival point, going about one and a half times as far as before, with only one step more. Acoustically speaking, the octave's frequency ratio 1/2 is replaced by the ratio 1/3 in the Bohlen-Pierce scale, making the tritave an analogy to the octave. Thus, an alternative harmonic system evolves in which - nota bene - the octave does not appear. Due to the step size that differs from the usual, the octave is simply stepped over and, likewise, the fifth. A musical system without our "favourite", most harmonic intervals may be hard to imagine in the beginning. Music without perfect fifths and octaves, what can this possibly sound like? Instead of those two soft and pleasing intervals, the BP scale provides two very rough and dissonant variants: It contains an interval close to a fifth, but about 30 cents sharp. And it has an almost-octave, but it is about 30 cents flat. So these two intervals which usually are our dearest, are now the *diaboli in musica*, the devils in the music. On the other hand, there is the tritave, and the BP scale also provides a number of intervals that are just slightly different from our usual system but a little softer or more consonant, for example the tritone. This traditional *diabolus in musica* is an interval which we usually perceive as rough, or let us say complex, and with strong beatings. Compared to the equal-tempered twelve-tone scale, it is slightly flatter in BP, and it turns out to be one of the consonant intervals because it has a frequency ratio of 5/7. And as you might already know, our auditory system prefers intervals of simple ratios and recognises them as consonant, soft, pleasant, beautiful. The harmonies within the BP system are different from our usual system and cannot be played on most instruments of "fixed pitch" such as a piano, or even a normal clarinet. In our usual tone system the notes of a major chord ideally have a frequency ratio of 4/5/6, and it is acknowledged that its harmonic characteristics are almost perfect. 4/5/6 are consecutive partials in the harmonic spectrum. The BP scale is based on an odd spectrum, resulting in a chord with a frequency ratio of 3/5/7, generating a completely different but apparently harmonic chord. The acoustic characteristics if the clarinet support the harmonies of the BP scale. With its predominantly odd partials, the clarinet overblows to the perfect twelfth (1/3) and, overblown a second time, to a major tenth (3/5), thereby producing producing the third and fifth partials. (For instance, c' overblows to g". To achieve the third register, the player lifts the left index finger, and e"' speaks.)[1]

The BP scale was discovered as early as 1971 by the German microwave electronics and communications engineer Heinz Bohlen in Hamburg, and independently in 1984 by American satellite engineer John Robinson Pierce. For the lack of acoustic instruments, the scale did not become popular until Canadian woodwind maker Stephen Fox created his first BP clarinets. He had received a commission from a composition professor at the University of Music and Drama (HfMT) in Hamburg, Germany, Georg Hajdu, who had been a strong advocat of the BP scale for many years, and who felt the urgent need of BP clarinets: Hajdu had realised that by overblowing to the twelfth, the clarinet naturally provided the frame of the BP scale. By pure accident I met Georg Hajdu in 2007, right after he had received the first pair of BP soprano clarinets. He asked me to be one of the first clarinettists to perform on the novel instruments, and I accepted the project, at that moment still not understanding what it was all about. It was only by the time that I opened my mind and my ears to this wonderful new tonal world with its "outer-space" harmonies, and I soon became passionate about it because I began to see the potential. Mainly through an improvisational approach I developed a clear sound imagination of BP, meaning that I was able to anticipate in my mind what I was going to play on the BP clarinet a moment later.[2]

The debut concert on the European side took place in Hamburg, Germany in 2008. At the same time, a group of performers and composers gathered around Stephen Fox in an ensemble named TRANSPECTRA, a group specifically dedicated to performing BP music. They premiered the project in

[1]Spectra consisting only of odd partials occur not only in the chalumeau register of the clarinet, but also in two fundamental waveforms: triangle and rectangle.

[2]This kind of connection between inner hearing and movements of music making can be called mental representation, see Altenmüller 2006

Guelph, Canada, involving two more BP clarinets that Fox had built for himself and clarinettist Tilly Kooyman.

The Hamburg team, too, worked as a BP clarinet duo from the beginning. My duo partner at the time was my late friend Anna Bardeli. The composers who contributed to the debut had created fascinating pieces, even though none of them had heard a BP clarinet in action before they started to compose. They had heard the BP scale, though, because computers and synthesizers nowadays can easily be programmed to play them. In the years following, as I got deeper and deeper into BP music, I performed a lot on the instrument to make it more known to audiences, musicians, and composers. Over time I became an expert and researcher in that field. The BP clarinet became an instant hit among composers interested in microtonality and unusual tunings, and since I was the one advocating the instrument, and one of very few players worldwide, I received more and more inquiries from composers:

- Do you have any colour trills?
- How high can you actually get?
- I want to combine a BP clarinet with a normal B♭ clarinet. Is that possible?
- Can you give me some multiphonics?
- Thank you very much for the multiphonics, but I need one containing this, this and that note. Can you do that for me?

It was necessary to make the transition from just noodling around to a more systematic approach, and to create knowledge about the instrument in order to provide materials to composers, and to encourage clarinettists to engage with BP clarinets. The outcome of several years of practical research of BP clarinets are summarised in this book, and I hope that clarinettists and composers find it equally helpful. In my research I concentrated on the BP soprano and BP tenor clarinets. The BP contra clarinet, which has been delivered by Stephen Fox to HfMT Hamburg in 2018, and entrusted to me, may be the subject of future research.

## 1.1 The basics of the BP scale

In the following, the ideas behind the BP scale will be outlined in order to help understand how and why the BP system was developed, and what it has to offer regarding harmony and new aural experiences.

### 1.1.1 Heinz Bohlen: A Curious Mind

Not a professional musician, but rather a professional in communication electronics, describing himself as "lacking any serious musical education" [Bohlen 1996-2013, last access: 30th July 2019], Heinz Bohlen (1935-2016) was a frequent guest at concerts of the composition class at HfMT Hamburg in the early 1970s.[3] The question which was the starting point of his work was simple, yet difficult to answer: Why is the standard tone system of our culture made of an octave, divided into twelve steps, and why is this system so dominant in the so-called Western world, that other possibilities were hardly considered and not used by his composer friends in Hamburg? Are there in fact any other possibilities of tonality? Why is it the way it is and not any different?

To his surprise, his composer and music theorist friends were not able to answer his questions satisfactorily. Diether de la Motte, professor of composition, for example, reportedly answered: "I don't know why that is, but you can ask my wife, she will know."[4] Helga de la Motte-Haber, acknowleged musicologist, pointed Bohlen to Paul Hindemith's *Unterweisung im Tonsatz* (1937) and said he would find answers to his questions in that book. Hindemith's writings, however, did not satisfy Bohlen, who consequently went on reading about the auditory system, psychoacoustics and music perception. He found one reason for our preference for 12div2 in the auditory system. Having gained understanding for the basics of music perception, and approaching music theory from a mathematical point of view, he was able to

[3] With regard to the complexity of his work on the BP scale, we may assume that Bohlen's view on himself is based on what one would call a Hanseatic understatement.

[4] Source: Heinz Bohlen's lecture at HfMT Hamburg on the occasion of the European premiere of BP clarinets, June 2008.

modify frequency ratios, and he finally suggested a scale of 13 steps within the perfect twelfth as an alternative.[5]

The derivation of the BP scale as suggested by Bohlen[6] is shown below; the just version of the scale which was its original form based on simple interval ratios, or consonant and "perfect" intervals. Step sizes in just scales are typically a little uneven. In order to be able to play equally well in all keys, equal-tempered tunings are nowadays widely preferred, providing unrestricted transposition by the use of equal step sizes. Therefore, Bohlen also suggests an equal-tempered version with a regular step size of 146.3c.

We will take advantage of the fact that we already know a lot about the scale from today's point of view and use a notation that was developed by Müller and Hajdu in 2012 specifically to represent the BP scale. (Notation, note names and clefs will be discussed in depth in Chapter 2.) On a staff of six lines, the BP scale is represented by simple progression on the staff. Each scale step takes a place on or between the lines. Accidentals are not needed in this notation, and the use of a clef is not necessary for now because absolute pitch does not matter at this point. The relative pitches with equal steps of 146.3c shall be sufficient as a reference value.

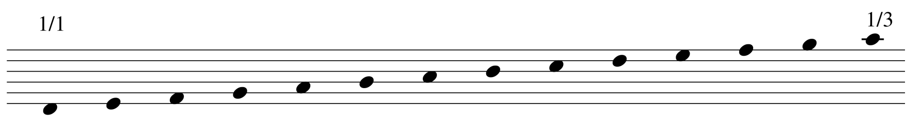



Figure 1: Notation of the BP scale on a six-line staff

The 3/5/7 chord in this notation looks as follows (allow me to anticipate and reveal that it is scale steps 0, 6 and 10):[7]

[5]Bohlen referred in particular to the work of Hermann Helmholtz, *Die Lehre von den Tonempfindungen*, Braunschweig, 1863. He found clear indications that combination tones, especially difference tones, decisively determined our perception of consonance and dissonance. Combination tones are a phenomenon in our auditory system. The term "combination tone" refers to two different variants of the same phenomenon, difference tones and summation tones.

[6]The general source for this part of the chapter is Bohlen's website, www.http://huygens-fokker.org/bpsite/index.html, last access: 1st September 2019

[7]Regarding step numbers in the BP scale, it is common practice to designate the fundamental tone of the scale as step zero, as it is in set theory. Depending on where one

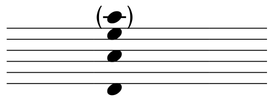


Figure 2: The BP wide triad (or 3/5/7 triad) in notation. The top note in brackets represents the root note in tritave transposition/repetition.

The BP triad including the tritave is 3/5/7/9, as can be seen in figure 2. Bohlen soon recognised that the first inversion can be built by cutting off the lower fundamental. The frequency ratio of the inverted triad is 5/7/9, the former root note a tritave higher and thus multiplied by 3. Bohlen named the 3/5/7 chord the "BP wide triad" and its first inversion the "BP narrow triad". The first inversion is transposed down by six steps in order to return to the initial pitch. By doing so, five pitches of the BP scale can be determined.

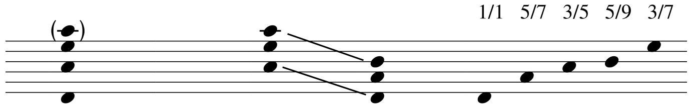



Figure 3: 3/5/7 chord and 5/7/9 chord (first inversion) and the resulting pitches of the BP scale.

To attain the second inversion, the lowest note of the first inversion is put up by a tritave (frequency multiplied by 3) and placed on top of the triad. Accordingly, the second inversion is 7/9/15.

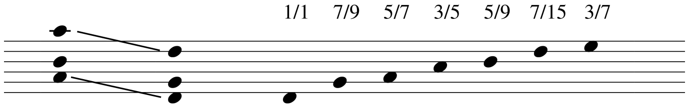



Figure 4: The second inversion, transposed down to root note, adds two more pitches to the scale, resulting in a scale of seven steps. Interval ratios are given in relation to the ground note (step 0).

The 3/5/7 chord and its two inversions form seven of the 13 scale tones: 1/1 – 7/9 – 5/7 – 3/5 – 5/9 – 7/15 – 3/7 – (1/3) The scale only needs to

studied, this may take getting used to (many classical musicians in Europe consider the fundamental tone step 1), but has the advantage that the BP interval names are close to the classic 12div2 intervals not only in name but also in interval size.

be further completed by filling in the missing tone steps. The smallest tone step occurs several times in the current 7-step scale, so we already know its size. In the BP notation this is of course very easy, but Bohlen initially worked without the advantage of a special notation and could only work with frequency ratios.

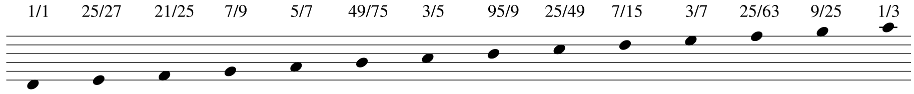



Figure 5: BP scale with frequency ratios; all ratios represent the ratio between the fundamental (step 0) and the respective tone.

### 1.1.2 Features of the BP scale

The just version of the scale, i.e. the derivation of the scale from intervals with simple frequency ratios, was the first result of Bohlen's investigations. Bohlen soon realised that an equal-tempered version of the scale is possible (similar to the equal-tempered 12div2 scale with its regular step size of 100c). For the equal-tempered version of Bohlen's new scale, the tritave (1902c) is divided by 13 which gives a step size of 146.3c. The frequencies of pitches in the equal-tempered scale can be calculated by multiplying the frequency of one note by $\sqrt[13]{3} = 1.08818224346$. For example, if the assumed starting note is 440 Hz, the next BP note is = 478.8 Hz.

The following table gives an overview of interval names, ratios of the just BP intervals and the step size in cents of the equivalent interval in the equal-tempered version of the scale. The right column gives a short verbal description of each interval to point out similarities and differences with close or related intervals of the 12div2 scale.

| scale step | interval name | ratio (just intonation) | cents value (equal-tempered) | description in comparison to 12div2 intervals |
|---|---|---|---|---|
| 0 | unison | 1/1 | 0 | |
| 1 | BP 1st | 25/27 | 146.3 | "three-quarter tone" |

| scale step | interval name | ratio (just intonation) | cents value (equal-tempered) | description in comparison to 12div2 intervals |
|---|---|---|---|---|
| 2 | BP 2nd | 21/25 | 292.6 | minor third, slightly narrow |
| 3 | BP 3rd | 7/9 | 438.9 | a very large major third; complex, with beatings. A whole 55c wider than the 4/5 pure major third |
| 4 | BP 4th | 5/7 | 585.2 | tritone, slightly (about 15c) narrow; soft, pleasant, consonant |
| 5 | BP 5th | 49/75 | 731.5 | a fifth about 30c sharp; harsh, strong beatings |
| 6 | BP 6th | 3/5 | 877.8 | major sixth, much narrower than in 12div2, almost a “neutral” sixth |
| 7 | BP 7th | 5/9 | 1024.1 | very similar to the equal-tempered minor seventh, but slightly wider |

| scale step | interval name | ratio (just intonation) | cents value (equal-tempered) | description in comparison to 12div2 intervals |
|---|---|---|---|---|
| 8 | BP 8th | 25/49 | 1170.4 | 30c flat from a pure octave and thus very dissonant |
| 9 | BP 9th | 7/15 | 1316.7 | comparable to a minor ninth in 12div2, slightly larger and thus softer, more consonant |
| 10 | BP 10th | 3/7 | 1463.0 | minor tenth, narrower than in 12div2 |
| 11 | BP 11th | 25/63 | 1609.3 | major tenth, comparable to a pythagorean (1608c) or an equal-tempered major tenth (1600c) |
| 12 | BP 12th | 9/25 | 1755.6 | between a fourth and a tritone an octave apart; an interval with joyful beatings, rough |
| 13 | tritave | 1/3 | 1902 | perfect twelfth |

As mentioned before, one of the characteristics that distinguishes BP from 12div2 is the lack of the perfect octave and fifth. The intervals closest to the perfect fifth and eighth, the BP 5th and 8th of 731 and 1170 cents respectively, are dissonant to such an extend that one might even entirely avoid them. On the other hand, some of the intervals that are considered dissonant in 12div2 appear as consonant in BP, due to a slightly different frequency ratio and intonation of the two pitches.

The tritone, a complex sound with - depending on the intonation - usually strong beatings, appears as the fourth step of the BP scale in the frequency ratio 5/7 or the interval size 585c and thus 15c smaller than the tritone in the equal-tempered twelve-tone scale. This interval is perceived as soft and consonant. As a component of the 3/5/7 triad in BP, this interval even has a special significance: in the stretched BP universe, the major triad (4/5/6) is replaced by a stretched triad 3/5/7 (comparable to a major sixth plus a tritone, but sounding very pure due to deviating intonation), catapulting us into another musical dimension.

As in 12div2, the equal-tempered version of the BP scale differs slightly from the "perfect", so-called just scale. This means that equal-tempered BP intervals approximate the just intonation intervals, but there is usually still a slight deviation between both. For current music-making practice on acoustic instruments in BP, this means that intonation corrections during ensemble playing are appropriate, but generally to a smaller extent than in classical orchestral and ensemble playing. Intonation corrections would range from -9 to +13 cents, depending on the specific interval.

### 1.1.3 BP tonality, modes, and the first BP instrument

Heinz Bohlen had developed his scale without having an instrument at hand to play it. The scale remained a purely theoretical construct for about two years after he first thought about it. Due to a lack of acoustic instruments that could play the scale, and of synthesizers that were simply not affordable at the time (the early 1970s), Bohlen initially had to forego putting his find into practice and making it audible. In the course of one and a half years after his discovery, he worked on a solution: he bought a kit for electronic home organs that was popular at the time and modified it so that the resulting instrument was customised to play his scale. Shortly before Christmas 1973, Bohlen switched on his organ for the first time and played. He was overwhelmed: his scale sounded unusual and strange, but undoubtedly harmonious!

In the course of the construction of the home organ it was necessary that Bohlen considered a suitable keyboard layout. The common keyboard layout for a twelve tone scale was not suitable to represent a scale of thirteen tones. The basic idea of alternating black and white keys ("whole tones and semitones"), on the other hand, seemed an important aspect for the player in terms of orientation on the keyboard. But how would he design a keyboard for a scale he had never heard before? How would he find a suitable reference mode, i.e. the mode that would be played on white keys only, and how would he arrange the black keys? Bohlen had to think about modes and keys, about tonality in his new scale.

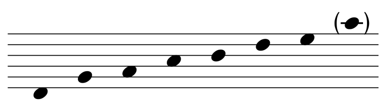


Figure 6: 7-tone scale resulting from BP wide triad and its two inversions

Returning to the seven tones resulting from the chord inversions, Bohlen realised that there were only two notes missing in that group of pitches in order to create a diatonic mode of small (146.3c) and large (292.6c) steps. Bohlen filled in the missing pitches, hereby completing his new mode. He decided to start his mode with "a hearty whole tone step"[Bohlen 1996-2013] of 292.6c, and to end it with a "lead tone step" (146.3c). The resulting mode contains 9 steps out of the original 13.

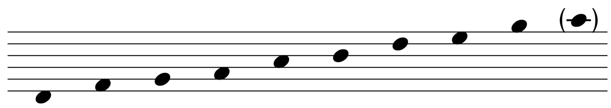


Figure 7: Lambda mode

Bohlen called this mode Lambda. Having a closer look at it, it reveals certain similarities with the structure of modes in 12div2, whose classical modes consist of two elements of four tones each, the tetrachords. Bohlen's new mode consists of two pentachords, groups of five notes. This results in a mode of nine tones, plus the repetition of the root a tritave above. (Of course other scale structures are also possible, as is also the case in the traditional system, e.g. in the blues scale, which contains six tones). Lambda mode is the basis of the so-called Lambda family. The modes belonging to the Lambda family have the same basic structure and are achieved by shifting the initial tone. (Accordingly, one could say that the "Ionic family" also contains the modes Dorian, Phrygian, Lydian, Mixolydian, Aeolian and Locrian.) Bohlen represents the modes of his Lambda family in a wheel that illustrates the structure of the modes (fig. 8). The grey fields indicate the selection of nine tones out of 13. Two consecutive grey fields indicate a small step; a gap between them indicates a large step.

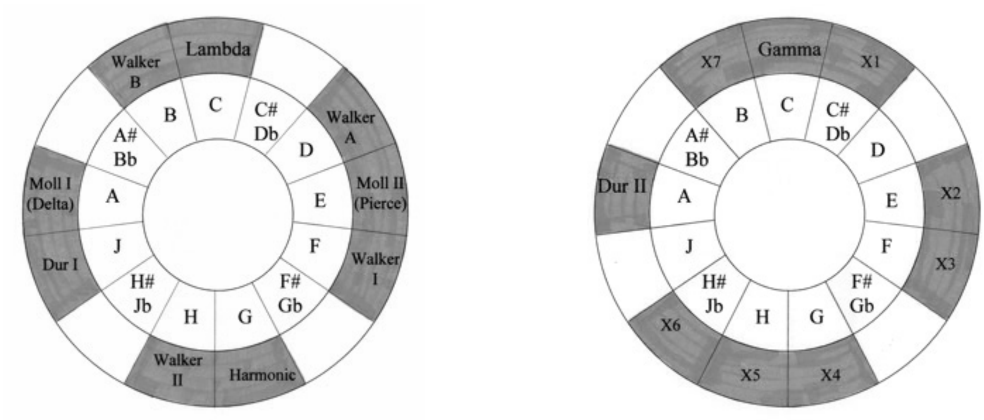



Figure 8: Bohlen's Lambda and Gamma families

Bohlen researched the modes of the Lambda family for their harmonic value, assuming that the more triads and inversions can be formed on their steps, the higher the harmonic value of a mode will be. In addition to the modes Dur I, Dur II, Harmonic, Moll I and Moll II, the mode Delta takes a special position. On the one hand, Bohlen chose it as the reference mode for his planned keyboard and thus as the form giving mode for the keyboard layout. On the other hand, in Delta mode, modulation to another group of modes can successfully be done: Delta becomes Gamma by altering the 9th step of the mode in order to create a kind of leading tone. However, Bohlen admits that most of the modes in the Gamma family are of rather limited harmonic value. (One of the Lambda family modes, Moll II, will be discussed below: interestingly, this mode was also developed by another discoverer of the scale and named the "Pierce mode".)

Bohlen did a thought experiment, modifying numbers in the frequeny ratios of intervals and triads, and he succeeded in deriving triads and a musical scale from it. The resulting scale he called the "13-tone scale". He could have named it the "Bohlen scale", but from my personal remembrances of Heinz Bohlen the reason why he did not do so might have been his modesty. He considered his own musical education elementary, and that probably contributed to his initial self-consciousness about his findings. There are letters from 1973 in which he discusses his idea with two acousticians, Jürgen Meyer[8] (Braunschweig) and Ernst Terhardt[9] (Munich). Terhardt, in particular, expressed concerns about the usefulness of the material and its feasibility.

### 1.1.4 John R. Pierce: A Flash of Insight

One of the curiosities of the BP scale is that it was found not once, but twice. To be fully accurate, it was found three times within a decade. The second discoverer of the BP scale, interestingly, had the same profession as Heinz Bohlen: communication electronics engineer John R. Pierce (1910-2002), who even worked in a similar field as Bohlen. As an engineer at the large telecommunications company Bell Laboratories (Bell Labs), he was significantly involved in the development of numerous communication technology components, and when the first television satellite was launched in 1962, a good part of it was to Pierce's credit. After his retirement from his engineering career, he moved to Stanford, California to work with his friend Max Mathews, pioneer of computer music and co-founder of the Center of Computer Research in Music and Acoustics (CCRMA) at Stanford

[8]http://huygens-fokker.org/bpsite/Meyer.html, last access: 30th July 2019

[9]http://huygens-fokker.org/bpsite/Terhardt.html, last access: 30th July 2019

University, where Pierce was assigned the illustrious title of Visiting Professor Emeritus. The purpose of this made-up title was to give Pierce access to the university's facilities such as the library, and to enable him to rent an apartment on campus [Goldstein 1992].[10] Mathews can be considered the discoverer of the 3/5/7 chord on the American side. In contrast to Heinz Bohlen a decade earlier, Mathews had access to the top computers of the 1980s through both Bell Labs and CCRMA, and he worked specifically on computer music projects. In a project about intonation hearing he was researching if there were individual preferences regarding the intonation of the major third in a traditional major (4/5/6) chord. To do this, he generated a just major chord on a computer. Additionally, he generated variations of the pure major chord with the major third being 15c sharp or flat, which is within the normal range of intonation of a major chord. To see whether these assumed individual preferences could be generalised, he generated the non-traditional 3/5/7 and 5/7/9 chords, each in both the just version and with deviations of +/-15c of the middle note.[11] Some time after the research project, Mathews told Pierce about it, and they wondered which scale might accomodate this apparently harmonic chord. It soon turned out that no division of the octave was suitable,[12] and thanks to a flash of insight by Pierce they found that the frame interval for the scale could be 1/3 instead of 1/2. Pierce named the resulting scale after himself ("Pierce scale" or, initially, "3579 P") and the 1/3 frame interval a "tritave" due to the triple ratio.

The new scale held Pierce‘s attention, and he began to explore the tonal possibilities of the material. As a most interesting fact, Pierce formed a "diatonic" mode of small and big steps just as Bohlen did, and even more interesting was that he arrived at a mode of nine steps which he called "Pierce mode". This mode happens to be part of Bohlen‘s Lambda family! In other words, Pierce came to the exact same results in his search of tonality as

[10] The interview of Andy Goldstein with John R. Pierce can be found on https://ethw.org/Oral-History:John_Pierce_(Part_3), last access: 30th July 2019

[11] The results of this experiment are quite interesting. Mathews, Pierce and Roberts describe it in their article *Harmony and New Scales* [Max V Mathews, John R Pierce, and Roberts 1987].

[12] This is not quite true. 41div2 contains both the 3/5/7 chord in very close approximation and the BP scale as a subset of every 5th tone.

Bohlen did, and “Moll II” and “Pierce” are in fact the same modes. Pierce suggests the 3/5/7 chord, which he calls “major” (remember: Bohlen called it the “BP wide triad”), as well as a “minor” chord which is a mirror of the 3/5/7 chord, just as a traditional minor chord mirrors the major chord. He recognises the 5/7/9 chord as the first inversion of 3/5/7.

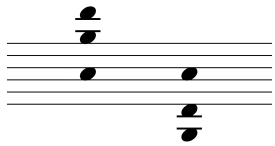


Figure 9: Pierce’s ”major” chord (or 3/5/7 chord) and its structural mirror, the ”minor” chord.

The thought behind the Pierce mode is that all scale steps can be harmonised by either a major or a minor chord or by one of their inversions. A high harmonic value of the mode may thus be assumed [Krumhansl 1987, pp. 44-48]. Pierce, Mathews and Roberts developed their thoughts on spectra, modes and chords, and their inversions. The group, represented by Max Mathews [Goldstein 1992] presented their research outcomes in the one-day conference *Harmony and Tonality* in Stockholm in 1986. Apparently, they had already been in contact about the tone material with music psychologist Carol Krumhansl who spoke about modulation and tonality issues of the scale in her own lecture in the very same conference. It is obvious that the group was inspired by Krumhansl‘s work and borrowed many of her thoughts and aspects in regard to the tonal potential of the scale. Around the same time, in the middle of the 1980s, they became aware of Bohlen’s work and his earlier publication [Bohlen 1978], and they acknowledged that he had found the exact same scale several years before them. Consequently, they renamed the scale to “Bohlen-Pierce scale” in their publications following [Max V. Mathews, John R. Pierce, et al. 1988, pp. 1214-1222; Max V. Mathews and John R. Pierce 1991, pp. 165-173].

In the said conference paper, they also write about possible sound spectra to match the scale, and about instruments:

> "What kind of instruments could play the Pierce scale? Although one might design acoustic instruments with appropriate timbres and pitches, such tasks would require a great deal of work. On the other hand, computers and electronic synthesizers can easily be programmed for these purposes, and they are the obvious first choice to play this music." [Max V Mathews, John R Pierce, and Roberts 1987, p.67]

The group kept working in the field and was very productive, and one of their aims or motivations was to use Bohlen-Pierce music in psychoacoustic research projects. The proceedings of the said conference in Stockholm are available online,[13] and with them comes an audio file with sound examples which we may assume were presented during the lecture. The file contains synthesised recordings of several BP chords; the Pierce mode, as well as a harmonised version of it; followed by several short compositions of computer music: a short canon, a small fugue, a song in A-B-A form and a ragtime.

Although it is not quite clear who of the three wrote the compositions, it may be assumed that it was Linda Roberts who composed them. Pierce talks about the discovery of the BP scale in an interview with Andy Goldstein. At some point, he talks about a female summer student or intern:

> "So Max Mathews used to have summer jobs for people while he was at Bell Laboratories, and he had them working on musical things. He had somebody who had something of a musical education who wrote pieces in this scale. They sounded as if they made a sense, but they were different. She wrote very conventional things. And I wrote one or two pieces in the scale." Goldstein 1992[14]

The description of the pieces as "very conventional" match the style of the pieces accompanying the presentation. It is also possible, of course, that Pierce contributed to the recordings in question.

[13] https://www.speech.kth.se/music/publications/kma/kma54.html, last access: 29th Jul 2019

[14] https://ethw.org/Oral-History:John_Pierce_(Part_3), last accessed: 30th July 2019

### 1.1.5 Kees van Prooijen

All good things come in threes, and so the scale was invented a third time, this time in The Netherlands by software engineer Kees van Prooijen. According to his own information in a Facebook post from November 23rd, 2017, his first notes on the subject date from 1972.[15] Van Prooijen published his article *A Theory of Equal-Tempered Scales* in 1978 [Prooijen 1978]. The article deals with various equal-tempered scales in an effort to find scales whose equal-tempered version matches its JI version as closely as possible. In his article, he proposes several scales in a form that is almost only understandable to mathematicians and mathematically inclined music theorists. Van Prooijen does not go into details of individual scales. It is noteworthy that he naturally makes several suggestions that use not the octave but the perfect fifth or twelfth as an interval of equivalency.[16] In the entanglement of numbers in the article, however, the scale is so hidden and so difficult to find that van Prooijen, the third discoverer of the scale, could almost be overlooked. Only in the year 2000 did he compose a piece of computer music that uses the scale.[17]

## 1.2 Instrument Design and Keywork of the BP Clarinet

### 1.2.1 Early Considerations 1973-2003

The idea about the clarinet as an appropriate BP instrument is not new. In fact, Jürgen Meyer, a well-known acoustician in his day who was in contact with Bohlen about his novel scale, was the first one to think about a clarinet to play the Bohlen-Pierce scale in 1973. In a reply letter to Heinz Bohlen, dated 10th May 1973, Meyer expresses some interesting thoughts. Meyer speaks about acoustic instruments whose spectra match the particular properties of the "13-tone scale" and obviously seeks sounds with odd-partial

[15] https://tinyurl.com/kees1972, last access: 30th July 2019

[16] As early as 1978 van Prooijen proposed in this paper the division of the perfect fifth into nine steps, a scale which became known from the mid-1980s on as *Carlos alpha*, discovered by Wendy Carlos.

[17] Source: personal email from Kees van Prooijen

timbres. He sees part of the properties he is searching for in the acoustics of clarinet and organ, two instruments with the waveform of stopped cylindrical pipes. For the first time, the idea of what later would be called a Bohlen-Pierce clarinet is uttered. Meyer points out that avoiding even-numbered partials is a pre-condition for tonal harmonies in the novel scale; a brilliant thought which is based on the knowledge that the perception of consonance is strongly connected to the spectra of the respective sound [John R. Pierce 1966; Sethares 2005, chap. 6], and which he applies to Bohlen's scale:

> "Voraussetzung für tonale Zusammenklänge ist natürlich die Vermeidung von geradzahligen Obertönen. Mit elektronischen Tongeneratoren läßt sich das ohne weiteres erreichen, im Bereich des konventionellen Instrumentariums gibt es dagegen wenig Möglichkeiten, denn bei den Klarinetten sind die entsprechenden Spektren etwa auf die unterste Oktave des Tonumfangs beschränkt, und gedackte Orgelpfeifen haben meist schon einen stärkeren 4. Teilton. Man könnte allerdings an entsprechend aufgebaute neue Mixturen denken."[18]

At this early stage, Meyer already considers the clarinet as a possible instrument to play the novel scale. Unfortunately, he immediately drops his idea due to considerations about the required spectrum. Meyer's utterance about the clarinet spectrum surprises at first glance: he points out that the clarinet's spectra are only suitable to the new scale in "the lowest octave". One would assume that he means the lowest *twelfth* since that is where the first register change happens and where one would guess that a change of spectrum happens. But Meyer had done thorough research about the clarinet sound earlier [Meyer 2009; first published in German in 1972, section 3.2.]. In the lowest notes of a B♭ clarinet from notated e to e' the even-numbered partials are suppressed while the odd-numbered partials are stronger; Meyer

[18]English translation: "A pre-condition for tonal harmonies is of course the avoidance of even-numbered partials. This can be achieved easily using electronic tone generators. Conventional instruments, in contrast, provide few possibilities: regarding clarinets, the appropriate spectra are confined to the lower octave of the range, and stopped pipes usually have a stronger 4th partial. However, one could think of adequatly building new mixtures." source: http://www.huygens-fokker.org/bpsite/Meyer.html, last accessed: 30th Jul 2019

shows that already around notated f' the spectrum starts to change: the first and third partials are indeed a lot stronger than the second partial, but already from the fourth partial on the even- and odd-numbered harmonics are equally strong. The register break itself between notated a' and b' does not cause any changes in the spectrum.[19]

Meyer also assumes that music based on the new scale would be difficult to listen to since it did not develop throughout several hundred years as the 12div2 system did, and the listener is not as acquainted with its harmonies.

He assumes that those intervals of the 13-tone scale which are similar to intervals of the 12div2 scale would be perceived in accordance to the familiar system and thus the listener might assign meanings to the known intervals "which do not meet the properties in the 13-tone scale":

> "Gewisse Schwierigkeiten dürften sich für den Hörer dadurch ergeben, daß sich die neue Tonleiter nicht historisch entwickelt hat und dementsprechend Hör-Erfahrung von einfacheren Vorstufen fehlt. Vielmehr ist die Hör-Erwartung wahrscheinlich schwer von der bisherigen Hör-Erfahrung zu lösen, so daß den 'bekannten' Intervallen eine Bedeutung zugewiesen wird, die nicht ihrer Rolle im 13stufigen System gerecht wird. Dies wird umso mehr der Fall sein, als das Ohr in gewissen Grenzen auch verstimmte Intervalle noch – bezogen auf das reine System – 'zurechthört' oder aber zu große Abweichungen davon als 'falsch' empfindet. Der Dualismus im Aufbau der beiden Systeme darf daher nicht über die Rangordnung des ersten und des späteren Systems hinwegtäuschen." [Meyer 1973][20]

[19]Meyer also discusses the sound of the throat notes (i.e. the notes between e4/e' and g♯4/g♯') and explains the perceived tone quality differences around the register break. A good read for clarinettists.

[20]English translation: "Certain difficulties might arise for the listener due to the fact that the new scale has not developed historically and accordingly there is no hearing experience on lower levels. Rather, the hearing expectation is probably difficult to detach from the previous hearing experience, so that the 'known' intervals are assigned a meaning that does not do justice to their role in the 13-step system. This will be all the more the case as the ear, within certain limits, 'corrects' out-of-tune intervals during perception, or perceives too large a deviation from them as 'wrong'. The dualism in the structure of the two systems must therefore not hide the hierarchy of the first and the later system".

Meyer had led many research projects in psychoacoustics and the acoustics of music instruments, and he makes his assumptions on the basis of his thorough knowledge. His assumption about the diffculties in perception listeners would face shows his own deep roots in the traditional system, himself being an active violinist. However, Meyer was not able to prove his assumption due to the fact that the 13-tone scale at that time was a theoretic structure which had not been played by any instrument as yet. Many years later, in 2007, Psyche Loui conducted a series of experiments in order to find out about how the Bohlen-Pierce scale is perceived by the listener who hears the scale and its harmonies for the first time, and about the process of acquiring the new system [Loui 2007]. However, Meyer liked Bohlen's idea of a home-built organ as a relatively inexpensive and easy-to-play instrument. He is enthusiastic and optimistic about developing a harmonic system through free improvisation and in a way relaxes his own concern that the recipient would hardly be able to get into the new system because of his own hearing experiences and expectations being in the way.

> "Mit Ihrem Instrument könnte man dagegen die Klangwirkung in freier Improvisation direkt erproben und so zu einer dem System entsprechenden Harmonielehre kommen." [Meyer 1973][21]

The two men were discussing a scale that was existent only in their minds. The idea of a Bohlen-Pierce clarinet was not taken and fell into oblivion for twenty years.

The scale, however, made its way to composers and computer musicians with an interest in tunings and scales. Composer Georg Hajdu had heard about the Bohlen-Pierce scale as a student in a seminar of Johannes Fritsch at the Hochschule für Musik und Tanz Köln in 1987. In 1991, as a graduate student of University of California, Berkeley, he conducted his first experiments in the context of the Bohlen-Pierce scale [Hajdu 2010]. His continuing research about the Bohlen-Pierce scale and suitable timbres – stretched spectra - led him also to the insight that the clarinet would be an ideal choice

[21]English translation: "With your instrument, on the other hand, one could directly test the musical effect through free improvisation and thus arrive at a harmony theory corresponding to the system."

to play in Bohlen-Pierce. Hajdu made use of the BP scale in the opening scene of his opera *Der Sprung* (1991). In lack of a real clarinet in BP he used an electronic wind controller (Yamaha WX-7) as a substitute for a clarinet. This MIDI wind controller was connected to an electronic program that "translated" the data from the wind controller into BP pitches, creating the illusion of a BP clarinet. However, the piece was premiered not with the wind controller but with a keyboard in BP due to the clarinettist having difficulty playing the wind controller.[22]

Hajdu was not satisfied using an electronic instrument to generate the sound of a BP clarinet. His vision was to have a real instrument, an acoustic clarinet designed to play in BP. It took him several years to find an adventurous woodwind maker to build a BP clarinet. He finally contacted *Musikk Instrument Akademiet*, a college for instrument making in Norway where Stephen Fox was one of the teachers. Fox, not only a clarinettist and woodwind maker, but a physicist as well, immediately showed interest in designing a BP clarinet. Attracted by the challenge of constructing a wind instrument with alternative tuning, he began to research about BP history and music ″to make sure our work would be compatible to what others had done″ [Email from Stephen Fox, 18th April 2012], and he started developing a BP clarinet with his students in Norway in 2004. The school soon had to close down - unfortunately -, but Fox continued working on the project in his own workshop in Toronto, Canada [Fox 2010].

### 1.2.2 The Becoming of the Modern BP Clarinet

In his lecture held at the Bohlen-Pierce conference in Boston, MA in March 2010, Stephen Fox spoke about the development process of the first BP clarinets:

> "The first choice that needed to be made was how long to make [the clarinet], in other words what key note to use. At the time I started all this it did not seem as there was a generally accepted reference pitch for the Bohlen-Pierce scale in absolute terms. The

[22] source: personal information from Georg Hajdu

obvious alternatives would be a' or c', so I just chose a'. That is very handy for making a clarinet because a' is the complete overblown tube length of the normal B♭ clarinet, so I could use the same body, tube essentially, the same bore, same mouthpiece and so on. The only differences are in the tone holes and the key work. For the BP clarinet it only takes 12 tone holes plus the bell to cover the entire low register, so the mechanism can be a lot simpler than with the normal clarinet which takes at least 18 tone holes to cover the pitch span. The bottom four holes are controlled by mechanism for the little fingers along the same lines as the normal clarinet. So far I have used Western style Boehm system keywork, but the German Oehler system could have been used just as easily." [Fox 2010]

For the lowest notes and the first notes of the clarion register[23], Fox chose the same key arrangement as for the Boehm clarinet, i.e. four keys for the right little finger and three keys for the left one (right: keys e/b', f/c', f♯/c'♯ and g♯/d'♯ of the traditional clarinet; left: e/b', f/c' and f♯/c♯'). The remaining pitches of the tritave are produced by six open finger holes, a thumb hole and a key above the first finger hole, operated by the left index finger, equal to the traditional throat a' key. Additionally, Fox put an a' trill key to the instrument, a useful extra feature not only when an a'/b' trill occurs, but apparently essential for every clarinettist who likes to discover the instrument's soft-sounding multiphonics.

In the whole, the Bohlen-Pierce soprano clarinet is of the same length as a B♭ clarinet with a sounding d (notated e; or, in Müller-Hajdu nomenclature, N3; see Chapter 2) as the bottom note. Compared to a B♭ clarinet, it has a considerably shorter upper joint and accordingly a longer lower joint. The deviation in length of joints from the traditional clarinet results from the fact that a fingered c' on the Bohlen-Pierce clarinet is a sounding c' +22 cents (U3) which means that it sounds about one and an eighth tone higher than a B♭ clarinet when the same fingering is used. Fox decided to separate the

[23] The clarion register is the range in which the clarinet overblows to the twelfth, i.e. b' through c"'.

(a) Left to right: BP soprano, contra and tenor clarinet

(b) BP contra clarinet, detail

Figure 10: BP clarinets

clarinet's body into two joints, making the break between the right and left hand fingers, as is usual. The clarinet can be played using a conventional B♭ clarinet mouthpiece. The author's first instrument came with two barrels, one fitting a French mouthpiece and the other fitting a German mouthpiece. This prototype also had plain finger holes which made playing the clarinet a bit uncomfortable, especially the right ring-finger hole which is relatively far away from the middle finger and quite big; a person with slim fingers can find it difficult to cover. Fox solved this problem in later instruments by cutting tone holes in the lower joint in an angle, allowing a narrower finger position. He also added chimneys to raise the open finger holes, giving the player a more comfortable feeling.

> "So how does one go about setting the tone hole positions on a woodwind instrument for a new scale? (. . . ) It was just done the way instrument makers always work which is knowing what works

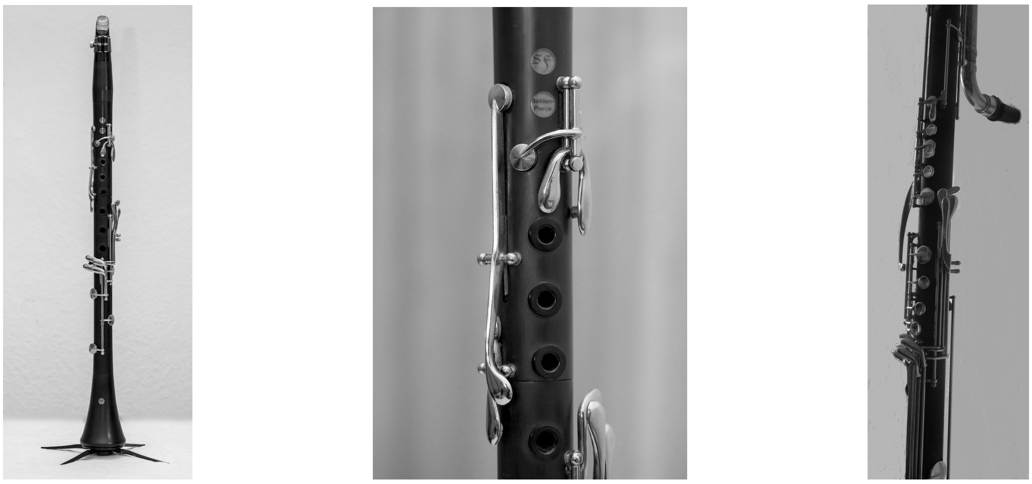
> now and then making changes by educated guesswork and some simple mathematics. For each note of the Bohlen-Pierce scale we know the frequency, and from that and the speed of sound we can calculate the wave length. For a clarinet type instrument, $\frac{1}{4}$ of the wave length equals the acoustical length of that note, and the acoustical length equals the actual distance from the top of the instrument down to the tone hole which controls that note. Plus an $n$ correction at the mouthpiece, which is the same for each note, plus an $n$ correction at tone hole. By measuring and analyzing normal clarinets we can ascertain those two $n$ corrections for different parts of the scale and then just apply them to the new acoustical length. That gives us the tone hole placement. And we make an instrument like that and play it and just make whatever changes are necessary. It worked okay, the instrument plays a good-in-tune Bohlen-Pierce scale over the first two registers, as much as a clarinet ever does; (...)in the altissimo range we had to experiment and find fingerings which would give good, stable, in tune Bohlen-Pierce pitches. In the beginning, there was no guarantee if this would be possible, but it is possible as high as we have gone so far, except for one note, the bottom altissimo note (equivalent of high c♯) which is a bit unstable and varies from instrument to instrument."[Fox 2010]

The first two BP clarinets were shipped to Hamburg, Germany in summer 2007 on Hajdu's request.

In 2010 Fox made a lower-pitched BP clarinet, the BP tenor clarinet. The BP tenor clarinet sounds 6 BP steps below the BP soprano clarinet, and it is about halfway in size between a traditional alto and bass clarinet. Fox based the design of the BP tenor clarinet on an alto clarinet with the same mouthpiece, neck and bell. The same fingering pattern as for the BP soprano clarinet can be used up to the top register; additionally, the BP tenor clarinet has a low e♭ key (a sounding U2 or E -26 c; see section 2.2).

In 2011 Fox built another instrument of the BP clarinet family, the so-called epsilon clarinet, a high-pitched instrument of the size of a traditional e♭ clarinet. It sounds four BP steps higher than the soprano clarinet. The name epsilon clarinet derives from TRANSPECTRA's own notation system and note names in which the middle note 440 Hz is called alpha, and the next notes upwards follow the Greek alphabet: beta, gamma, delta, epsilon (see section 2.1.2). Its lowest note is R3 / a♭ -17c. At this time there are two epsilon clarinets, one from pearwood after the customer's request and one from Fox's favourite material, delrin; both instruments are in the possession of the same person, an amateur clarinettist in the USA.

And finally, Fox completed the BP clarinet choir with his construction of a BP contra clarinet, commissioned by Georg Hajdu and HfMT Hamburg, in 2018. Fox and Müller unveiled this spectacular instrument during their presentation on BP clarinets at the annual convention of the International Clarinet Association, ClarinetFest 2018, in Oostend, Belgium. The BP contra clarinet sounds one tritave lower than the soprano. Fox's material of choice in this prototype was not delrin, but rather nylotron.



(a) BP soprano clarinet; this specimen has two extra keys on the upper joint (g♯ and e♭)

(b) BP soprano clarinet, detail of upper joint with two extra keys which do not give BP pitches but rather some flexibility regarding clolour fingerings multiphonics or microtonal trills.

(c) BP contra clarinet, detail

Figure 11: BP clarinets

Three people, three questions, three different approaches. And yet, they all come to the same result. Bohlen and Pierce in their search for tonality even developed modes from the material which resemble each other to such an extend that it is astounding. In the early times of computer music, and with hardly any acoustic instruments at hand that fulfill professional standards, the BP scale survived in computer music studios, mainly at a few American universities. Max Mathew's development of an electronic instrument which he calls the *radio baton* (1987) inspired Richard Boulanger to compose two pieces in BP for this instrument.[24] As he became a university teacher himself, he taught his students about the scale. Among them was Elaine Walker who composes pop music in BP and other microtonal tunings. This way, the

[24] *I Know of no Geometry* and *Solemn Song for Evening*, the latter one featuring a voice part.

scale was carried on in the Anglo-American area and set a musical tradition in motion, which we are following today.

Hajdu's acquaintance with Bohlen and his re-integration into the Bohlen-Pierce project complete the circle. The appearance of BP clarinets and other acoustic BP instruments[25] has boosted interest in the scale. As of today, musicians from Canada, Germany, Estonia, Serbia, Belgium, The Netherlands and the USA are active performers of BP music, and composers in Europe and North America have contributed a total of three dozen compositions featuring BP clarinets, with hopefully many more to come.

[25]Other acoustic instruments in BP include guitars, e.g. by Ron Sword, and a pan flute by flutemaker Ulrich Herkenhoff. Stephen Fox successfully converted a standard alto recorder into BP and gives instructions for the conversion on his webpage.

# 2 Notation

When working in BP or other alternative tunings, musicians and composers face the problem of notating music in other scales than 12div2. A great number of microtonal accidentals have been developed since the beginning of the 20th century to notate even the tiniest intervals. Many different systems of accidentals such as the almost traditional Stein-Zimmermann notation, Helmholtz-Ellis notation and its JI "extension" by Marc Sabat, or Ezra Sims's 72-tone accidentals are in use, some of them making it necessary for musicians to specialise in a chosen system due to a high degree of complexity of the accidentals. Notation of non-octave systems is particularly difficult. Any trial to notate within the usual five line system brings up problems since Western musicians have a strong sense of what a notation in the five line system means: in the interpreter‘s mind it is connected to the Western standard system and other octave-related scales. Notating a non-octave scale within this system easily results in irritation about step sizes and harmonic frames. The question about how to notate the BP scale is essential due to the fact that current BP instruments are designed under many different aspects which are specific to each kind of instrument. Consequently, notation systems may be instrument specific to meet the needs of the respective instrumentalists, e.g. op de Coul notation, BP clarinet notation. On the other hand, for a BP ensemble of mixed instruments, and for composers writing in BP it would be useful to read scores in a standard BP notation in order to be able to compare pitches and discuss intervals and harmony. Several suggestions for BP notation have currently been made. Manuel op de Coul for instance considers one of Bohlen‘s early modes as a reference and thus works with accidentals, similar to notation in the twelve tone system. This can be convenient for players of keyboard instruments, provided that they use a keyboard layout based on the particular reference mode, and keyboard layout is probably a main reason for the decision for a diatonic notation. However, this suggests the use or acceptance of BP modes. And while keyboard players will find diatonic notation comfortable to read related to their keyboard layout, players of other BP instruments will be disturbed by a diatonic notation which does not meet the properties of their particular instrument‘s design.

A clarinettist, for example, will hardly be able to play from a diatonic notation based on a BP mode. The keywork design of Fox‘s BP clarinets suggests an instrument specific notation closely related to traditional clarinet notation, in fact a fingering notation for the clarinettist: a notated c♯” for instance would be read and fingered by the clarinettist like a notated c♯” on a traditional clarinet, not taking into account that the actual sounding pitch on BP clarinet is c”-7c in that specific case. Vice versa, a keyboard player (or any other instrumentalist) cannot use the clarinet fingering notation because it uses an apparently strange mix of half- and whole tone steps which does not display the real intervals. For example, the notated intervals of e-b♭ and c’-b’ are actually the same BP interval (6 BP steps), because the keywork of the BP clarinet has the usual keys for the left and right little fingers but six open tone holes thereafter.

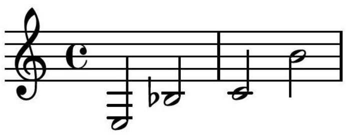


Figure 12: Example of clarinet fingering notation; these intervals both represent the same BP interval, a BP 6th.

There is no doubt that this kind of notation is comfortable for the clarinettist, but it is impossible to handle for other musicians, and it is a severe difficulty for composers. Talking and thinking about theoretical aspects such as intervals and chords is hardly possible. To show the confusion BP musicians have to deal with in their music practice when using instrument specific notations, one might have a look at the original edition (2008) of Georg Hajdu’s score of *Beyond the Horizon* (fig. 13) for two BP clarinets and synthesizer in BP tuning and with a normal 12div2 keyboard layout (that is what was available at the time of its premiere, and what is generally widely available).

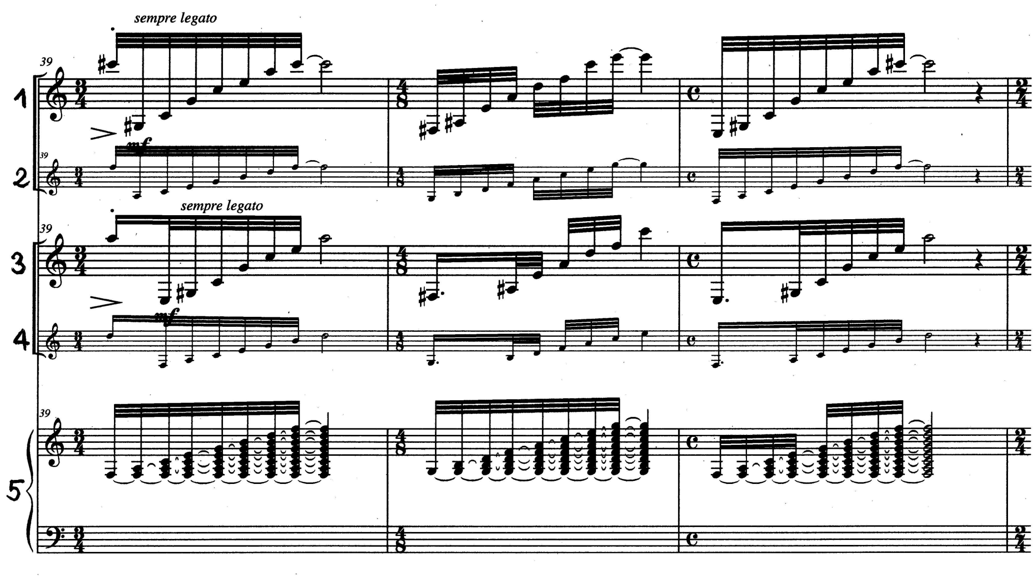



Figure 13: Excerpt from *Beyond the Horizon* (2008) by Georg Hajdu. This example shows the irritation created by instrument-specific BP notation systems: staff lines 1 and 3 are written in clarinet fingering notation. Staff lines 2, 4 and 5 show the synthesizer part (5) in a notation for performance on a standard 12div2 keyboard tuned to BP as well as the two clarinet parts (2 and 4) transcribed to the same notation.

The score shows representations for two kinds of instruments: the BP clarinets in fingering notation for the clarinettists (staffs marked 1 and 3), the synthesizer in notation for the keyboard with 12div2 layout (staff 5) plus the clarinet parts transcribed to keyboard notation (staffs 2 and 4). Although the score allows the ensemble to rehearse, the notation is inconsistent, and the players are not able to read each other's sounding pitches from it.

In the following, three proposals for BP notation will be discussed: a diatonic notation by Manuel op de Coul which is based on Heinz Bohlen's own attempts to notate his scale; a chromatic notation proposed in 2007 by TranSpectra, a Canadian ensemble founded on occasion of the North American premiere of the BP clarinet project; and finally, a chromatic notation suggested by Nora-Louise Müller and Georg Hajdu, the driving forces behind the BP clarinet project on the European side.

## 2.1 Earlier Proposals for BP Notation

The example from *Beyond the Horizon* (fig. 13) shows that a specific notation for BP music is needed in order to make it possible to read and write scores in concert pitch. There have been earlier proposals for BP notation, some of which shall be discussed in the following.

### 2.1.1 Op de Coul

Manuel op de Coul's[26] notation is one of the first specific notation systems for BP music. Based on Bohlen's own approach, op de Coul suggests two five-line staves with treble and bass clefs marked *BP*. As a reference mode he chooses *Lambda,*[27] and the note names c d e f g h j a b for the Lambda mode. All other modes are notated by adding sharps or flats (fig. 14).

The staff conveniently covers, on a five-line system, the range of two tritaves so that clefs do not need to be changed very often. Lambda results in an asymmetric keyboard layout with 9 white and 4 black keys which can easily be learned by keyboard players. However due to the similarities of the note names, clefs and staves to standard notation, musicians may get mixed up. For instance, the BP interval c-c is meant to be a tritave, but is notated like the traditional c'-e" which causes a double confusion in terms of the meaning of the interval: c-c is usually considered an octave, but here it indicates a tritave, plus one would read a tenth in standard notation which has nothing to do with either. The confusing nomenclature notwithstanding, op de Coul's notation has the great potential of being established specifically as a standard notation for keyboard instruments. A notation system using accidentals implies agreement on a reference mode - in this case C Lambda – which can be identified with a certain keyboard layout. As on a traditional

[26] http://www.huygens-fokker.org/bpsite/ as of July 2013. The source does not say how op de Coul's pitches are anchored; since it has been common MIDI practice to map alternative tunings to c4 one may assume that op de Coul decided to do the same. However, absolute pitch is a matter of music practice rather than of notation, and op de Coul's notation can as well be mapped to a'/N4 = 440-443Hz.

[27] steps 1,3,4,5,7,8,10,11 and 13 of BP scale or scale structure 2 1 1 2 1 2 1 2 1; see section 1.1.3

keyboard, notes with accidentals would be represented by black keys while C Lambda would be played on white keys only.

Elaine Walker's work, for instance, perfectly connects to op de Coul‘s ideas. Walker has been thinking about BP keyboard layouts since the early 2000s, originally using a layout based on Lambda mode, following op de Coul‘s suggestion. It turned out to make orientation difficult for the player due to its very regular distribution of black and white keys[28]. Walker thus decided to rather use a Dur II layout. This layout provides a clearer arrangement through its slightly irregular distribution of black keys within a tritave.[29]Op de Coul's notation system can easily be modified in terms of the reference mode to fit Walker's keyboard layout.

Looking at it carefully, it becomes obvious that, provided the use of a matching keyboard layout, op de Coul's notation is comfortable and easy to learn for an experienced keyboard player. Nevertheless the use of a reference mode and accidentals consequently is critical for players of other instruments, because instruments (e.g. string and wind instruments) may be constructed under very different aspects and not based on a reference scale.

[28]Walker on www.ziaspace.com/_microtonality/BP, last access: 30th July 2019

[29]A detailed description of the two keyboard layouts can be found on Elaine Walker‘s webpage. She has been building BP keyboard instruments since 2010. http://www.ziaspace.com/_microtonality/BP

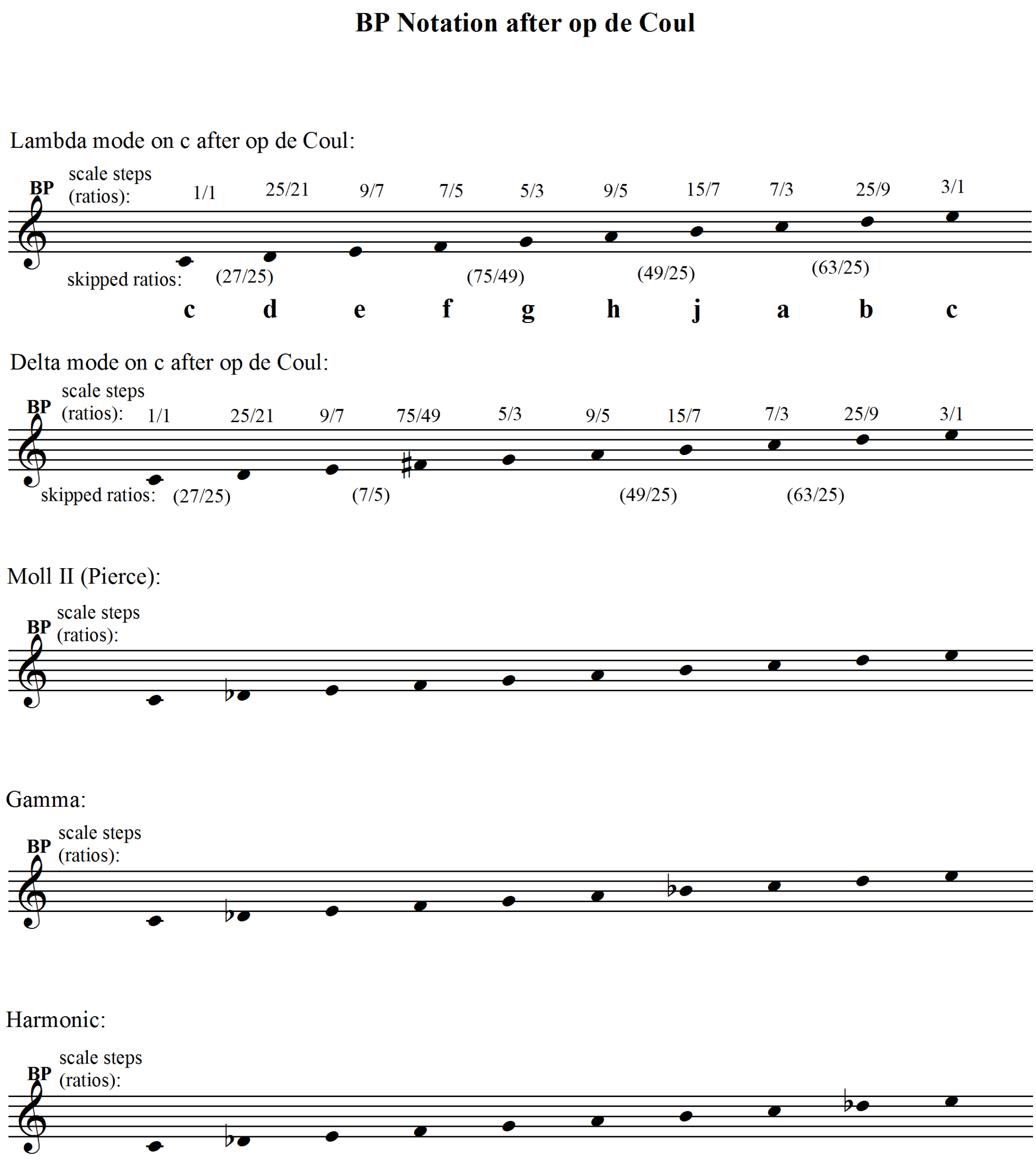



Figure 14: BP notation after op de Coul. The example shows notation of some of Bohlen's modes based on op de Coul's suggestion of Lambda as a reference mode.

### 2.1.2 tranSpectra

A chromatic notation system which does not need accidentals could be used by any BP player, regardless of the specific construction of the various instruments, at the same time simplifying the composer's task of notating for specific instruments, releasing him from the Sisyphean labour of transcribing parts to a specific instrument or, from the beginning of the process, writing in several different, instrument specific notations. Moreover, a chromatic notation does not restrict us to a narrow BP harmonic theory but stays open to experiments in tonality and harmony. Therefore, the members of tranSpectra, one of the first ensembles dedicated to Bohlen-Pierce music, suggest a chromatic notation system which makes no use of accidentals and still allows to notate Bohlen-Pierce music in concert pitch.[30]

A traditional five line staff accomodates the Bohlen-Pierce pitches, with A440 on the first ledger line below staff in soprano clef (fig. 15). This appears to be a good idea since players of all BP instruments can get used to reading from a chromatic notation, rather than from one that suggests a reference mode and which uses accidentals. The tranSpectra collective's suggestion fulfils the need of a notation system that can be read by any player. Note names are taken from the Greek alphabet, starting from $\alpha$ (alpha) and following through to $\nu$ (nu), clefs are named S (soprano), A (alto) and B (basso). Greek note names cannot be mixed up with traditional note names, which is an important detail. Yet the system has one disadvantage: one five line staff does not even cover the range of one tritave. Therefore it is necessary to make use of at least two staves or clefs for instruments providing a greater range. Possible solutions are frequent clef changes - for instance, playing pieces in the range of the clarinet from $\alpha 2$ to $\alpha 4$ or higher, clef changes between S and A would be obligatory - or continuous notation on two or three staves, which takes up a lot of space on the music sheet and is thus not practical regarding page turning.

[30]Proposals for chromatic notations in 12div2 have been made by Josef Matthias Hauer in the 1920s [Blaukopf 1966, p. 35] and by Albert Brennink in 1976 (Reed 1997, page 10.2 or http://musicnotation.org/system/a-b-chromatic-notation-by-albert-brennink/, last access: 30th July 2019).

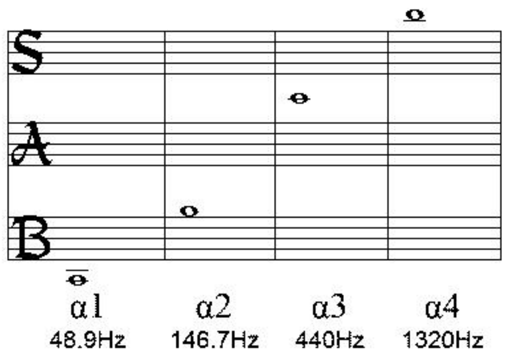



Figure 15: BP notation as suggested by tranSpectra

## 2.2 Müller-Hajdu Notation

The Müller-Hajdu notation[31] is a chromatic notation with each of the 13 scale steps on or between lines. It does not use accidentals and hence is independent from a reference mode or specific instrument layout. It thus resembles other chromatic notation systems invented in the 20th century such as the chromatic notation by J. M. Hauer[32] or Ailler-Brennink notation,[33] or the chromatic BP notation by tranSpectra. The staff consists of six lines as suggested by Müller. This makes it possible to notate a range of two tritaves, using four ledger lines above and below staff which is reasonably practicable for musicians (fig. 16).

Hajdu contributed the note names, taken from the last 13 letters of the alphabet, N-Z, to avoid confusion with traditional note names a-g. Most acoustic BP instruments have an important matching tone with the standard system, the sounding a' (440-442 Hz). This note, named N4 in Müller-Hajdu notation, is located in the middle of the staff, indicated by an N clef. The system can on first sight be distinguished from the traditional five-line staff;

[31]Suggested by Nora-Louise Müller and Georg Hajdu; Müller suggests notation on six lines in two systems for treble and bass instruments respectively (soon after named N and Z clef, as well as U clef for the BP tenor clarinet); Hajdu contributed the note names and added the T clef.

[32]Blaukopf 1966; Hauer developed a dodecaphonic composition technique as early as in 1919 and in 1931 suggested a chromatic notation system which he uses in his 1932 opera *Die schwarze Spinne*.

[33]The notation systems developed by Johann Ailler (1904) and Albert Brennink (1976) are very similar and thus referred to as Ailler-Brennink notation, see Reed 1997.

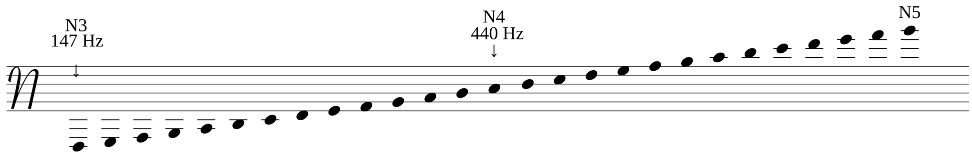



Figure 16: BP chromatic notation after Müller and Hajdu: the range of two tritaves conveniently fits on a 6-line staff in N clef.

there is no danger of mixing up the two notation systems. A system with six lines is still legible for musicians; more staff lines, though, may lead to problems due to increasing visual complexity and thus latency in reliably identifying scale steps. The N clef perfecly accommodates the range of a Bohlen-Pierce soprano clarinet. For lower instruments or voices the T or the Z clef may be chosen instead (fig. 17).

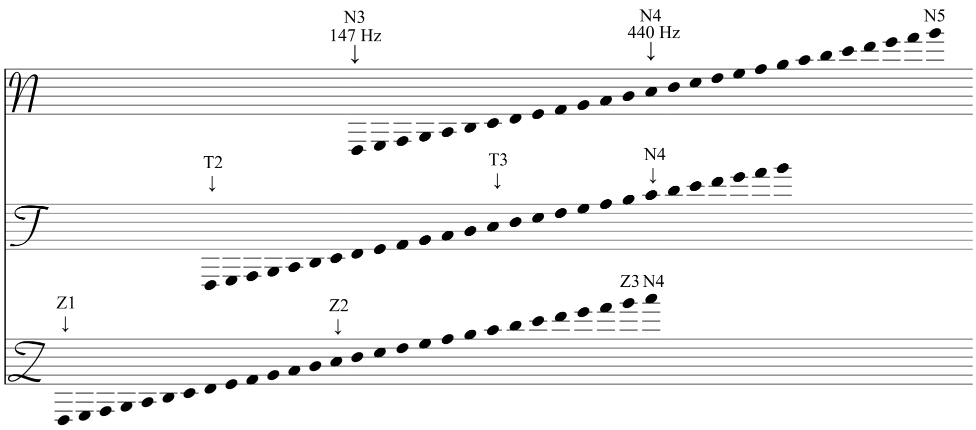



Figure 17: Müller-Hajdu notation in N, T and Z clefs. Notes that are aligned vertically represent the same pitch.

Note that the optical effect between N and Z clefs is similar to that between treble and bass clef in the standard notation system: the two notes on the first ledger lines above and below staff respectively have the same pitch (T3). This system is comfortable for Western musicians through its subtle use of a visual illusion: for example, in N clef, N3 is located on the fourth ledger line below the staff; the same pitch in Z clef is situated on the third line from top. The eye is tricked and recognises these two notes as the same pitch, since on first sight it looks like a d in traditional bass or treble clef. Hence the musician intuitively recognises the tritave relation between the two notes since it visually reminds of an octave relation in the 12-tone system. This effect works throughout the N and Z clef systems. The visual effect of the T clef in relation to N and Z clefs is similar. For the BP tenor clarinet an additional U clef – six BP steps below the N clef – is suitable. A clarinettist only has to learn one clef because the relation between N and U clef is the same as between soprano and tenor clarinet, i.e. same fingerings for same note lines and spaces. This comfort is more than useful for the player because the danger of getting mixed up in performances is eliminated.

For the sake of aesthetics, musicians and composers may feel free to choose fonts for the N, T, Z and U clefs following their personal taste. Whether you prefer a minimalist or a rather rustic style, you may choose between many options (fig. 18).

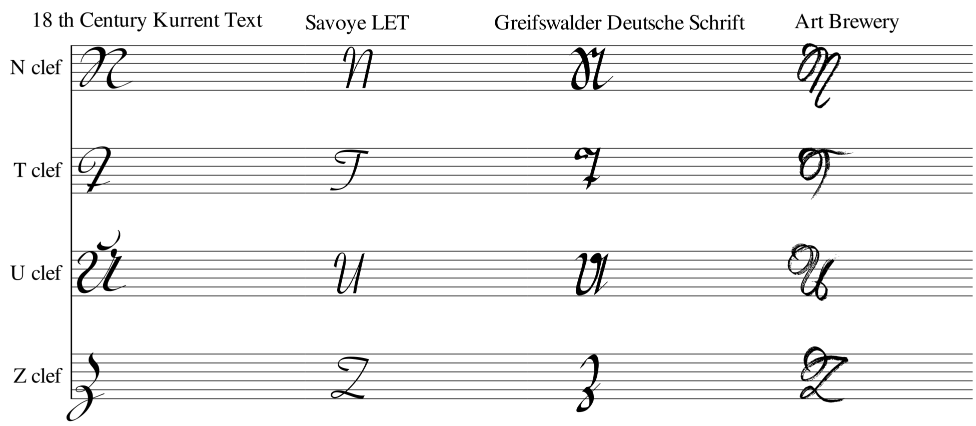



Figure 18: N, T, U and Z clefs represented in a variety of fonts.

Figures 19 and 20 show the pitches of BP soprano and tenor clarinet in both clarinet fingering notation and Müller-Hajdu notation, alongside with the sounding pitches. It can be used as a transcription and transposition help between BP clarinets, or to compare sounding pitches of BP clarinets with a traditional, 12div2 based notation system.

Several composers today are already using Müller-Hajdu notation, and some performers of BP music on various instruments have adapted to it. This shows that Müller-Hajdu notation, although originally designed from a clarinettist's point of view, is useful as a standard notation for composers and ensembles working on BP music.

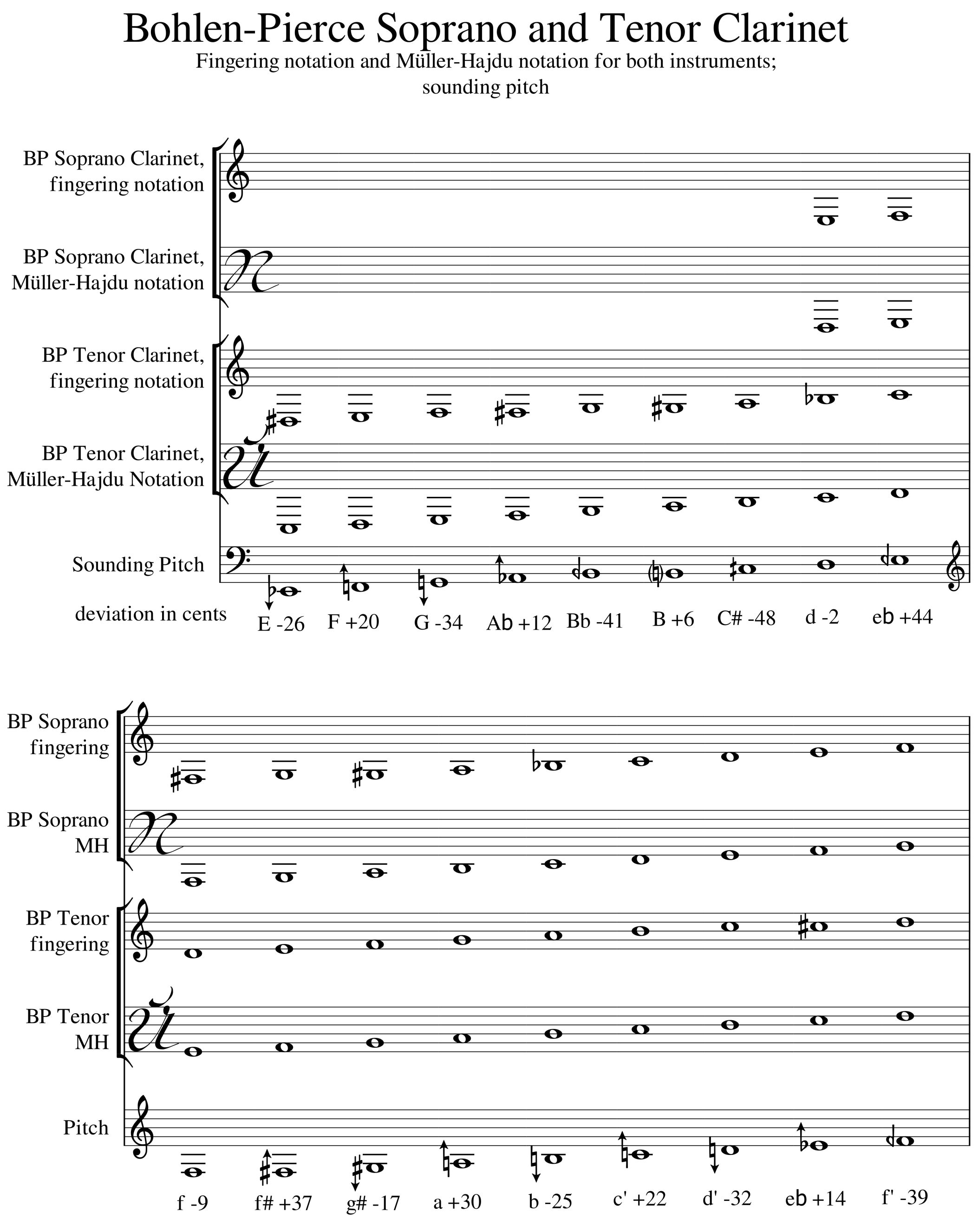



Figure 19: Müller-Hajdu notation and BP clarinet fingering notation for both BP soprano and tenor clarinet

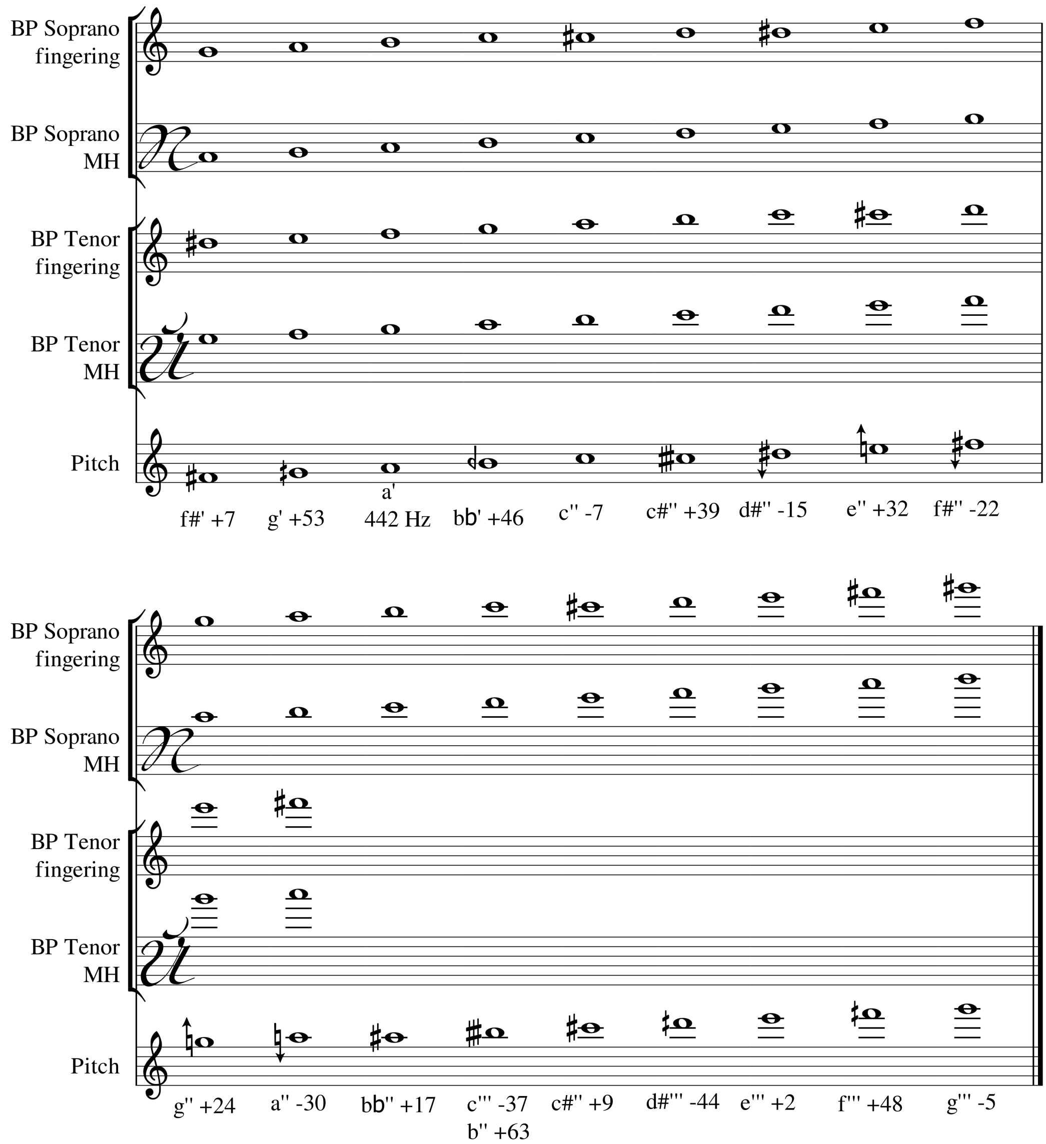



Figure 20: Müller-Hajdu notation and BP clarinet fingering notation for both BP soprano and tenor clarinet

# 3 Playing Techniques

The instruments of the BP clarinet family are designed to take the common clarinet mouthpieces and reeds, and the keywork system is similar to that of a standard Boehm clarinet. This means that any experienced clarinet player can play BP clarinets, although there are some challenges. From a normal clarinet player's view, there is a wider finger spacing in the right hand of the BP soprano clarinet which the player has to get used to; in the first BP clarinet models the hole for the right ring finger was quite big *and* relatively far away from the middle finger which may be difficult for players with slim fingers. Fox improved this in later models: by adding chimneys to the tone holes, he was able to choose a more ergonomic position of finger holes. The chimneys provide a better comfort in covering the tone holes, plus it is possible to place holes at an angle so that finger holes can be closer together.

The first models have bells with very thick walls and are therefore quite heavy; in connection with the longer lower joint (compared to a normal B♭ clarinet) and the resulting high position of the right thumb, this may cause problems to the player's thumb and tendons due to the greater weight. A neck strap can be helpful. The author's soprano clarinet, made in 2011, has a lighter bell on her instigation, which solved the problem.

The clarinettist faces particular challenges in the altissimo register. Fingerings in the lower altissimo register are very similar to Boehm B♭ clarinet, but there are some differences that need to be memorised. In wind instrument playing, particularly in high registers, it is very important to have an exact pitch imagination since one is playing on the overtone series; the player needs to consciously aim for the desired overtone in order to achieve the right note. Furthermore, it is necessary to learn and recognise BP intervals to know how to play and bend the notes to play perfectly in tune. Fingerings in the upper altissimo register differ from those on standard Boehm clarinets. Suggestions for upper altissimo fingerings on BP soprano and tenor clarinet are given in chapters 5.2 and 5.3.

Although built on a high precision level and providing very good intonation, slight intonation corrections may be suitable now and then. Learning BP intonation is not as difficult as one would think. Learning the BP system and intonation as a duo, as done by the author and her clarinet partner Anna Bardeli in their preparation to the premiere concert in 2008, turned out to be an optimal way to get familiar with BP intonation.

Many of the just intonation BP intervals are of simple ratios and thus can be learned by ear to a certain extent, by searching for the highest level of consonance in a sound or by listening to combination tones. An important point is that the players must overcome the temptation to correct the "octave -30 c", i.e. the BP 8th with the frequency ratio 25/49 and the BP 5th with the ratio 49/75 (731c) which most players will be tempted to correct to a perfect fifth. This may be the most difficult part in learning the BP system, since chamber and orchestra musicians are trained to play pure fifths and octaves by any means, even if it requires a great amount of intonation correction. Intuitively, new BP clarinettists will most likely do so automatically when playing BP music and thus should always be aware of this important difference between BP and the traditional system.

## 3.1 Glissando and Pitch Bend

Two of the most often used playing techniques in both contemporary classical and popular music are glissando and pitch bend.

Pitch bend means an alteration of a given pitch by changing details of the embochure, such as mouth cavity, tongue position or lip tension. The possible ambitus of a pitch bend on clarinet differs widely, depending on the regisHoppe 1992, p. 55ter and the tube length of the note. Pitch bend does not imply a change in fingering [Rehfeldt 1994, p. 59; ].

Literature review about the popular playing technique glissando and the less often used term portamento reveals that there are inaccuracies and misconceptions about the definitions of the two.

*The New Grove* gives an ambivalent definition of *glissando*:

> "Glissando (italienized, from Fr. glisser: 'to slide'; It. strisciando). A term generally used as an instruction to execute a passage in a rapid, sliding movement. [...] Because of the nature of the piano and the harp, every individual tone or semitone of such glissando scales is clearly heard, no matter how rapid the 'sliding' [...]. On the other hand, with the voice, violin or trombone, a sliding from one pitch to another is more readily effected without distinguishing any of the intervening notes, a method of sliding which is often called PORTAMENTO. Other instruments capable of sliding are the clarinet, the horn and the timpani. By their very nature, both types of sliding must be legato and relatively rapid. In practice, the terms glissando and portamento are often confused and used interchangeably. However, if the distinctions made above are kept, it follows that the piano and the harp, which have fixed semitones, can play glissando but not portamento; and the voice, members of the violin family and the trombone can produce either type of sliding, although glissando is far more difficult for them."[34]

Following this definition, glissando would be a rapid chromatic or diatonic movement between pitches, whereas a sliding movement would be called portamento. Rehfeldt [Rehfeldt 1994, p. 57] underlines this definition, referring to another authorative source, *The Harvard Dictionary of Music*[35]. Hoppe [Hoppe 1992, p. 59] on her part refers to Rehfeldt's text[36] plus to a congruent definition given in one of the books by Ronald Caravan [book title not specified by Hoppe]. By going in unison with these two authors while overlooking the complementary definition of *portamento* given in *The New Grove* as quoted below, she misses an important part:

[34]The New Grove Dictionary of Music and Musicians, Macmillan Publishers, London 2001

[35]2nd edition, Cambridge 1969. The current edition from 2003, by the way, gives a slightly different definition of both terms glissando and portamento.

[36]Hoppe refers to the original 1977 edition of Rehfeldt's *New Directions for Clarinet.*

"Portamento (ii) (It.). In instrumental music the term portamento generally denotes an expressive effect – 'the emotional connection of two notes' (Flesch) – produced by members of the violin family and certain wind instrument in emulation of the voice [...] It gradually gained regular acceptance as an expressive colouring in string playing during the late 18th century and was executed most commonly in solo contexts during upward shifts in slurred bowing, the relevant finger sliding rapidly between the appropriate notes. [...]" [*The New Grove*, 2001]

(Definition no. (i) explicitly refers to voice practice and is therefore left out here.) The above definition includes the information that portamento (in 18th century music) means an upward shift; a sliding downward movement is not mentioned. This raises more questions as to what a sliding downward shift could be called, or if the given definition of portamento is clear at all. The *Riemann Musiklexikon* gives a clearer, more complementary definition of both terms. It is pointed out that portamento usually is part of performance practice and done "al gusto" of the interpreter, while glissando is explicitly notated by the composer:

"glissando [ital. 'gleitend', von frz. glisser], Abk.: gliss., das aufwärts oder abwärts gehende Gleiten durch ein größeres Intervall, im Gesang oder auf Instrumenten ohne feste Tonhöhen durch Verschleifen der Tonstufen. Im Unterschied zum → Portamento, das dem Bereich des (ausdrucksvollen) Vortrags angehört und oft fälschlich als gl. bezeichnet wird, ist das echt Gl. stets ein fester, schriftlich fixierter Bestandteil des vorgetragenen Werkes. [...] [Die Klarinette] vermag nicht nur ein chromatisch fortschreitendes Gl. auszuführen (wie bei den oben genannten Instrumenten mit fixierten Tonhöhen), sondern zudem auch ein kontinuierlich-fließendes Glissando." [*Riemann Musiklexikon*, 1995]

In the same edition, *portamento* is defined as follows:

"Portamento [ergänze: di voce, ital.], auch portar la voce [frz. seit etwa 1800: port de voix 'Tragen der Stimme'], die Ziehung

> der Stimme (J. Fr. Agricola 1757), das gleitende Ansingen (oder Anspielen) eines Tones bzw. die mehr oder weniger gleitende Ausführung von Intervallschritten, die – im Unterschied zum → glissando – meist nicht vom Komp. vorgeschrieben, sondern dem Belieben des Vortragenden überlassen ist. [...] Außer auf Saiten- ist das P. auch auf Blasinstrumenten möglich."

The article speaks of *portamento* as the "more or less sliding performance of interval steps". The possibility of a sliding movement as glissando is mentioned later in the article, referring specificly to the clarinet.

Richter [Richter 1986, p. 142] refers to an older edition of *Riemann Musiklexikon* and interprets the terms *glissando* and *portamento* in the same way as the 1995 edition.

Mahnkopf and Veal do not define the two terms in the glissando section of *The Techniques of Oboe Playing* [Mahnkopf and Veale 2001] at all. Their understanding of *glissando* becomes clear in practical directions given by them, *glissando* being played by a "continuous opening or closing of toneholes" and embouchure corrections if necessary. This technique leads to a sliding movement between pitches.

Likewise, Weiss and Netti do not define the term *glissando* and do not mention the term *portamento* at all. From their writing it becomes obvious that to them, too, *glissando* means a sliding connection between tones with a continous pitch change [Weiss and Netti 2010, pp. 173-175].

The differentiation of the terms *glissando* and *portamento* is per se justifiable since they are two distinguishable techniques, as can be seen from the various definitions in *New Grove* and *Riemann Musiklexikon*. From the above given examples it becomes evident that, in practice, the term *glissando* is used for both a diatonic/chromatic as well as a continuous sliding movement. The fact that Weiss/Netti and Veale/Mahnkopf do not give any definition of *glissando* and skip the term *portamento* shows that the latter term is not much in use among wind players and possibly not even known to many of them. Since music practice so strongly prefers the term *glissando*, the insisting on the difference between portamento and glissando in the sense that glissando means a step-wise movement, while a sliding movement should be called portamento, can be questioned. Raasakka [Raasakka 2010, p. 50], like the majority of wind players, defines *glissando* as "a smooth transition from one pitch to another", and at the same time makes his own suggestion for *portamento*. He describes *portamento* as "a stepwise transition somewhere between scale passages and a glissando [. . . ] combining chromatic scales, glissando and a wide vibrato, as the case may be" [ibid., p. 52]. He suggests a "rapid microtone scale" as one potential way to produce this kind of portamento. Raasakka gives proof of his understanding of the technique by quoting examples of compositions for clarinet by Finnish composers which are partly outcomes of his own collaborations. In a way, Raasakka gives new life to an almost forgotten expression, at the same time inspiring a modern interpretation of a very old technique.

Use of glissando in notated, classical music dates back to the early 20th century. Arthur Honegger demands a short glissando in his *Sonatina* for clarinet and piano (1922), and the huge glissando in the initial clarinet solo of George Gershwin's *Rhapsody in Blue* (1924) is legendary. However, there is evidence that glissando has been in use for much longer, not only in jazz but also in classical music. In 1880, Heinrich Joseph Baermann publishes his *Travestie op. 45* for clarinet and piano, a parody piece which asks for several strikingly strong, "ugly" effects such as purposely bad intonation, and, at the key change to sounding F major (the original edition of publisher Joh. André, Offenbach lacks bar numbers) "ungeheures Heinen" (an "enormously weeping sound"). Connecting a notated d" and g" in the clarinet part by a straight line, Baermann obviously aims for a wide glissando. He does not describe how this effect can be achieved, which may lead to the assumption that the technique was known among clarinettists and could be performed at least by a number of players. Baermann's composition, on the other hand, probably spoofs popular manners of interpreters at the time - be they professionals or amateurs - and it thus may be assumed that many woodwind players (to Baermann's and maybe even to the audience's regret) often made a too extensive use of *portamento*.

### 3.1.1 Glissando on the BP Soprano Clarinet

Regarding glissando, the BP soprano clarinet does not act very differently from a common B♭ clarinet. Experienced clarinettists and composers can build upon their previous knowledge of B♭ clarinet glissandi and on printed and online sources regarding this technique. [37]

The following paragraph describes glissando ranges in different clarinet registers and gives examples in both clarinet fingering and Müller-Hajdu notation.

**The Chalumeau Register** Glissando, as a sliding upwards or downwards movement between pitches, can be done by fingering (e.g. a slow, sliding finger movement) and will usually be supported by embouchure changes as used in pitch bending. Therefore, a glissando is generally more difficult to achieve in the low (chalumeau) register since intonation is not as flexible as in higher regions of the instrument's range.

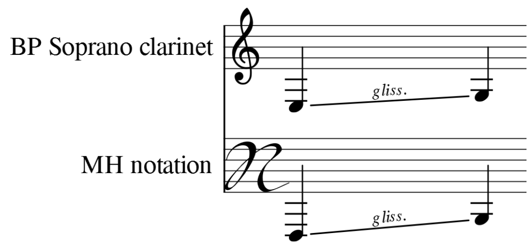



Figure 21: Chalumeau register glissando on BP soprano clarinet, example 1: N3-Q3

On the lowest notes (N3 – Q3 or e – g) glissando is almost impossible to achieve. Intonation changes with the embouchure give only very little results, and the keywork mechanism hinders a gradual opening and closing of the corresponding tone holes. Nevertheless, an upward glissando through these lowest pitches can be possible in a very slow tempo, with slow finger

[37]The blog of clarinettist Heather Roche is particularly recommended. Roche describes clarinet matters in a very detailed manner, and she gives a great variety of audio examples https://heatherroche.net/2014/02/18/on-soprano-clarinet-glissandi/ last visit: 20th Feb, 2018, last accessed: 30th July 2019.

movement allowing the player to carefully control the gradual opening of the keys. It will not be perfectly smooth, and the performance is likely to be better in *piano* than in *forte*. A downward glissando movement through the same range is not recommended because a gradual closing of the key mechanism is usually not successful.

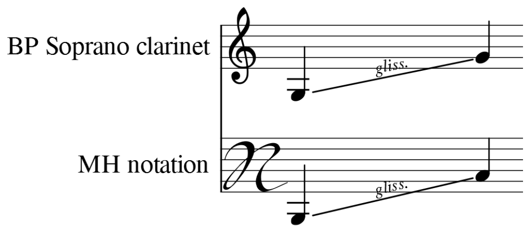



Figure 22: Chalumeau register glissando on BP soprano clarinet, example 2: Q3-Y3

In the upper range of the chalumeau register (Q3 – Y3 or g – g') a slow sideways movement of the fingers, pulling them away one by one from the tone holes, gives a smooth glissando. The BP soprano clarinet does not have any keys in this range (except for R3 / g♯), and the modulation of tone hole openings controlled directly by the player's fingertips can be done in a medium tempo.


Figure 23: Chalumeau register glissando on BP soprano clarinet, example 3: Y3-N4

From Y3 (throat g') to N4 (b') a glissando is not as easily and smoothly possible. The keys can be opened very slowly, achieving N4 with the a'-key plus the trill key for the right index finger.

Z3 usually is the highest pitch in the chalumeau register, but it can be extended to N4/b' by the use of the described trill fingering. Pitches higher than N4 must be played in the clarion register. The glissando cannot be performed without a register break at this point. Camouflage in an upward glissando may be possible by first using the trill fingering for N4 and then switching to the regular fingering in the clarion register (as an overblown N3). By using this technique the register break happens between two notes of (almost) the same pitch.

In accordance with the above notes the performance of a continuous glissando throughout the lowest tritave of the instrument may be possible to a certain degree. If a composer decides to stipulate such a long glissando in the chalumeau register, it must be taken into account that it can only be performed in slow tempo, and preferably in an upward movement.

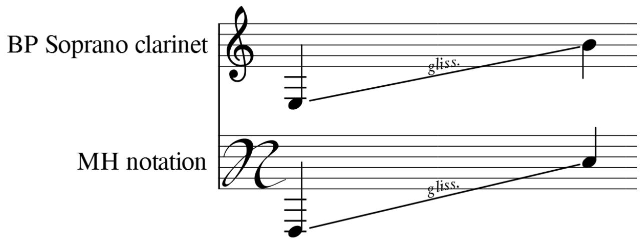



Figure 24: Chalumeau register glissando on BP soprano clarinet, example 4: N3-N4

**The Clarion Register** In the lowest pitches of the so-called clarion register (i.e. notes in the middle register, with the speaker key open) the player faces the same difficulties in glissando playing as in the lowest chalumeau register. Intonation is not as flexible as in higher regions of the instrument's range with the consequence that pitch bend can hardly be used to support the glissando, and the fact that tone holes are operated by keys makes modulation of tone hole sizes difficult or even impossible.


Figure 25: Clarion register glissando on BP soprano clarinet, example 1

An upward glissando through the pitches N4 – Q4 (notated b' – d") can be possible in a very slow tempo, with slow finger movement gradually opening the keys. It will not be perfectly smooth. A downward glissando movement through the same range is not recommended.


Figure 26: Clarion register glissando on BP soprano clarinet, example 2

A slow sideways movement of the fingers, pulling them away one by one from the tone holes makes a smooth glissando possible in the upper range of the clarion register (Q4 – Y4 or d' – d"'). The BP soprano clarinet does not have any keys in this range but open tone holes (except for R4/d♯"), and the modulation of tone hole openings controlled directly by the player's fingertips can be done in a medium tempo. Unlike in the chalumeau register, pitches are more flexible in this range and can be modified by embouchure manipulation to a certain extend. The glissando will be very smooth, as in the famous opening of Gershwin's *Rhapsody in Blue* (1924).

**The Altissimo Register** In the high clarinet register intonation is very flexible and can be manipulated by embouchure to a great extent. This technique is called pitch bend. The combination of smooth finger movement and pitch bend allows for an uninterrupted continuous glissando. Most professional clarinet players can do a continuous glissando from about U4 (g”) upwards to any note in the high register or vice versa.

Above the lower altissimo register (pitches higher than P5 or g♯”’), in the very high registers, partials of the overtone series are closer to each other than in lower registers. Consequently, register breaks appear more often, and “jumps” in the glissando may happen when a note accidentally flips to another partial than the intended one. The purposeful performance of a glissando through several of these “flips” is often referred to as an *overtone glissando* [Raasakka 2010, p. 55].

### 3.1.2 Glissando on the BP Tenor Clarinet

The BP tenor clarinet has no open tone holes but plateau keys for all fingers, plus the obligatory keywork for the left and right little fingers. This keywork design makes it more difficult to play a smooth continuous glissando. While modulation of the tone hole openings is possible on the soprano clarinet due to its open tone holes, it is impeded by the plateau keys of the tenor clarinet. This affects the chalumeau and lower clarion register more than higher registers, since glissando can be helped by embouchure modulation in higher registers.

**The Chalumeau Register** The lowest pitches of the chalumeau register on the BP tenor clarinet are covered by keywork, just as the BP soprano clarinet. Thus, the possibilities and difficulties in glissando playing are comparable to those on the BP soprano clarinet.

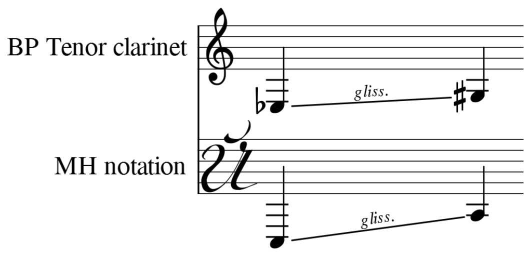



Figure 27: Chalumeau register glissando on BP tenor clarinet, example 1: T2-Y2

Glissando between these lowest notes on the instrument (T2 - Y2 or low e♭ – g♯ ) is possible to a certain extent only, and it is likely to be bumpy. Intonation is not as flexible as in higher registers, which means that supporting the glissando by bending pitches is not possible. For the rest of the chalumeau register (Z2 – U3 or a – b', using the trill key for the right index finger) the same restrictions apply due to the plateau keys which cover the tone holes.

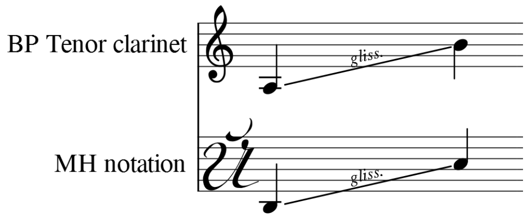



Figure 28: Chalumeau register glissando on BP tenor clarinet, example 2: Z2-U3

Movement in both directions, be it upward or downward, will create an irregular, "bumpy" glissando. It will sound smoother in *piano* or *pianissimo*, while imperfections will be more audible in *forte* or *fortissimo*.


Figure 29: Clarion register glissando on BP tenor clarinet, example 1: T3-X3

**The Clarion Register** Glissando in the lower range of the clarinet register of the BP tenor clarinet lacks smoothness and agility. The clarion register of the BP tenor clarinet may start on T3 due to the low e♭ key (T2) for the right little finger which can be overblown to T3/b♭'.


Figure 30: Clarion register glissando on BP tenor clarinet, example 2: X3-T4

Between X3 and P4 pitch bending is still limited, and the covered tone holes impede a smooth glissando. From O4 or P4 on upward, pitch bending is possible to a greater extent than on the lower notes which can be used to make the glissando smoother. Even though glissando can be played unnoticeably over the register break to the altissimo register, it is possible to avoid changing the register by extending the clarion register up to U4 / e"' if necessary.

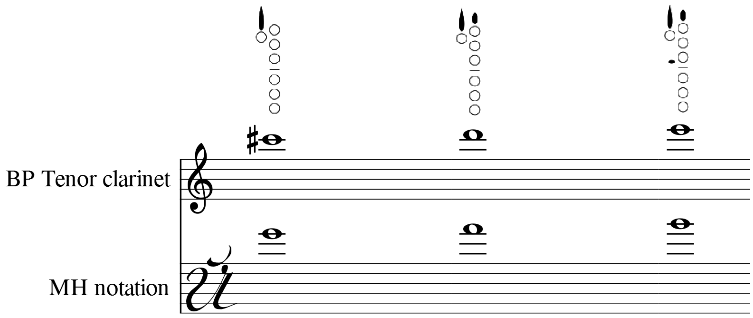



Figure 31: Fingering suggestions for S4-U4 (c♯"' to e"') as part of the clarion register

U4 can be bent down by several steps, depending on individual abilities of the performer and to what the material (reed-mouthpiece combination) allows. A flexible performer may be able to bend the note down as much as five steps.

**The Altissimo Register** In the high register (S4/c♯"' and above), a long continuous glissando is possible combining fingering changes with the pitch bend technique. Possibilities and restrictions mentioned for the BP soprano clarinet in the altissimo register apply to the BP tenor altissimo register as well.

## 3.2 Pitch Bend

*Pitch-bend* (or *lip-bend*) is a playing technique for wind instruments in which a pitch is inflected downwards by changes in the vocal tract of the player [see Rehfeldt 1994, p. 59]. Tongue position plays an important role in pitch-bending. Typically, the tongue position of the player influences intonation. Lip tension, on the contrary, is often stated to be the influencing parameter. This is a common misunderstanding. Lip tension is a relevant parameter in forming sound colour and intensity; intonation is only affected indirectly: a decrease in lip tension often results in a change of tongue position.[38] An experienced wind player, however, is able to disconnect both movements, resulting in a change of tone colour which does not affect intonation, and vice versa, intonation changes which do not change tone colour too much [Wolfe et al. 2001-2015]. The second major parameter in pitch bending is the size of oral cavity which can be changed according to the requested effect. The terms *pitch-bend* and *lip-bend* are often used interchangeably; the term *lip-bend* must be considered incorrect and is thus not used here[39]. The term *pitch-bend*, on the other hand, offers more flexibility regarding execution. It relates to the requested sound effect rather than to the applied technique. This makes sense because pitch-bending and glissando techniques (e.g. half-hole fingering) are often used in combination to achieve the required change of pitch, for instance in the lowest register where pitch-bending by changes of embouchure (tongue position and oral cavity) do hardly result in significant pitch alterations. This applies to all kinds and sizes of clarinets, not only to

[38] The fact that many experienced – even many professional – players are not conscious of this correlation, reveals dramatic conditions in modern clarinet pedagogy. It is remarkable how few clarinet pedagogues pick up tongue position as an aspect of their clarinet lessons, despite its central role in tone production and overall playing quality. See Larry Guy, *The Development of Tongue Position* in *The Clarinet* Vol. 35 No. 4, Sept 2008, p. 36-42

[39] Several other terms for this and similar techniques are in use as well. *The New Grove Dictionary of Jazz*, 2nd Edition, gives a summary in the entry regarding *glissando* and differentiates details of *doit, drop/fall off/spill, flip, lift, lip, plop, rip and scoop.*

BP clarinets. The middle register from notated d" or e" on upwards to c"' - or even up to the lower altissimo register, notated d"' or e"' - provides the greatest flexibility; notes can easily and effectively be bent down in this range. Further up, in the upper altissimo register, "jumps" may occur which in fact are register breaks, and the continuity of the pitch-bending is interrupted.

**About the pitch-bend chart** The following pitch-bend chart shows the possible range of pitch-bending in various areas of the clarinet's pitch range. The chart does not show every single note, but rather examples which can give an idea about how far a specific note can be bent down, e.g. if the specific note which a composer is looking for is not in the chart, a neighbouring note can be taken as an example for the approximate pitch-bending range. All cent values and notated pitches are approximate. The extent to which a certain note can be bent exactly in a specific situation depends on the mouthpiece-reed combination chosen by the interpreter and the interpreter's personal abilities. For the lowest notes which are not very flexible regarding embouchure changes, two kinds of values are given: the *lip-bend* value, i.e. the cent value by which the note can be "lipped" down (i.e. bent down by changes of tongue position and oral cavity, see above), and an additional cent value that shows by how much the pitch can be influenced by partly covering a tone hole. It is common amongst clarinettists to use this technique in the lowest register (or in higher registers as well) to help the amount of pitch-bending. It must be taken into account that partly covering a tone hole may change the sound colour considerably towards a darker, more "muffled" nuance.

When pitch-bending down from a note in the altissimo register, a register break happens at some point. The pitch to which the note can be bent down is indicated in the table. The sound then "jumps" down to a certain pitch which is also indicated. In higher regions of the altissimo register, two or more such register breaks can happen. Again, the exact point at which this happens can only be determined in terms of approximate pitches. Different players with different setups may achieve slightly different outcomes. Pitch-bending is usually possible in a downwards movement only. (An upwards movement makes use of fingering techniques.) The pitch can be bent back up to the original note as along as no register break has been crossed. Once the pitch-bending has gone across a register break, it is not possible any more to bend the pitch back up. In case of a required upwards movement the clarinettist would make use of glissando technique, i.e. the pitch achieved by pitch-bending down is taken as a new starting note for an upwards glissando. A very appealing effect occurs on the BP tenor clarinet when bending notes between S4 and V4: the tone slides downwards into a beautiful dyad.

About accidentals in the following music examples: a sharp or natural with an arrow tip indicates a slightly sharper or flatter note. An exact prediction of cent values is not always possible, for this reason the notation stays intentionally vague. Small deviations will occur between different performers and their different reed-mouthpiece combinations; occasionally, even the local climate in the performance space may play a role.

### 3.2.1 Pitch Bend on the BP Soprano Clarinet

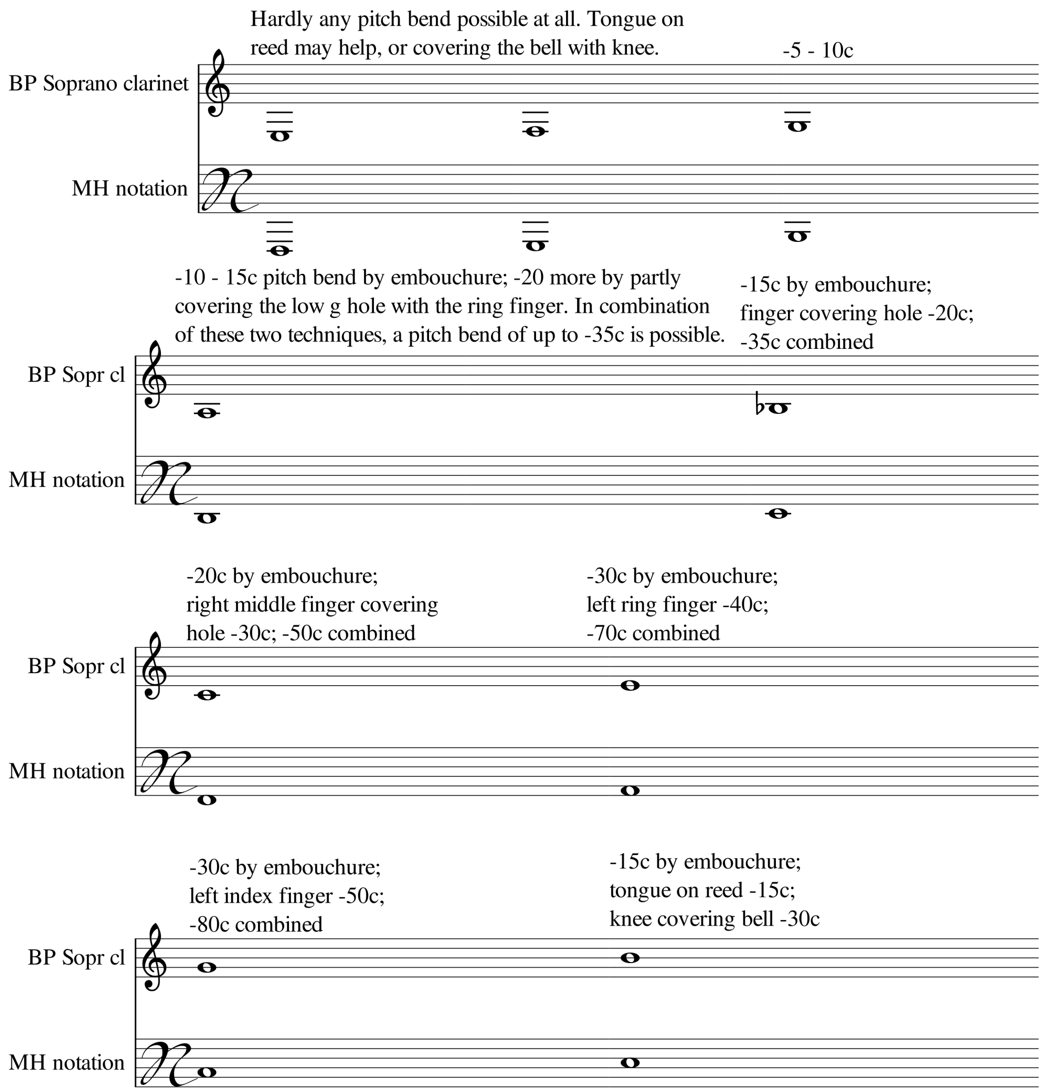



Figure 32: Pitch bend on BP soprano clarinet, no.1

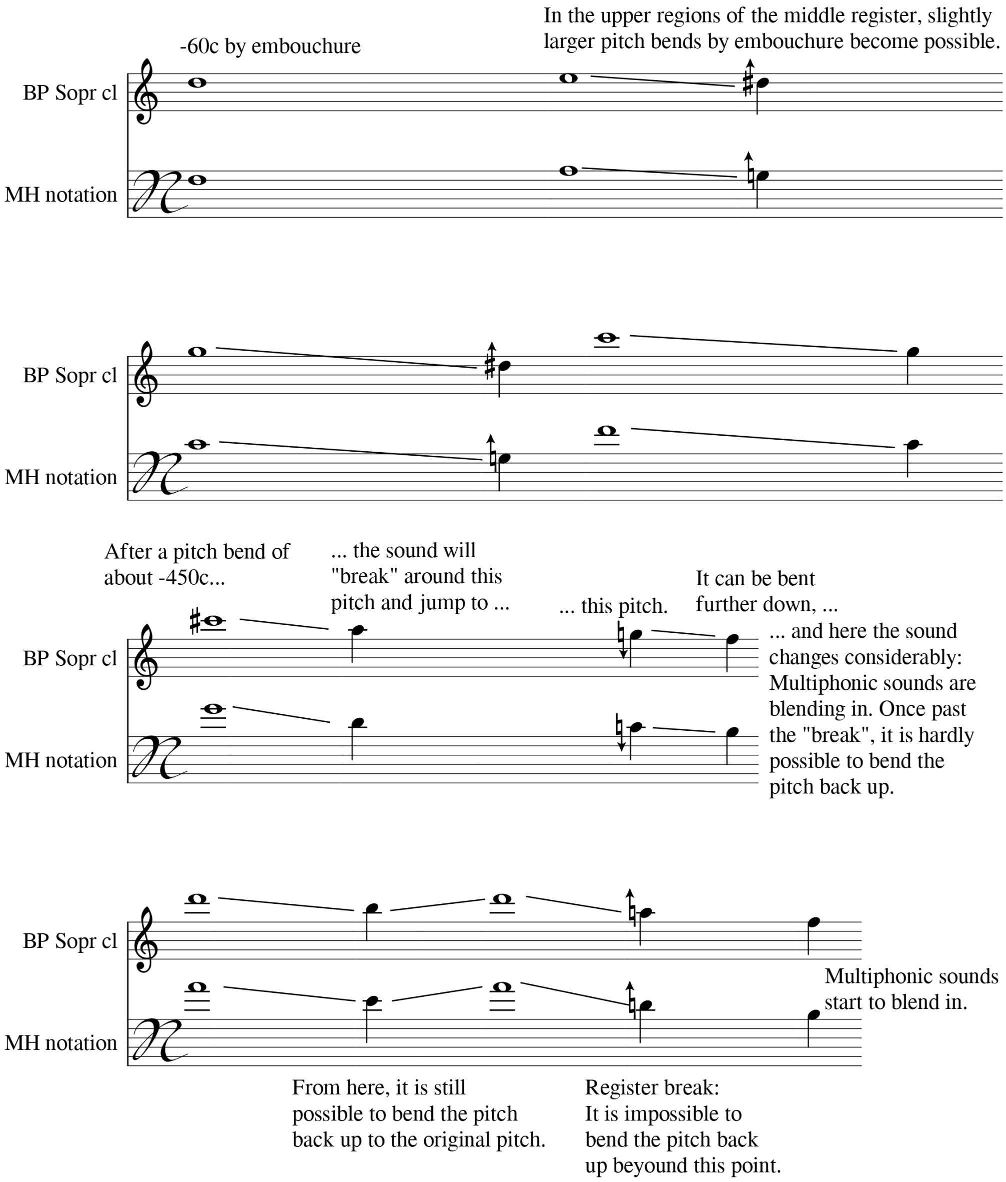



Figure 33: Pitch bend on BP soprano clarinet, no. 2

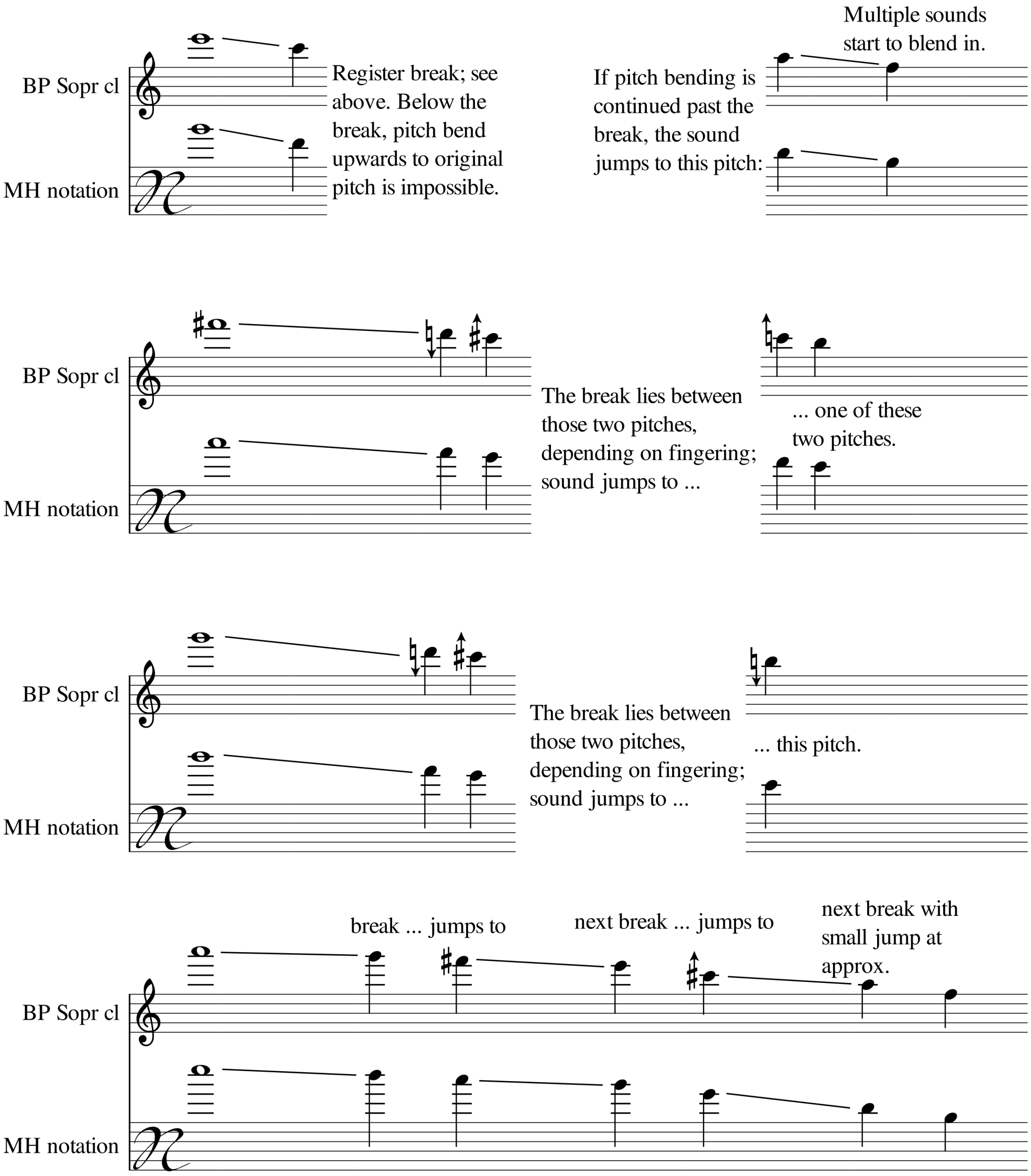



Figure 34: Pitch bend on BP soprano clarinet, no. 3

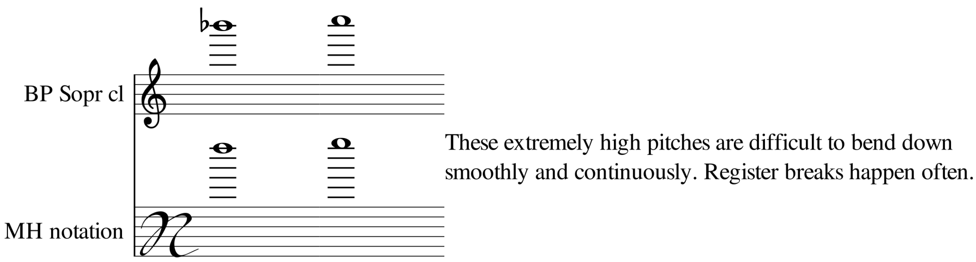



Figure 35: Pitch bend on BP soprano clarinet, no. 4

### 3.2.2 Pitch Bend on the BP Tenor Clarinet

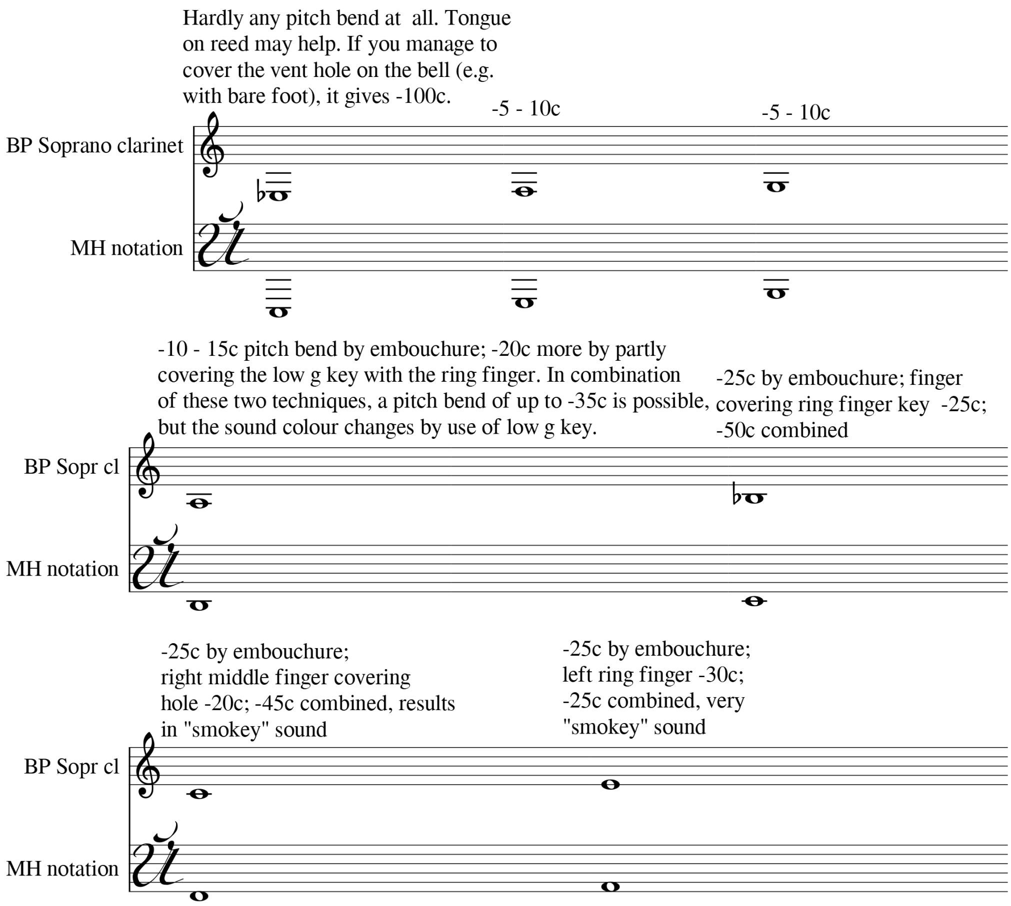



Figure 36: Pitch bend on BP tenor clarinet, no. 1

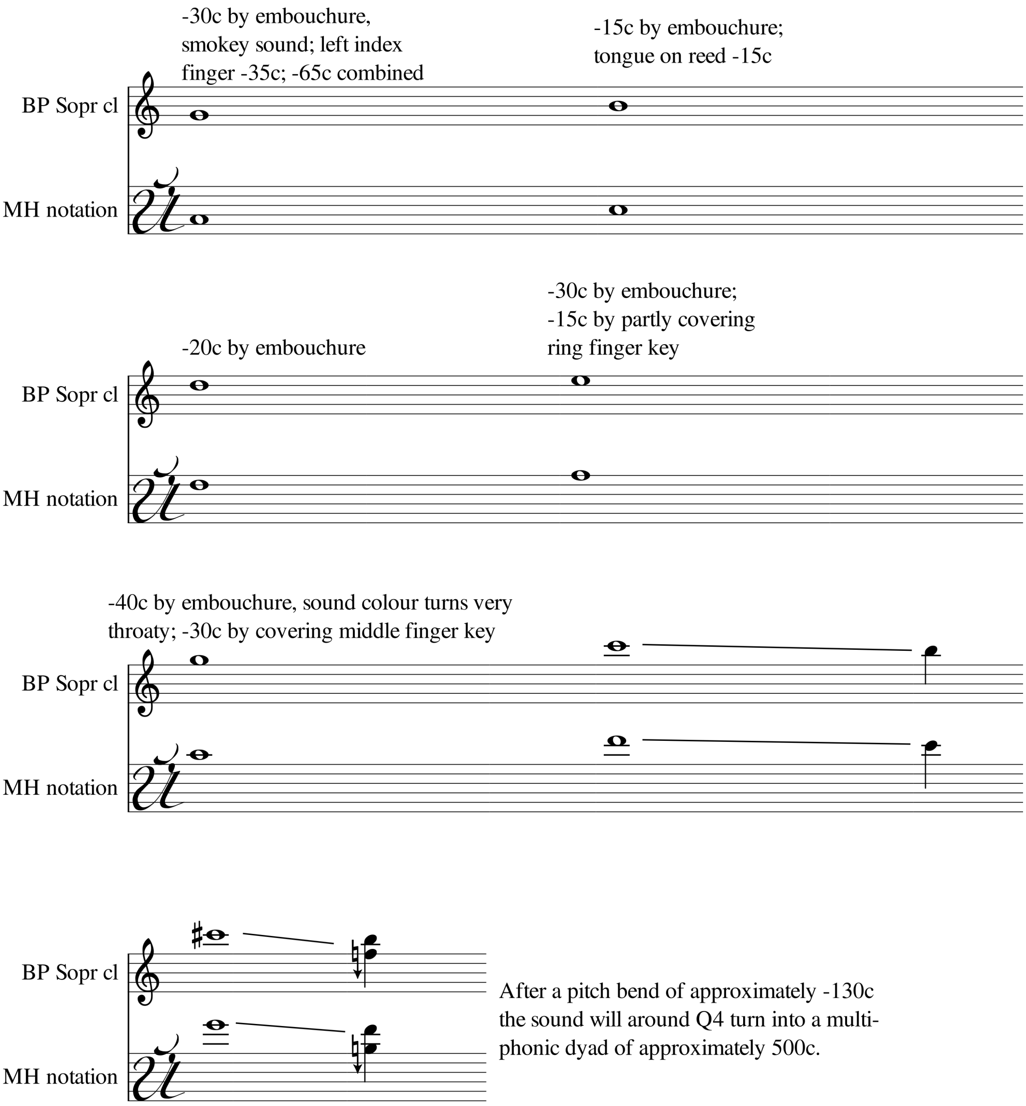



Figure 37: Pitch bend on BP tenor clarinet, no. 2

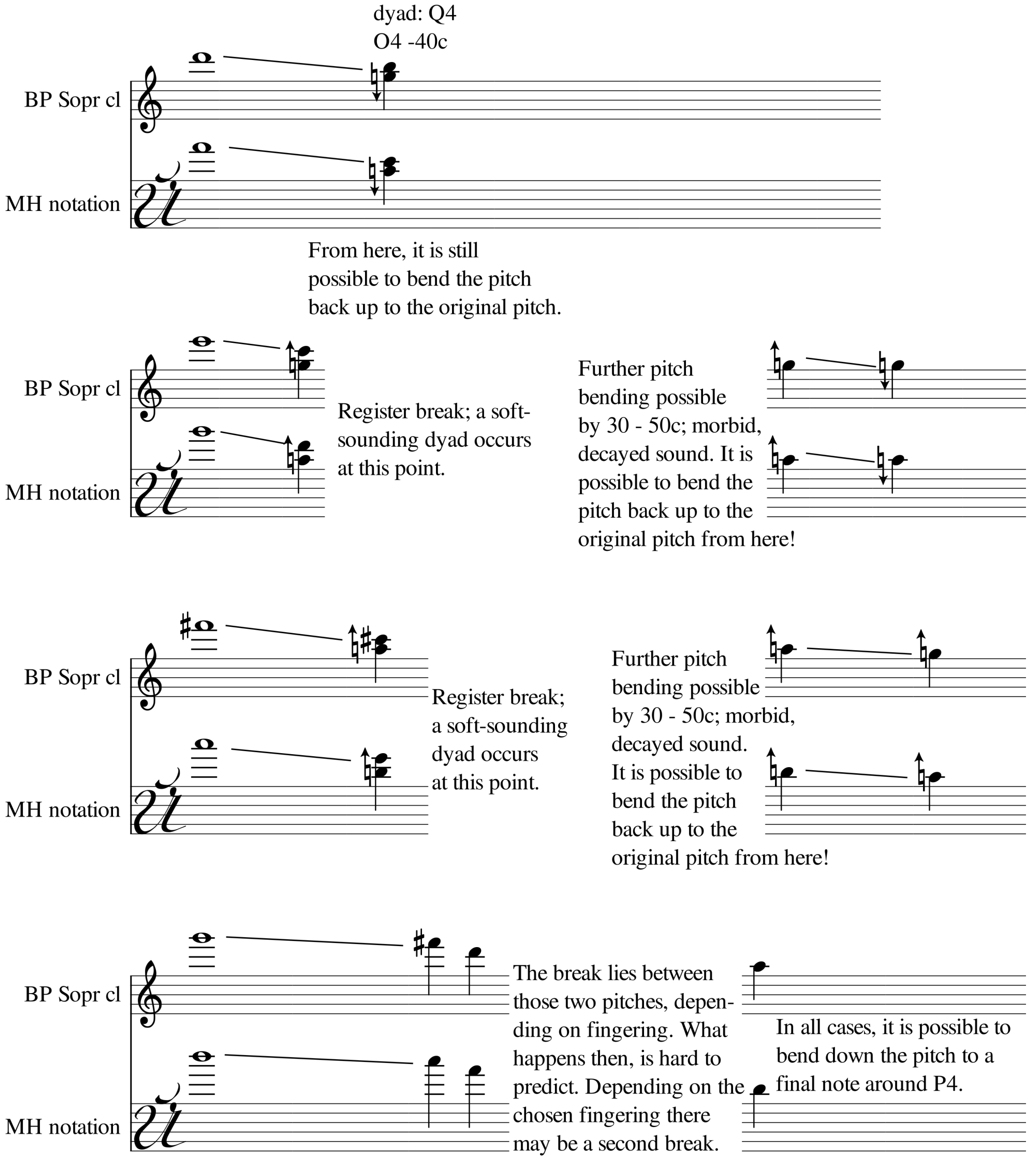



Figure 38: Pitch bend on BP tenor clarinet, no. 3

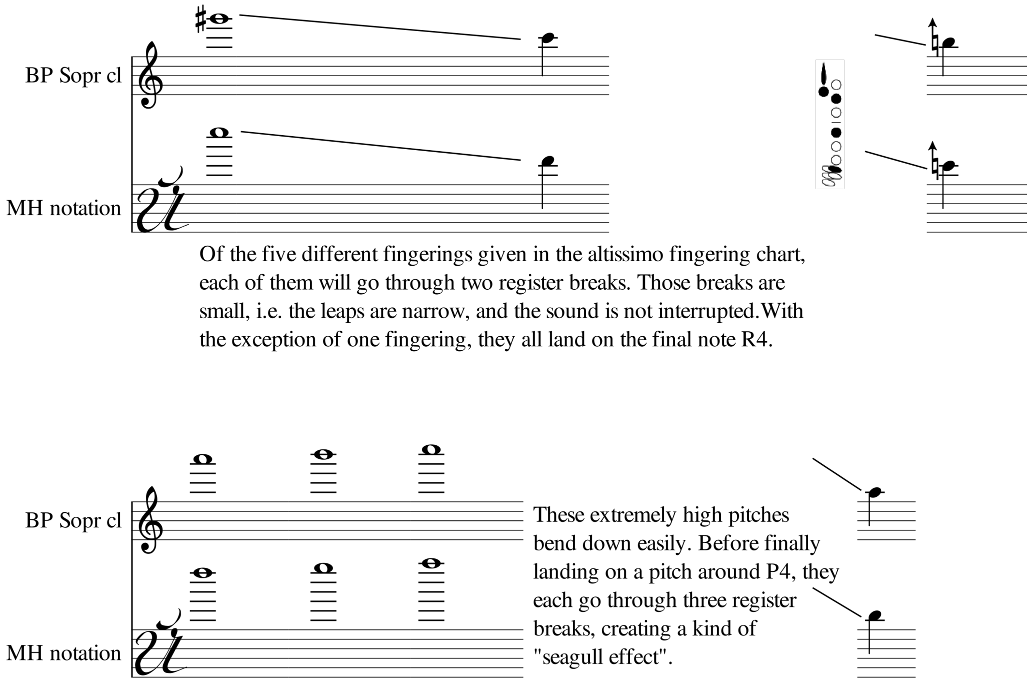



Figure 39: Pitch bend on BP tenor clarinet, no. 4

# 4 Multiphonics on Bohlen-Pierce Clarinets

Multiphonics are sounds in which two or more pitches can be heard simultaneously, generated by an otherwise monophonic instrument. They are a popular playing technique in 20th and 21st century wind music, although there is evidence for the occasional use of multiphonics on woodwind instruments from the second half of the 18th century onward [Hoppe 1992, p. 120].

Krassnitzer [Krassnitzer 2002, pp. 15-17] distinguishes three classes of multiphonics from the clarinettist's point of view: a) Multiphonics by overblowing (often referred to as *sons fendus* or *split-sounds*), b) multiphonics by underblowing (finger position of a tone in the clarinet or altissimo register with the register key open, the wind player producing undertones by a "wrong", usually too loose embouchure), and c) multiphonics by special fingerings. The first kind of multiphonic can only be produced on the lowest notes of the clarinet. Each tone is a natural complex of many tones which are called partials. They usually blend with the lowest note (first partial) and thus are not perceived as individual notes, but rather as the specific timbre of the sound. In split-sounds, partials are "allowed to pass through" by the player so that they appear as individual pitches within a tone cluster. Interestingly, the resulting sound is not a natural overtone series as one might expect. Instead, it is a "honking" sound, a cluster of inharmonic partials that are created by strong interferences and heterodyne components which are much stronger than if they appeared as harmonic partials. (The phenomenon of heterodyne components will be explained in 4.1.3). Essential for the production of split sounds are the reed player's adjustments of embouchure and oral cavity.

The third kind of multiphonic, following Krassnitzer, is generated by special fingerings which are not used to generate regular notes. Cross-fingerings, in this case, are most suitable for the production of multiphonics.

Although Krassnitzer's differentiation of his three types of multiphonics may be obvious to every clarinet player, the acoustic principles in all multiphonics are the same, whether the sounds are created by overblowing, underblowing or by special fingerings.

## 4.1 Acoustic Principles of Multiphonics on Clarinets

The phenomenon of multiphonics in woodwind instruments is complex, but based on simple acoustic principles such as nodes in standing waves, the characteristics of cross-fingerings, and heterodyne components. These principles shall be explained below to enable clarinettists and composers to understand how multiphonics are generated and how they can be influenced and predicted.

### 4.1.1 Nodes

To understand how multiphonics are generated, it may be useful to understand the concept of physical nodes. In acoustic phenomenona such as register changes (overblowing), alternate fingerings or multiphonics, nodes of the acoustic waves inside the tube play an important role. Nodes are responsible for the harmonic series in musical sounds. String players, for example, generate harmonics (flageoletts) by placing a finger and pressing it down only half-way at a physical node, where the vibrating string has a minimum amplitude [Hall 1991, p. 221 of the German edition, Musikalische Akustik, Mainz 1997/2008]. Register holes on woodwind instruments are placed at or relatively close to nodes [Wolfe et al. 2001-2015, last accessed: 30th July 2019]. Benade explains nodes by the example of sloshing water in a trough [Benade 1976/1990, p. 89], e.g. imagine the water level in the trough is high (+1) on one end and low (-1) on the other end, and the water sloshes so that these states change. In the exact middle of the trough is a point where the water level is always 0, a pivot point, and this point is called a node. The same principle works for air waves in a tube or cylinder. If a tone hole is opened along the length of the clarinet tube, a node may be induced at the opening. Nodes are responsible for a wind instrument's ability to produce different pitches with the same length of tube, as is the case when playing in different registers. Furthermore they can, in combination with cross-fingerings, generate multiphonics as will be explained below.

### 4.1.2 Open tone holes as generators of two simultaneous pitches

Most multiphonics are generated by the use of special fingerings, i.e. a non-standard combination of open and closed tone holes. Such a combination functions as an alternate fingering which lets the fundamental note sound, although muffled compared to standard fingering combinations. Additional harmonic partials also sound and blend with the tone. This fundamental often sounds "muffled" because it is a cross-fingered note. A cross-fingering is a fingering position with an open tone hole somewhere along the tube length - the effective end of the tube - with one or more tone holes further down the tube being covered.

If the open tone hole in the cross-fingering also induces a node, a multiphonic will result. The open tone hole has to be just big enough to reflect some of the sound waves, – i.e. the pitch defined by the tube length at this open tone hole – and at the same time the hole has to be small enough to let pass another group of the sound waves and let them flow to the end of the entire tube length. This condition makes it possible for two pitches to sound at the same time [Wolfe et al. 2001-2015, last accessed: 30th July 2019].

A multiphonic consisting of exactly two distinguishable pitches is called a dyad. Most multiphonics contain a number of distinguishable pitches, although generated in the same way as described above, by the purposeful use of specific cross-fingerings. Benade explains this by further acoustic phenomenoa, e.g. heterodyne components of the sound, which shall be explained in the next section.

### 4.1.3 Heterodyne components as elements of multiphonics

The previous paragraph explained how two pitches at a time can be produced on a clarinet: exotic cross-fingerings and physical nodes as the cause of dyads. However, most multiphonics consist of a multitude of pitches. So-called heterodyne components are the cause for these additional frequencies. They are the results of mechanical processes in the vibration of the air column. Similar effects are generated inside the human hearing organ following the same principle, called combination tones (summation and difference tones, the latter also known as Tartini tones).[40] These two phenomena follow the same principles but are nevertheless to be distinguished. Combination tones happen during auditory perception, while heterodyne components are generated at the sound source and thus can be measured e.g. by spectral analysis.

From the two pitch frequencies of a clarinet multiphonic/dyad (named f1 and f2), diverse heterodyne components evolve, for example:

f2 – f1
f1 + f2
2f1 – f2
2f1 + f2
and so on.

The following three examples shall illustrate heterodyne components as elements of multiphonics. The examples are taken from the multiphonic fingering chart for BP soprano clarinet (section 4.3), which were developed using Macacque[41], software which not only gives a precise notation of the single pitches but their frequencies in Hz as well.

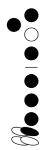


Figure 40: Fingering of multiphonic S-10

[40]The phenomenon of difference tones was first described in 1740 by organist and composer Georg Andreas Sorge [Gollin and Rehding 2011, p. 75]; in 1754 Giuseppe Tartini mentions it in his *Trattato di musica secondo la vera scienza dell'armonia* [ibid.]. From this phenomenon, Helmholtz derived his concept of summation tones (see Helmholtz 1863, p. 227-236).

[41]Macacque in combination with MaxScore, both by Georg Hajdu, http://www.computermusicnotation.com/

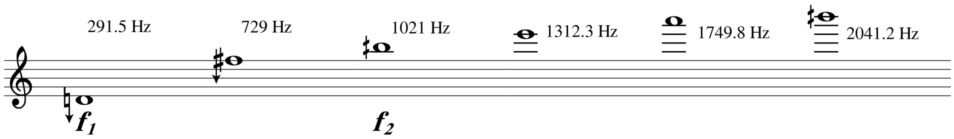



Figure 41: Components of multiphonic no. S-10, concert pitch

In multiphonic S-10, the two pitches generated by the cross-fingering are at 291.5 and 1021 Hz. Since cross-fingerings are responsible for the tube lengths and resulting pitches, it seems natural that these two notes are *threshold notes* of the sound: pitches which can be played one at a time and can be used to glide or "sneak into" the multiphonic sound [see Mahnkopf and Veale 2001; Weiss and Netti 2010, p. 62].

f1 = 291.5 Hz
f2 = 1021 Hz

Resulting heterodyne components are:
f2 – f1 = 1021 – 291.5 = 729.5 Hz
f1 + f2 = 1021 + 291.5 = 1312.5 Hz

Not only the two main pitches can create heterodyne components; the heterodyne components themselves can produce additional audible frequencies. Consequently, the sound characteristics of a multiphonic can be highly complex. Likewise, frequencies contained in the harmonic overtone series of one or more pitches may appear.

f2 + (f2 – f1) = 1021 + 729.5 = 1750.5 = a"'

Furthermore, the a"' at 1750.5 Hz equals f1 x6, i.e. f1 an octave plus a tritave higher:

f1 x 6 = 291.5 x 6= 1749 Hz.

Thus, a"' has not only the quality of a heterodyne component, but at the same time is part of the harmonic overtone series of d'.

Two more correlations are:
(f2 – f1) + (f1 + f2) = 2f2
729 + 1312.3 = 2041.3 = 2f2
With 2f2 = 2042 Hz being at the same time part of the harmonic overtone series of f2.

The small differences between the frequencies in the notated examples and the mathematical results may be caused by rounding differences.

Multiphonic no. S-03 as a second example:

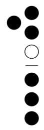


Figure 42: Fingering of multiphonic S-03

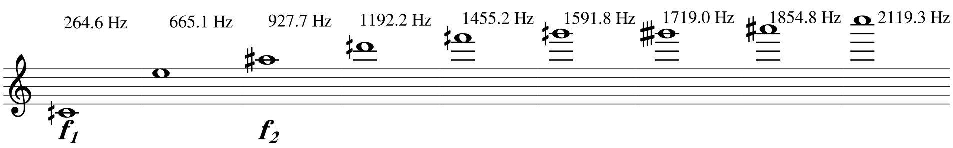



Figure 43: Components of multiphonic no. S-03, concert pitch

The dominant pitches (and threshold notes) in multiphonic S-03 are c' (264.6 Hz) and a♯" (927.7 Hz).

f1 = 264.6
f2 = 927.7

665.1 = f2 - f1
1192.2 = f1 + f2

1455.2 = 2f1 + f2 [= 1456.9]

1591.8 = 2f2 - f1

1719.0 = 3f1 + f2 [= 1721.5]

1854.8 = 2f2

2119.3 = 2f2 + f1

A third example, multiphonic S-01:

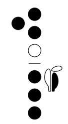


Figure 44: Fingering of multiphonic S-01

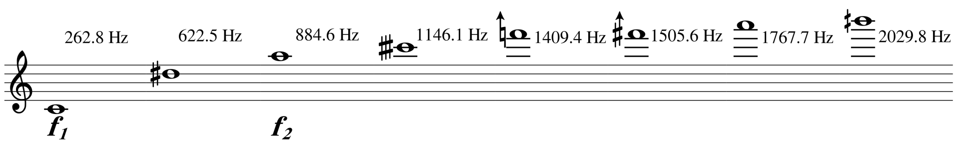



Figure 45: Components of multiphonic no. S-01, concert pitch

f1 = 262.8 Hz

f2 = 884.6 Hz

622.5 Hz = f2 − f1

1146.1 Hz = f1 + f2 [= 1147.4 Hz]

1409.4 Hz = f1 + (f1 + f2) [= 1410.2]

1505.6 Hz = f2 + (f2 − f1)

1767.7 Hz = f2 + (f2 − f1) + f1, or simply 2f2 2029.8 Hz = 2f2 + f1

### 4.1.4 Residual tones

Occasionally, when listening very closely, a sound lower than the lowest pitch of the instrument can be heard, just in a very few specific cases. This would be a missing fundamental, a virtual bass tone which is added by our brain and thus does not show up in frequency analysis; it is generated by the auditory cortex itself [Hellbrück and Ellermeier (2004, p. 122-124)].

## 4.2 Methods of Analyzing Multiphonics on BP Clarinets

Naturally, multiphonics on the BP clarinet are different from those on the B♭ clarinet due to the different tone hole locations. Nevertheless, an experienced clarinettist will be able to produce multiphonics in the same manner as on a traditional clarinet. Literature about theory and practice of multiphonics on clarinets is comprehensive, thus it is assumed that the reader is familiar with basic knowledge about the production of multiphonics such as sensitive embouchure adaptions.[42]

This chapter considers multiphonic fingerings which involve the use of plainly open or closed tone holes; fingerings involving half-holes may be subject to later explorations. *Sons fendus* are not considered in this work. They are spectral sounds that can be generated on the lowest notes only, and they are very similar to those on a B♭ clarinet. Multiphonics can differ from instrument to instrument and from player to player. The outcome depends on construction details of the clarinet, reed strength, reed-mouthpiece combination, and performance technique. Thus, this catalogue can only give directions about multiphonics. All BP soprano multiphonics listed here have been tested thoroughly on two different BP soprano clarinet models by Stephen Fox – an early one from 2007 with plain open tone holes and another one from 2011, featuring chimneys on the open tone holes. The latter model is the one which is currently built by Stephen Fox. Since the BP tenor clarinet by Fox is unique at the time of publication, it was the only instrument used for producing BP tenor multiphonics. Deviations from the given outcomes are possible; occasionally it may even be the case that a multiphonic which is given in the list cannot be produced on one or the other BP clarinet. This catalogue is not – and cannot be – comprehensive. Due to the

[42] Recommended literature includes *Rehfeldt* (1994), *Sparnaay* (2011), *Krassnitzer* (2002), *Watts* (2015).

simpler keywork and fewer toneholes, the BP clarinet may have signifcantly fewer multiphonics to offer than a traditional clarinet (Krassnitzer lists about 850 multiphonics for German clarinet, and even his huge collection does not cover all the possibilities). Not all fingering combinations have been tried, and the introduction of half-holes, as mentioned above, would produce a significant number of additional sounds. Last but not least it should be mentioned that almost every multiphonic fingering has more than one possible resultant sound, most of the time regarding the number of higher (harmonic and inharmonic) partials which can be controlled, to a certain extent, by an experienced clarinettist.

### 4.2.1 Notation and Categorisation

Categorisation of multiphonics is possible in various ways (which all are of good use to performers and composers) due to multiphonics having very different properties in terms of stability, dynamic range, roughness or softness, beatings, top and bottom notes etc. [see Krassnitzer 2002; Rehfeldt 1994, p. 43-46; Weiss and Netti 2010, p. 60-62]. The multiphonics in this catalogue after sorted after objective criteria, implementing factors that are of interest and importance to composers. This includes, besides the dynamic range of a sound, the lowest and highest pitch of a sound, the latter one often being a matter of choice by the clarinettist; the overall character of a multiphonic, based on Rehfeldt's categories, such as "soft", "rough", "rolling" etc. Pitches to or from which a multiphonic can be "sneaked" in to and sometimes out of, so-called *threshold tones*, [see Weiss and Netti 2010, p. 62; Mahnkopf and Veale 2001], are given in the notation as well. The following categories by Rehfeldt, with one extra category (no. 5) added by the author are used for the BP multiphonics collection:

category 1: all dynamics, flexible
category 2: soft attacks, crescendo to mf-f, more resistant
category 3: quiet; little or no crescendo
category 4: loud, with beats

category 5: soft, with beats
category 6: dyads, soft
category 7: variable in upper partials, shrill, two or more partials possible

All multiphonic sounds in the fingering charts are sorted from the lowest note upwards. If there are several sounds with the same base pitch there is no further distinction in order. Categorisation is given in extra tables at the end of the fingering charts. Some multiphonics appear in more than one category, either because they are variable in their characteristics while maintaining the same group of pitches, or because there are several different sounds to be produced by use of the same fingering. Several authors remark that in a multiphonic, one usually hears all the notes as a colour, rather than as separate pitches [Weiss and Netti 2010, p. 59; Sparnaay 2013]. Sparnaay developed his own way to deal with this issue: in *The Bass Clarinet: A Personal History* he suggests two notations for each multiphonic. One notation shows what notes the sound is actually composed of, i.e. a relatively detailed notation of the multiphonic, with the subtle notes printed grey. The second notation is a little more general for the performer to read – most performers usually write a fingering chart above the notated sound anyway, while the exact pitches are of little use for them to know while performing, at least in the more complex sounds. Sparnaay's notation shows the notes the listener can actually distinguish, e.g. the top and bottom notes, and some indistinct block of noise in the middle.

In this compilation, however, I decided to give notations in various notation systems: a very detailed notation of the actual sound (i.e. concert pitch) is given in eighth-tone notation. Notation proposals in both BP clarinet fingering and Müller-Hajdu notation have also been elaborated, although they do not provide the same precision as the eighth-tone notation: the transcription of the multiphonics into Müller-Hajdu notation and BP clarinet fingering notation use eighth-tone accidentals as well since the idea of the use of third-tone accidentals by Xenakis and Wyschnegradsky respectively, (as suggested in –> chap. 7) came up only after the documentation of the BP multiphonics was already finished. If composers need to know the exact pitches contained in a sound, they might consult the eighth-tone notation which gives a very good approximation to the actual sound. The BP clarinet fingering notation will rather be consulted by clarinettists, who need a more general, "uncluttered" notation that shows exactly which sound is meant but at the same time does not clutter the score or disturb the performer's visual perception. Thus, the sounding notation given in the tables will have most of the possible notes – although for practical reasons, the number of pitches notated has usually been limited to a maximum of seven or eight – whereas the practical notations for the clarinettist are given in several variants if applicable, showing the most obvious pitches such as top and bottom note and the pitches that are most present in the middle of the sound. This may help the clarinettist to generate the desired sound by helping to point out which pitches are important for the clarinettist to concentrate on when playing the sound. The sounding notation – the one which might interest the composer – is given in eighth-tone approximation. Translating these nuances of 25 cents into BP clarinet notation results in unclear notation due to the fact that BP steps (146.3 cents) are notated irregularly in BP clarinet fingering notation: sometimes written as whole tone steps, e.g. f' – a', and sometimes as half-tone steps, e.g. c" – c"♯, reflecting the keywork of the BP clarinet. The result of an exact notation of the multiphonics in BP clarinet notation would be confusion.

Some of the multiphonics in this compilation make use of the trill key on the upper joint, operated by the right index finger. In contrast to a traditional B♭ clarinet, this key can be reached by the right index finger while the other fingers of the right hand cover holes on the lower joint. This is because the trill key is a little longer than on a B♭ clarinet and thus situated lower on the upper joint; since there are no other right side keys on the BP clarinet's upper joint, Fox decided to put the trill key in a more comfortable place. Even clarinettists with very small hands can reach the trill key while the right hand fingers are covering tone holes on the lower joint; if a clarinettist cannot for some reason, he or she might use the right thumb to operate the trill key.

Three kinds of noteheads have been used, representing dynamics of the single pitches:


Figure 46: Representation of dynamics by the use of varied noteheads

A notation example of multiphonics T-49 and T-50 for BP Tenor clarinet is given below. Multiphonics are numbered S-01 through S-72 (BP soprano clarinet) and T-01 through T-53 (BP tenor clarinet). Numbers are given only at the beginning of each system, meaning that the multiphonic example in the second bar is T-50. In this case, both sounds are generated by the use of the same fingering, as can be seen from the fingering diagram. This means that by embouchure adaptions both sounds are possible. Notes in the second half of the bar are "threshold tones", i.e. notes which can be played separately and from which the player can glide into the multiphonic sound.

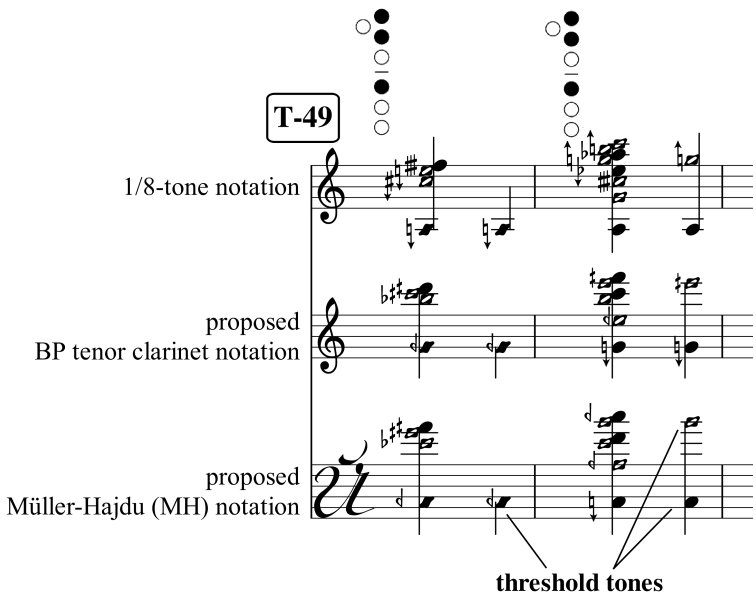



Figure 47: Notation example: multiphonics T-49 and T-50

### 4.2.2 Analysis Method

The question of how to approach analysis of multiphonics requires some preliminary considerations. Some multiphonics, e.g. dyads (two pitches sounding at a time), are clearly heard as an interval; some sounds can be perceived as a kind of triad or chord. More complex sounds, however, which are composed of a number of pitches, are usually not perceived as chords; to the contrary, most listeners hear them as a “cloud of sound” or cluster, as a sound colour whose character is defined by denseness and number of pitches. These sounds are rated as more or less rough, sometimes as unpleasant or dissonant, and some sounds captivate the listener by their pulsating beatings which can range from a soft oscillation to a strong rolling.

Analysis of the multiphonics was carried out with computer assistance. All soprano multiphonics were recorded on a Stephen Fox Bohlen-Pierce soprano clarinet from 2011, which has open tone holes with chimneys. A German mouthpiece with a tip opening of 0.96 mm and a facing length of 25 mm was used. The reed was *Pilgerstorfer Classic breit 3 ½*. Tuning pitch is a’ = 443 Hz. The multiphonics were approved by double-testing them on a 2007 BP clarinet by the same maker without chimneys. All multiphonics gave the same aural impression on both models and thus were admitted to the compilation. For the tenor multiphonics, a 2010 Bohlen-Pierce tenor clarinet by Stephen Fox was used, with a Vandoren B40 alto clarinet mouthpiece and Rico alto clarinet reeds. The recording device used was a Roland Edirol R-09 with internal microphones, 16-bit recording quality .wav format. The recording device was placed at a distance of approximately 1m to the clarinet. Several multiphonics were recorded in a row. For editing they were imported into Audacity, split into single files and exported as wav 16-bit.

The sounds were then imported into spectral analysis software Spear,[43] version v0.7.4 r.148, for further processing and editing. In this process, the aural impression was important, i.e. due to the, in many cases, high number of partials contained in a sound, only those for further analysis and notation which clearly added to the characteristics of the sound were picked and re-

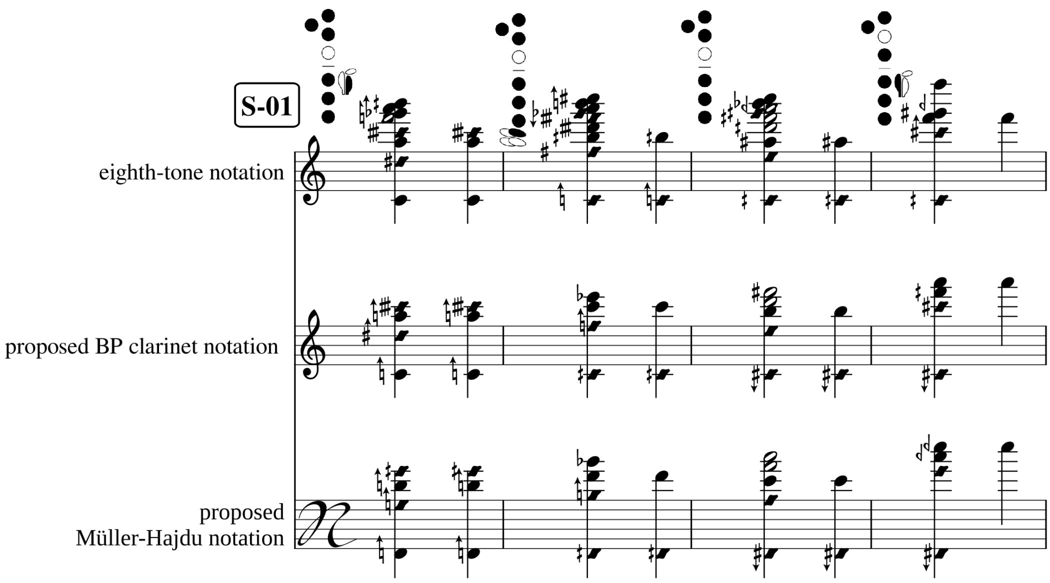
[43] http://klingbeil.com/spear/

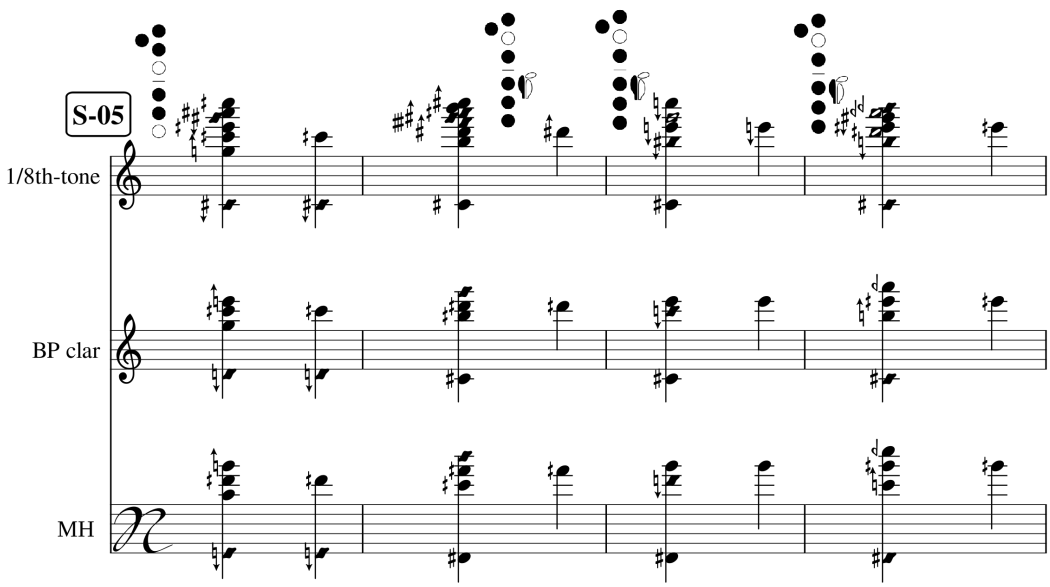
tained for analysis. For this reason, generally all very quiet partials below -60 dB were deleted; mostly even those under -45 dB. Occasionally, e.g. in multiphonics that are very quiet, there are single partials in the sound which have an audible influence on how the sound is perceived. They are either slightly audible as pitches in the sound and thus add colour to it; or they are not audible as single pitches but still very present in the spectrum and for example add roughness to the sound. These partials, although very quiet, were not deleted but left to remain in the sound. The decisions were made by listening on headphones. The transient (i.e. the initial 0.5-1 sec) of each sound was cut off to achieve higher accuracy in pitch measurement in Macaque[44], which was used for further analysis. In some sounds, even more than the transient was cut off. One or the other clearly audible partial in a multiphonic sound may speak later than others, "sneaking into" the sound. Since these partials, too, may be essential to the aural impression, it was ensured that they were detected by the frequency analysis software. Of importance for this work are the aural perception of a multiphonic and the practice of its notation; for this reason it has been forgone to analyze the complete sound spectrum of each multiphonic. The notation is limited to the most important, i.e. most clearly perceptible components of each sound. For reasons of practicability, frequencies above ca. 2300 Hz (approx. bb"") are not notated because they are outside of the usual range of a B♭ clarinet. These extremely high partials do not appear to have form-giving influence on the sound of a multiphonic and therefore have been omitted deliberately. Generally, most sounds were limited to a total maximum of 7 pitches to avoid a cluttered score. The sdif-files from Spear were processed by Macaque which gives a conventional eighth-tone notation of the respective sound in Max Score. Subsequently the outcomes were transcribed into Müller-Hajdu notation and BP clarinet notation to suite the needs of both performers and composers. The fingering charts were created using Bret Pimentel's Fingering Diagram Builder.[45]

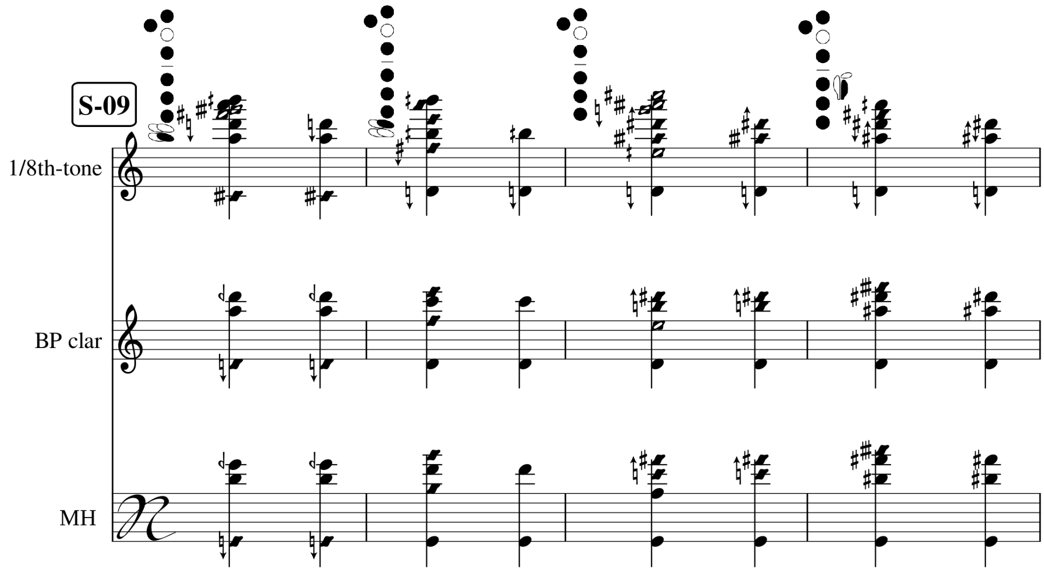
[44]Macaque and MaxScore are available at www.computermusicnotation.com.

[45]fingering.bretpimentel.com/#!/clarinet/ last accessed: 30th July 2019

## 4.3 Fingering Chart: Multiphonics on BP Soprano Clarinet

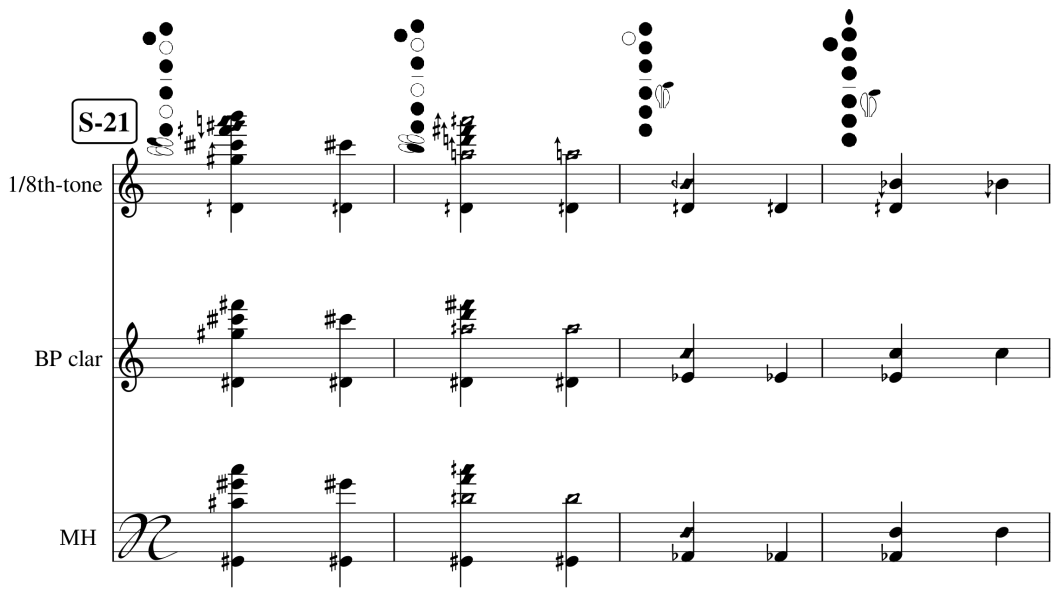



S-09
1/8th-tone
BP clar
MH


S-13
1/8th-tone
BP clar
MH

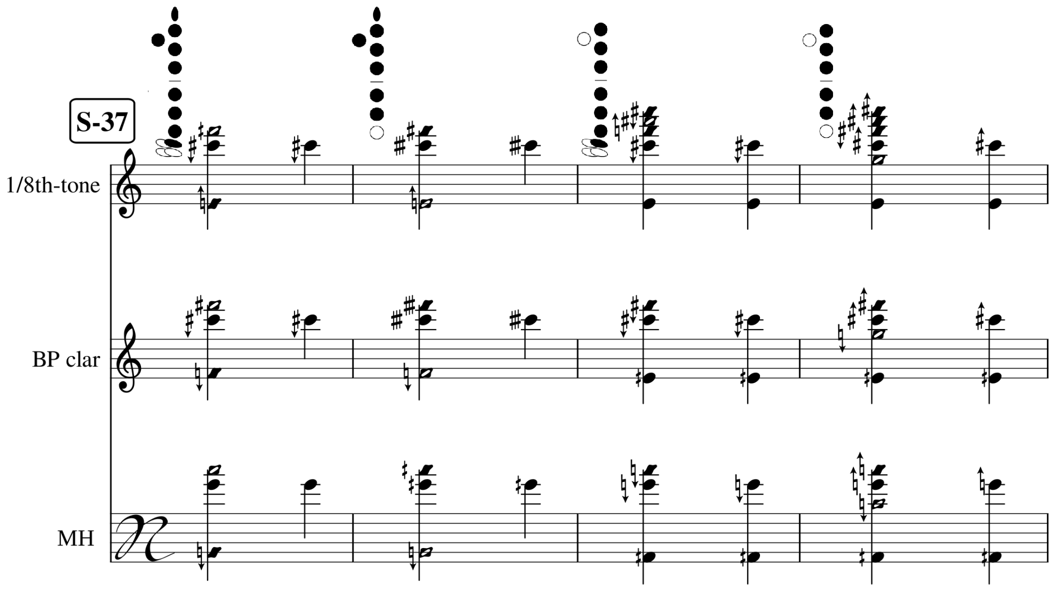

S-17
1/8th-tone
BP clar
MH


S-21
1/8th-tone
BP clar
MH

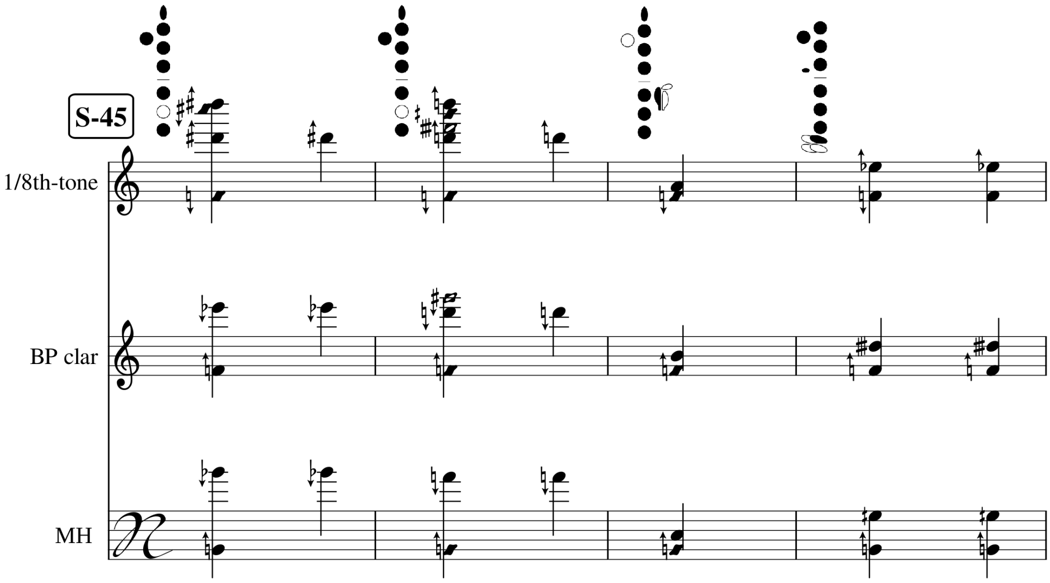

S-25
1/8th-tone
BP clar
MH


S-29
1/8th-tone
BP clar
MH

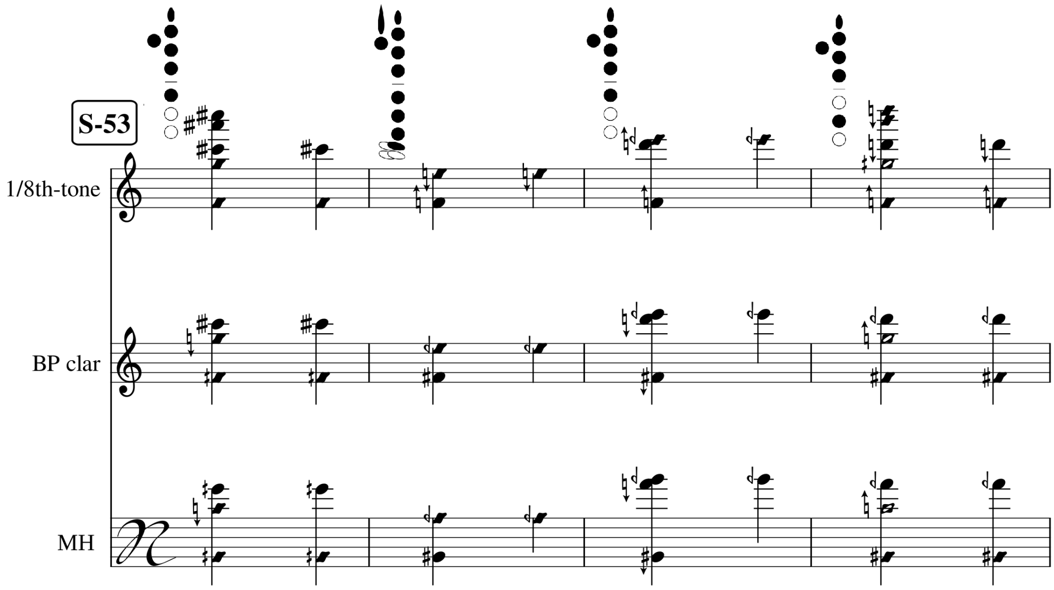

S-33
1/8th-tone
BP clar
MH

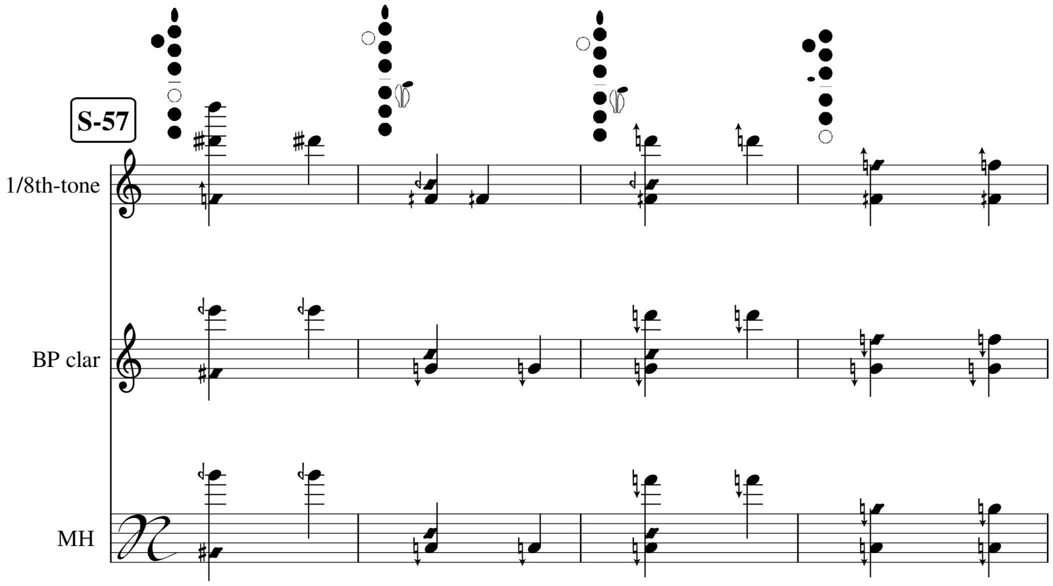

S-37
1/8th-tone
BP clar
MH

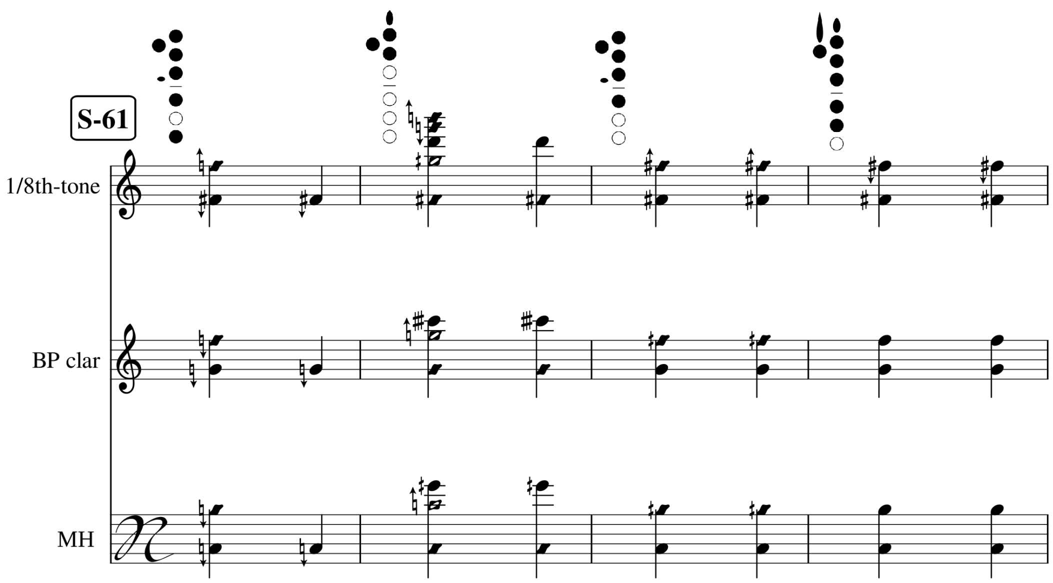

S-41
1/8th-tone
BP clar
MH


S-45
1/8th-tone
BP clar
MH


S-49
1/8th-tone
BP clar
MH


S-53
1/8th-tone
BP clar
MH


S-57
1/8th-tone
BP clar
MH


S-61
1/8th-tone
BP clar
MH

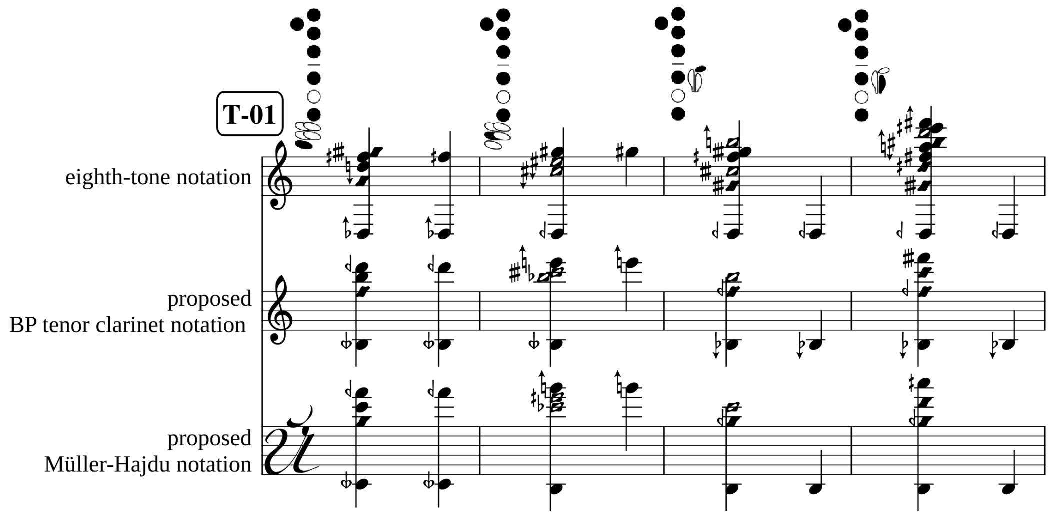


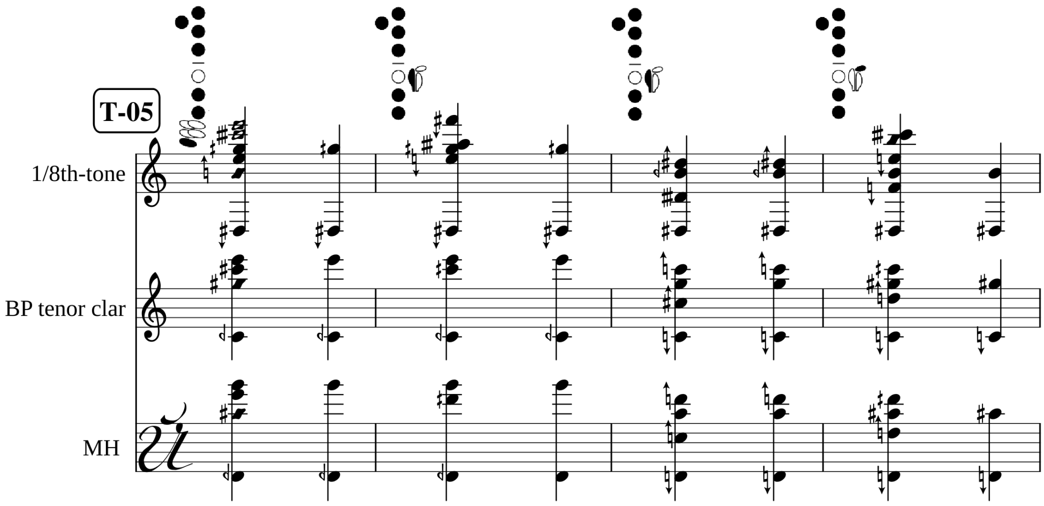
S-69 to S-72 are variants of the same fingering. Asking for specific threshold notes might be somewhat challenging for the performer.

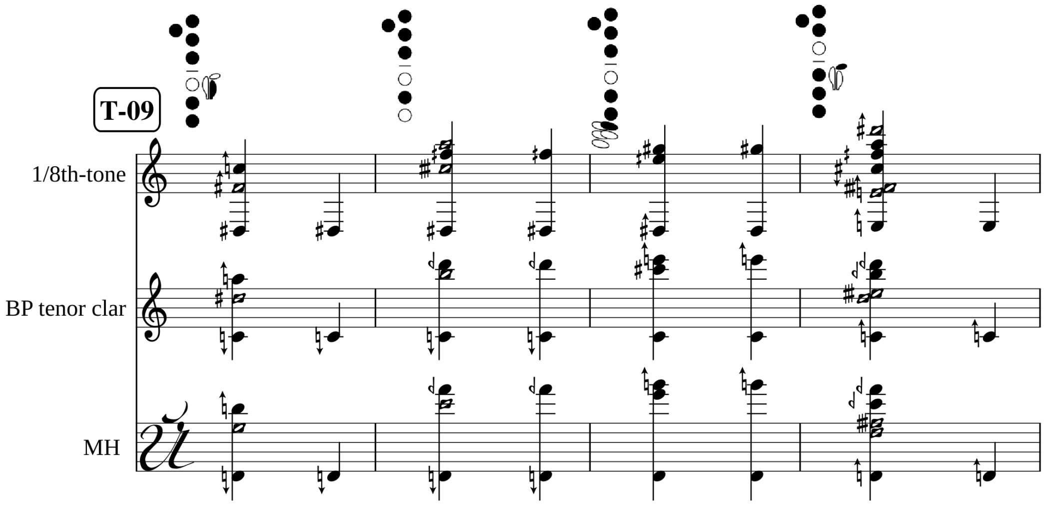
### 4.3.1 Categorisation of BP soprano clarinet multiphonics

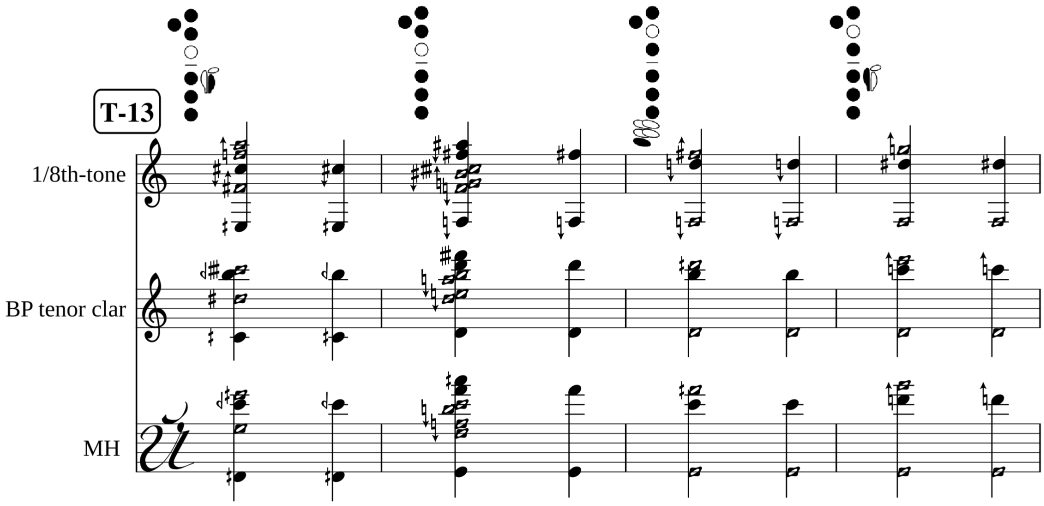
| description of sound | multiphonics on BP soprano clarinet |
|---|---|
| all dynamics, flexible, very stable; extremely rough, strong interferences | S-01, 02, 03, 05, 06, 10, 11, 12, 15, 17,18, 19, 21, 22, 25, 29, 30, 43, 45, 46, 51, 53, 57 |
| soft attacks, cresc to mf-f, more resistant | S-09, 16, 31, 33, 39, 40, 55, 56 |
| quiet; little or no crescendo | S-34, 37, 38, 50, 52, 57, 59, 61, 62, 65, 66, 67, 68, 70 |
| loud, with beats, “rolling” | S-09, 20, 21, 30, 56 |
| soft, with beats, “rolling” | S-19, 30, 33, 60, 61, 63, 64, 67 |
| dyads; soft sounds | S-13, 14, 23, 24, 26, 27, 28, 32, 35, 36, 41, 47, 48, 58, 61 |
| variable in upper partials, shrill, more than two partials possible | S-49, 54, 57, 69, 71, 72, 04, 07, 08, 11, 33, 34, 50 |

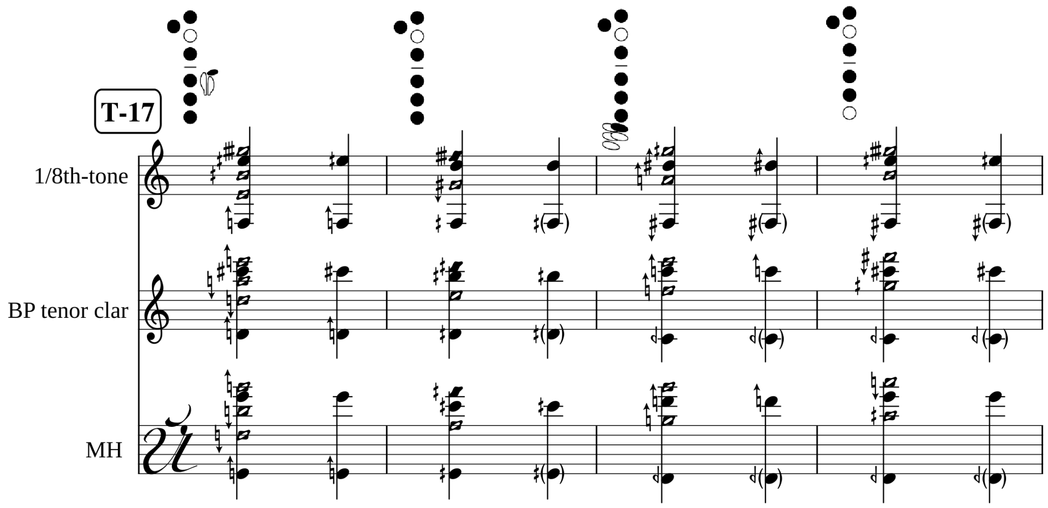
## 4.4 Fingering Chart: Multiphonics on BP Tenor Clarinet



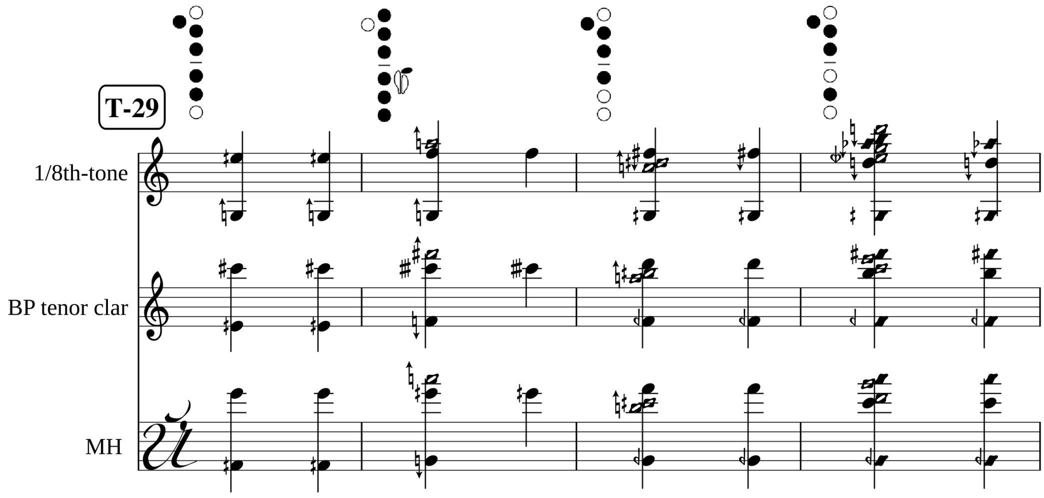

T-09
1/8th-tone
BP tenor clar
MH


T-13
1/8th-tone
BP tenor clar
MH


T-17
1/8th-tone
BP tenor clar
MH

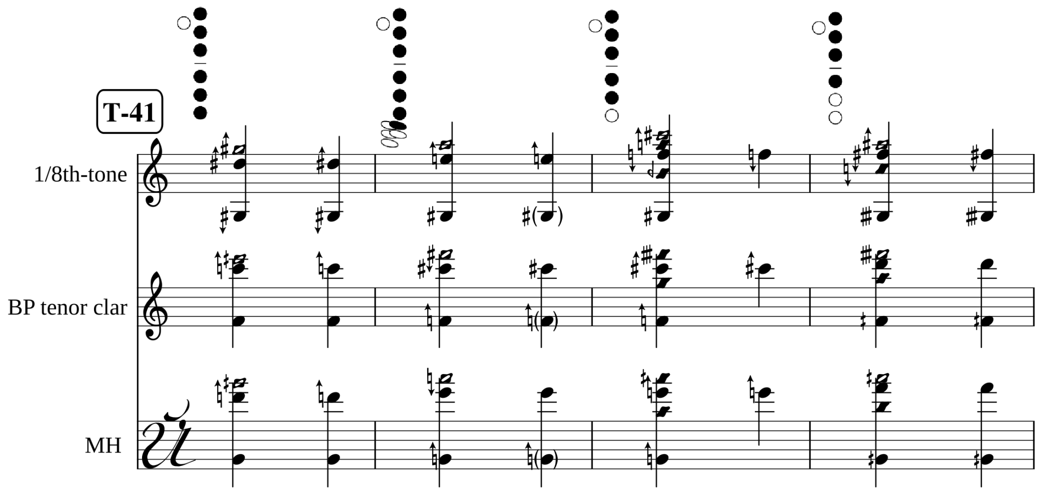

T-21
1/8th-tone
BP tenor clar
MH

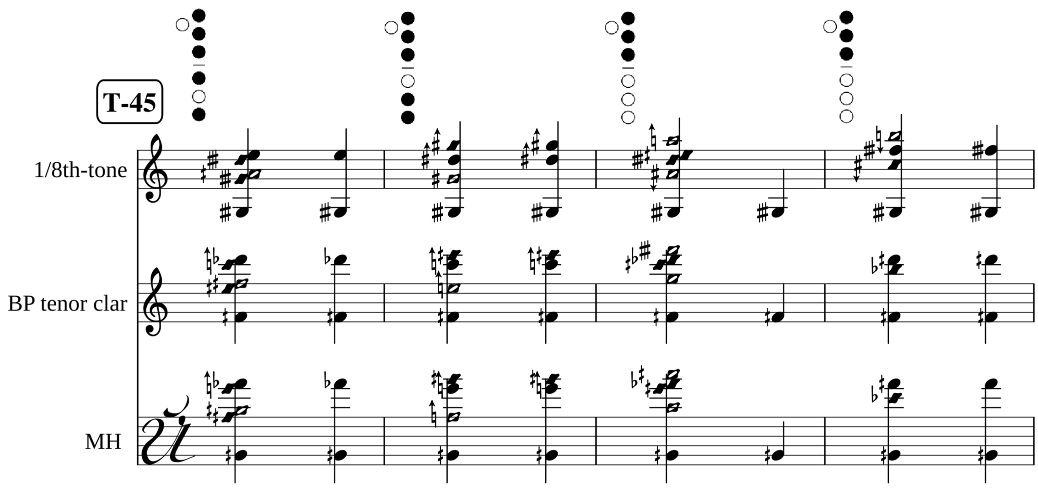

T-25
1/8th-tone
BP tenor clar
MH

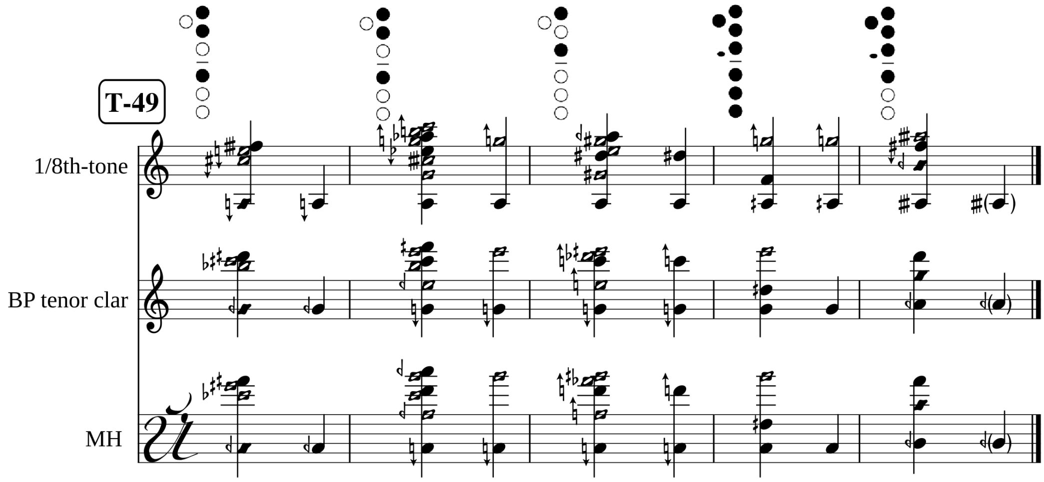

T-29
1/8th-tone
BP tenor clar
MH


T-33
1/8th-tone
BP tenor clar
MH


T-37
1/8th-tone
BP tenor clar
MH


T-41
1/8th-tone
BP tenor clar
MH


T-45
1/8th-tone
BP tenor clar
MH




### 4.4.1 Categorisation of BP tenor clarinet multiphonics

| description of sound | multiphonics on BP tenor clarinet |
|---|---|
| all dynamics, flexible, very stable; extremely rough, strong interferences | T-03, 06, 14, 16, 27, 48, 50 |
| soft attacks, cresc to mf-f, more resistant | T-01, 02, 04, 05, 06, 07, 10, 11, 15, 17, 22, 24, 28, 31, 34, 35, 36, 43 |
| quiet; little or no crescendo | T-08, 09, 12, 13, 18, 19, 20, 21, 23, 26, 29, 30, 32, 38, 39, 41, 42, 47, 49, 52 |
| loud, with beats, "rolling" | T-51 |
| soft, with beats, "rolling" | T-07, 17, 25, 33, 35, 37, 42, 45, 46 |
| dyads; soft sounds | T-(09), (21), (23), (30), 40, (41) |
| variable in upper partials, shrill, more than two partials possible | |

# 5 The High Register on Clarinets in General

Playing in the highest register – the altissimo register – of a woodwind instrument requires much experience, embouchure control and inner hearing. Books and webpages offer a huge number of fingering charts for high notes on clarinets. Relatively few of these sources take into account that fingering is not the prevalent matter in high register playing, and less experienced clarinet players will soon notice that a fingering chart may not help their problems in achieving high pitches. This chapter discusses matters of playing technique, embouchure and acoustic theory of the clarinet's altissimo register in general, which starts at notated c♯”’ (c♯ above staff).

## 5.1 Playing on the Overtones

A sound usually consists not only of the fundamental note (the pitch we predominantly hear in a sound, or the first partial) but of many overtones. A natural timbre contains the fundamental (1st partial), the octave above it (2nd partial), the twelfth (a fifth an octave apart, 3rd partial), the major third two octaves apart (5th partial) and so on. The partials up to the tenth are the following:

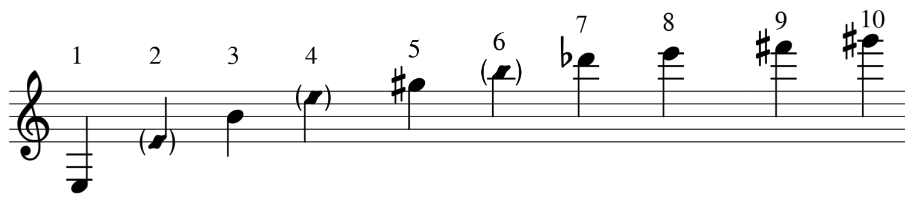



Figure 48: Spectrum of notated low e on B♭ clarinet

The seventh partial is a minor seventh two octaves apart and rather narrow – signficantly narrower than in the equal tempered scale (as played by e.g. a modern piano). Please note that the 7th partial is particularly flat in the clarinet spectrum. In fact, it is so flat that it appears not as a minor seventh but rather as a major sixth. In the above example it means that a d♭”’ is sounding instead of a d”’ which would be expected [Brymer 1976, p. 80 of the German edition, Die Klarinette, Frankfurt/Main (1983)]. Please note that the 2nd, 4th and 6th partials are written in parentheses and with different noteheads because these partials are suppressed in the clarinet’s timbre. It is impossible to achieve these partials by overblowing. The third and fifth partial are much more present in the clarinet’s timbre and can be heard in a note played on a clarinet by an attentive listener.

“Overblowing” a wind instrument means to achieve high pitches by playing on the overtone series of a fundamental pitch. On the clarinet, every pitch from b’ on is achieved by overblowing. The infamous squeaks are nothing else than very high pitches which are produced unintentionally! Without wanting it, the player has “cut off” the lower pitches of a sound and hit one of the overtones instead.

**First Steps in the Altissimo Register**

A popular and good teaching method for the high register is to overblow a low note twice, i.e. e.g. a – e- c♯.

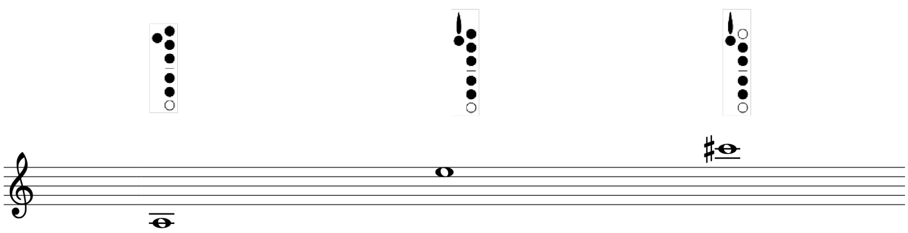


Figure 49: 1st, 3rd and 5th partial of notated low a on a B♭ clarinet

Overblowing the first time, the speaker key opens and induces a physical node in the vibrating air column and makes the 3rd partial – the perfect twelfth – sound (e.g. a – e”).

While the clarion register is obtained by overblowing to the 3rd partial, the altissimo register speaks when the note is overblown a second time.

To overblow to the altissimo register – the 5th partial or a major third plus two octaves – the first tone hole (left index finger) is opened additionally to the speaker key and functions as a second speaker hole. Some notes in the lower altissimo register require a correction of the fingering (right index on g♯ /d♯ ” key) in order to achieve correct intonation; this may be due to the fact that the first tone hole is relatively big when functioning as a register hole, thus resulting in a tone which is a little sharp in pitch. A bass clarinet and some alto clarinet or basset horn models have a closed key for the left index with a very small hole in the middle. In the altissimo register, this key is used as a half hole in the way that the left index is positioned on the edge of the key and leaves the small hole in the middle open.

The third register can go as high as c♯”” or even d””, being played as the 5th partial above a’ or b♭’ respectively. Experience shows that it is hard or even impossible to achieve higher partials than the 5th above throat notes (i.e. notes “at the barrel” with a short tube, f♯’ to b♭’). It is not quite clear what the reason is.

On notes produced by a longer tube it is possible to go much higher than the 5th partial. There is no limit – theoretically. For example: c♯”’ can be achieved not only as the 5th partial above a, but also as the (very flat) 7th partial above low e. Peter Maxwell Davies uses higher partials in his composition for B♭ clarinet solo, *The Seven Brightnesses*. In the example (fig. 50) the clarinettist plays a low e and simultaneously emphasises the higher partials up to c♯”” as the 14th partial:

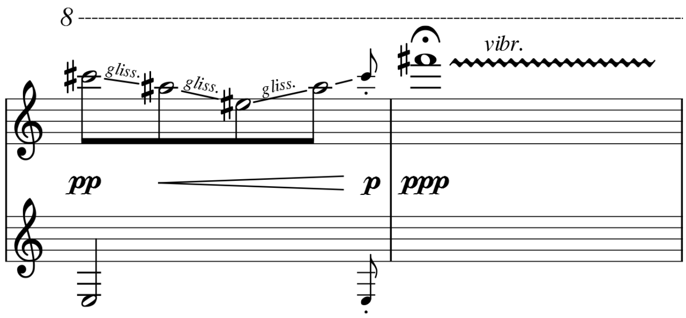



Figure 50: Excerpt from Peter Maxwell Davies, *The Seven Brightnesses*

The notated a♯"' may be an outcome of Maxwell Davies' work with clarinettist Alan Hacker. The author's personal experience shows that it is actually difficult to achieve since it is likely that a"' sounds instead since it seems to be more dominant in the spectrum.[46]

### Practical Considerations

A traditional method for playing high notes involves high pressure of the lower lip and jaw against the reed. From the author's experience, this is often more hindering than helpful because it dampens the reed and blocks its movement. To play in very high registers it is often more helpful to place the upper teeth a tiny bit further away from the tip of the mouthpiece (i.e. take a little more mouthpiece into the mouth) in order to allow the reed to vibrate more freely[47]. High pitches are achieved by playing on the overtone series. The clarinettist's lips can dampen the reed or let it vibrate more freely. Let the reed vibrate freely, and all the high partials will be there, and consequently all the high pitches can be achieved. Advanced saxophone players practice "top tones" regularly. Clarinetists can profit from practicing top tones, too, and might want to add them to their daily practice routine[48].

### Special Fingerings and Intonation Corrections

Besides the basic fingerings which can be found in any fingering chart, each player finds his or her own fingerings to suit their needs in certain situations. These fingerings may be found by pure chance and lucky accidents or by systematic research. It is a fact that the higher the register, the more fingerings

[46] It is also possible that different players achieve higher partials of different pitch and intonation, and it would be interesting to know whether Maxwell Davies would be bothered about deviations from his score regarding higher partials, or if he would not mind.

[47] source: clarinet lessons with Prof. Hans Deinzer 1999-2004; see also Stein 1958, p. 40

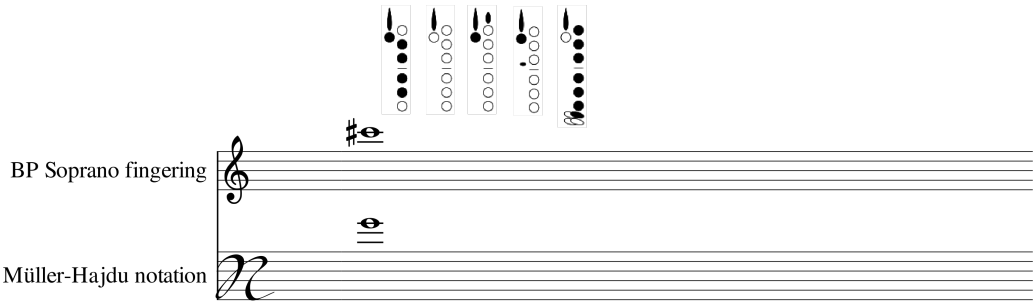
[48] Players who are searching for inspiration to practice top tones on a clarinet may look for the almost classic book by Sigurd Rascher, *Top Tones for the Saxophone* or the lesser-known, but by some saxophone players preferred volume *Saxophone High Tones* by Eugene Rousseau. Ben Britton gives many exercises in his book *Complete Approach to Overtones*: http://www.benbrittonjazz.com/completeapproach/toovertones/, last acces: 30th July 2019

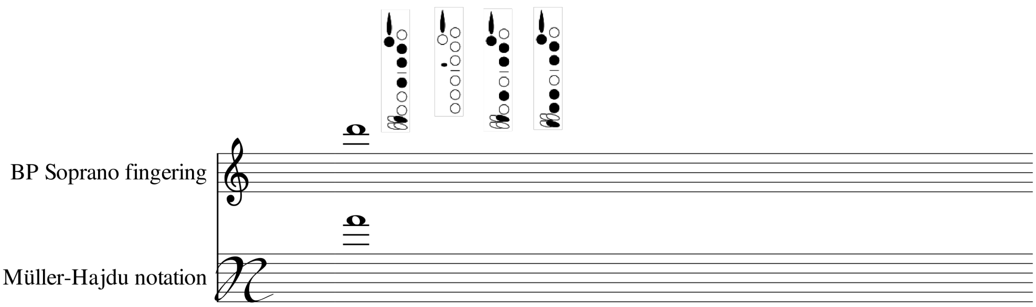
for a pitch can be found, providing a range of sound colours, tone qualities and intonational variations.

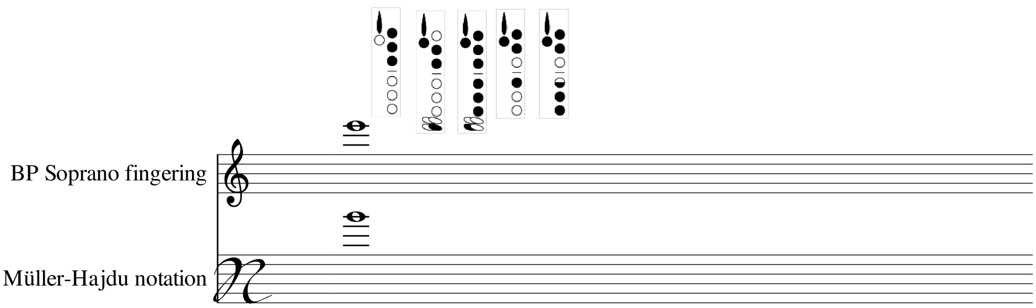
The following fingering charts provide both clarinet fingering and Müller-Hajdu notation. Again, thank you to Bret Pimentel for his marvellous Fingering Diagram Builder.[49]

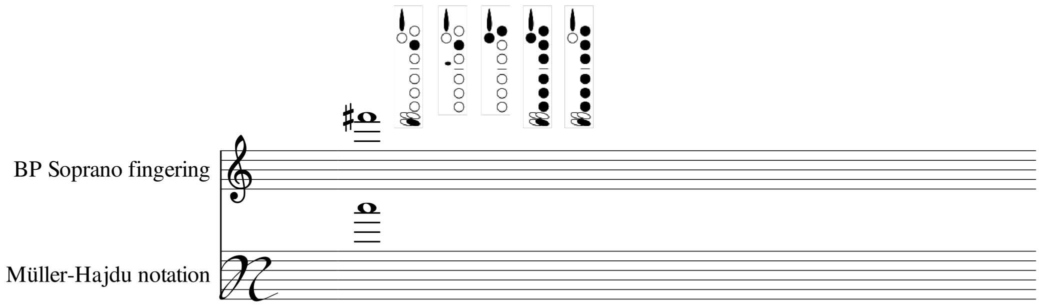
[49] https://fingering.bretpimentel.com/#!/clarinet/, last accessed: 30th July 2019

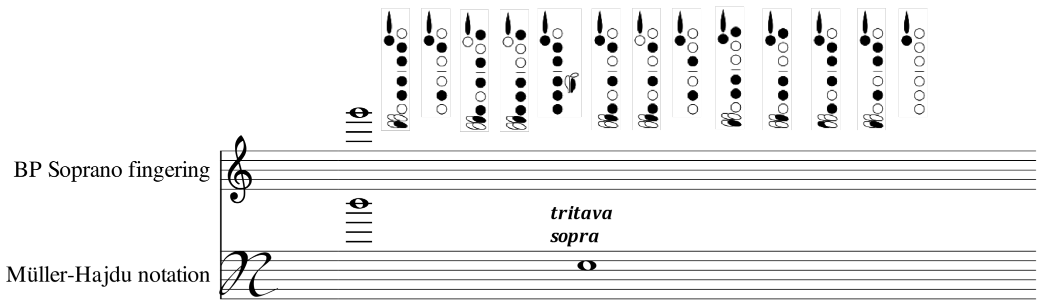
## 5.2 Fingering Chart: The High Register on BP Soprano Clarinet

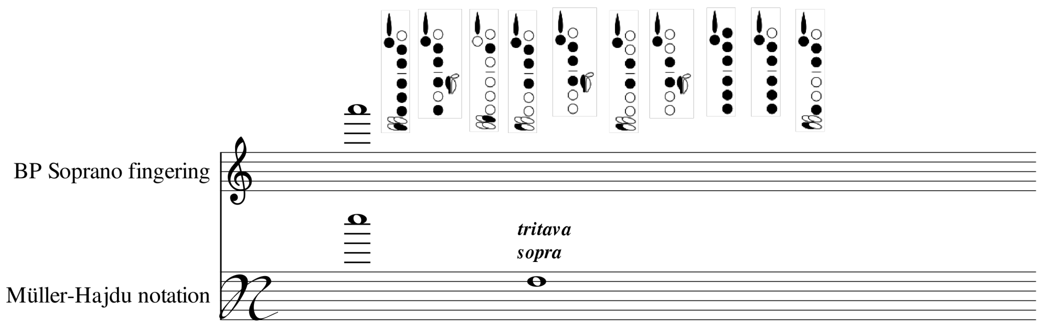


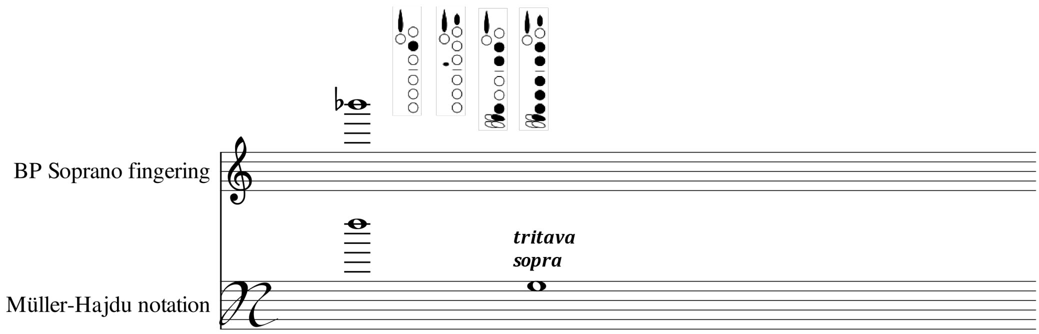



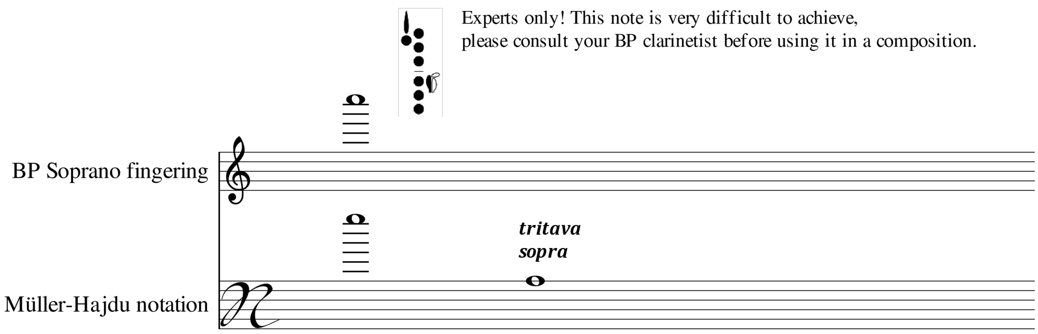




BP Soprano fingering
Müller-Hajdu notation

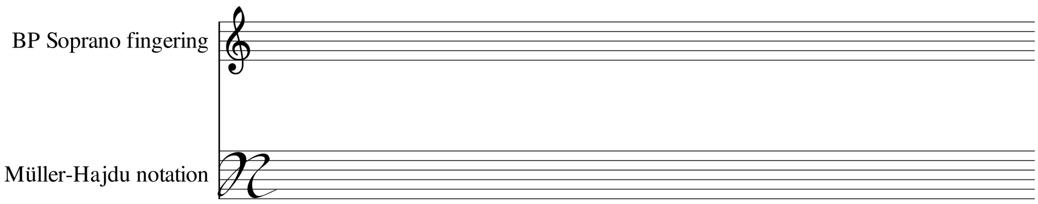

BP Soprano fingering
tritava
sopra
Müller-Hajdu notation


BP Soprano fingering
tritava
sopra
Müller-Hajdu notation

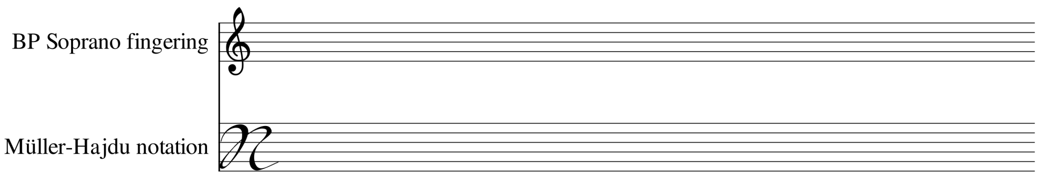

BP Soprano fingering
tritava
sopra
Müller-Hajdu notation



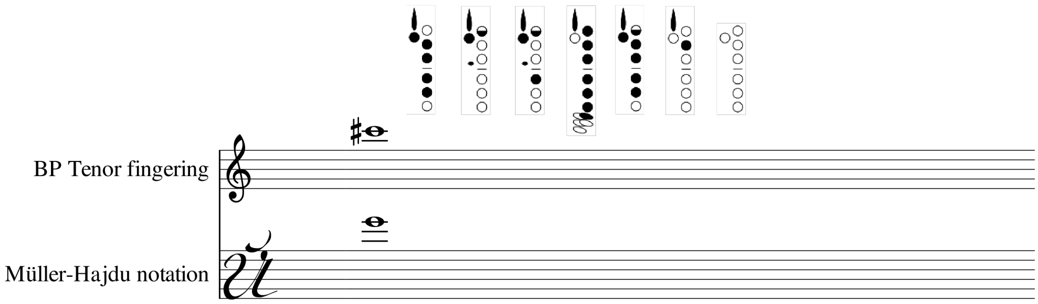

space for your own notes

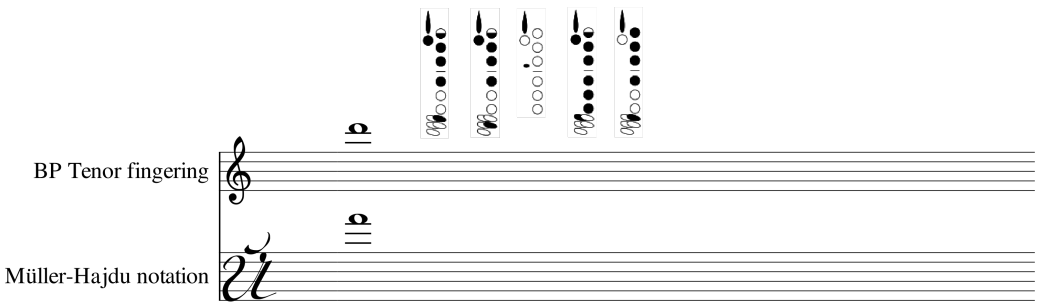


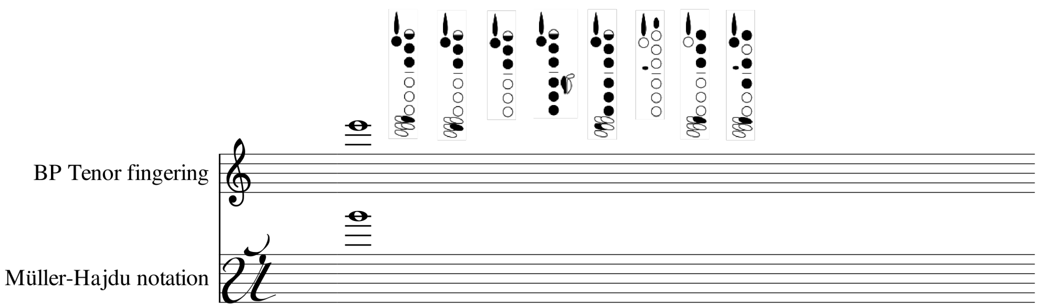

space for your own notes

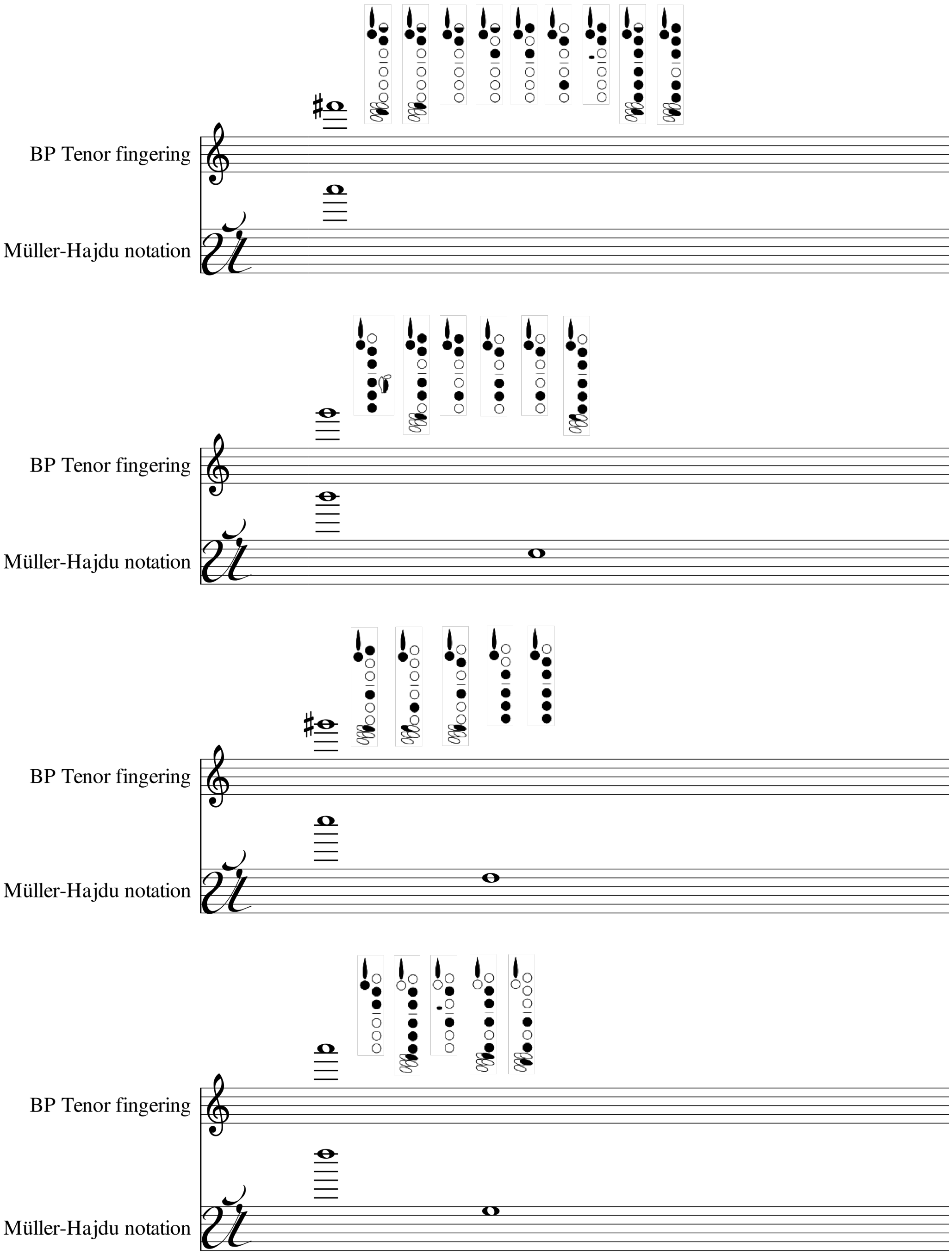


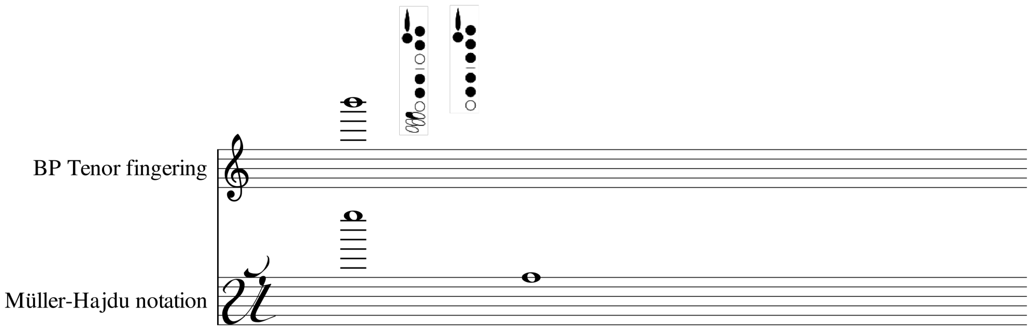
## 5.3 Fingering Chart: The High Register on BP Tenor Clarinet

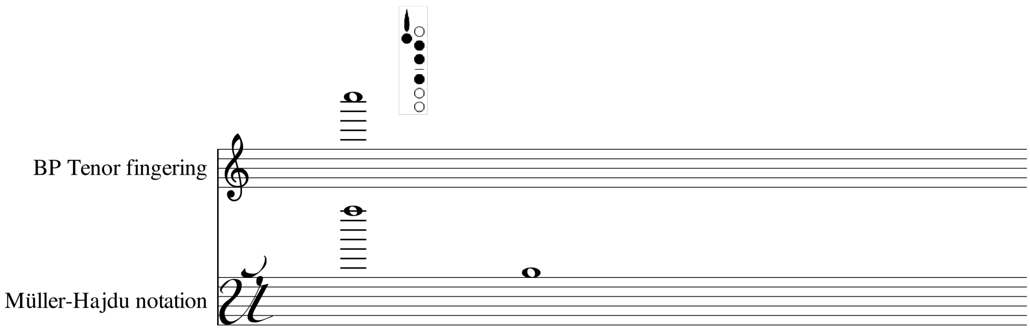


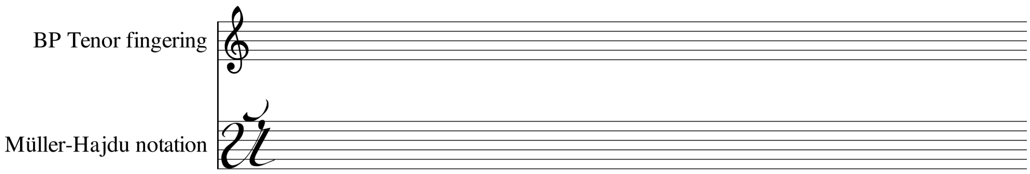




BP Tenor fingering
Müller-Hajdu notation
BP Tenor fingering
Müller-Hajdu notation
BP Tenor fingering
Müller-Hajdu notation
BP Tenor fingering
Müller-Hajdu notation




space for your own notes



# 6 Repertoire

Since its premiere in Germany and Canada in 2008, about 40 pieces involving one or more BP clarinets have been composed and performed. Some compositions are discussed in this chapter, with particular attention to repertoire created in Europe.

## 6.1 List of Works Featuring BP Clarinets (2019)

### BP clarinet solo, with or without electronics

James Bergin, *Liebesleid* (2010) for BP clarinet solo
Todd Harrop, *Zaubersephir* (2011) for BP tenor clarinet and electronics
Todd Harrop, *Bird of Janus* (2012) for BP clarinet solo
Peter Köszeghy, *Utopie XVII (chochma)* (2009) for BP clarinet and fixed audio
Hans-Gunter Lock, *Probierstück No. 1* and *Probierstück No. 2* for BP contra clarinet solo (2019)
Katarina Miljkovic, *For Amy* (2010) for BP clarinet and electronics
Nora-Louise Müller, *Lady Low Delay* (2019) for BP contra clarinet and delay
Anthony de Ritis, *Five Moods* (2010) for BP clarinet and tape
Julia Werntz, *Imperfections* (2010) for BP clarinet solo

### BP clarinet duos, with or without electronics

Owen Bloomfield, *Wanderer* (2008) for two BP clarinets
Manfred Stahnke, *Die Vogelmenschen von St. Kilda / The Bird People of St Kilda* (2007) for two BP soprano clarinets
Peter Köszeghy, *Sedna* (2011) for BP clarinet, BP tenor clarinet and fixed audio
Johannes Kretz, *Hoquetus II* (2010) for two BP clarinets and live electronics
Arash Waters, *Little Duet* (2011) for two BP clarinets

**Duos for BP clarinet and traditional clarinet, with or without electronics**

Sascha Lino Lemke, *Pas de deux* (2008) for B-flat clarinet, BP clarinet and live electronics
Fredrik Schwenk, *Night Hawks* (2007) for B-flat clarinet and BP clarinet
Roger Feria, *RE: Stinky Tofu* (2010) for bass clarinet and BP clarinet
Frank Zabel, *Sie sind zu lange im Wald geblieben* (2011) for bass clarinet and BP tenor clarinet

**BP clarinet trios**

Ákos Hoffmann, *Duo Dez* (2015) for two BP soprano clarinets and BP tenor clarinet
Nora-Louise Müller, *Morpheus* (2015) for two BP soprano clarinets and BP tenor clarinet

**BP clarinet quartets**

Clarence Barlow, *Pinball Play* (2010) for four BP clarinets

**Chamber music and ensemble works including BP clarinets**

Owen Bloomfield, *When the Ravens Descend* (2010) for soprano voice, BP clarinet and BP tenor clarinet
Jim Dalton, *Contemplating Duality* (2013) for BP clarinet and marimba
Emily Doolittle, *Body of Wood* (2010) for soprano, BP clarinet, cello and percussion
Georg Hajdu, *Beyond the Horizon* (2007) for two BP clarinets and synthesizer in BP
Georg Hajdu, *Burning Petrol* (2015), an arrangement for BP ensemble after Alexander Scriabin's *Vers la flamme*, for two BP soprano clarinets, BP tenor clarinet, electric guitar, synthesizer, double bass and percussion (tam-tam, kalimba; one player)

Peter Michael Hamel, *Die Umkehrung der Mitte* (2007) for two BP clarinets, viola, marimbaphone & vibraphone (normal tuning; one player)

Peter Hannan, *No brighter sun – no darker night* (2009) for soprano, two BP clarinets, cello (BP) and malletKAT (BP)

Todd Harrop, *Calypso* (2008) for two BP clarinets, percussion (hand drums, BP chimes) and fixed audio

Todd Harrop, *Maelström* (2015) for BP clarinet, BP tenor clarinet and BP electric guitar

Benjamin Helmer, *Preludio e Passacaglia* (2015) for BP tenor clarinet, viola, electric guitar and kalimba (all in BP)

Neele Hülcker, *Dumosus* (2010) for oboe, BP clarinet, BP tenor clarinet and double bass

Christian Klinkenberg, *The Leaves that Hung but Never Grew* (2018) for BP ensemble (clarinet, electric guitar, electric bass, violin, chimes, two drumsets) and storyteller

Christian Klinkenberg, *The Glacier*, a microtonal opera including BP clarinets (2019)

Hans-Gunter Lock, *Kolm fragmenti (Three Fragments)* (2014) for BP clarinet, BP alto recorder and BP piano

Hans-Gunter Lock, *Sügav ruut nr. 1 (Deep Square No. 1)* (2017) for BP clarinet and BP synthesizer

Hans-Gunter Lock, *Sügav ruut nr. 3 (Deep Square No. 3)* (2017) for BP clarinet, BP alto recorder, BP tubular bells and BP synthesizer

Stratis Minakakis, *Anacharsis I* (2010) for BP clarinet, violin and percussion (dumbek)

Jasha Narveson, *Wire* (2010) for two BP clarinets and percussion

Manfred Stahnke, *Just Intonation in Bohlen-Pierce – ein klingender Essay* (2015) for BP tenor clarinet and viola in just 7/3 tuning

Gayle Young, *Cross Current* (2010) for two BP clarinets, BP recorder, amaranth, percussion

## 6.2 Selected Repertoire - A Detailed View

Having a closer look at existing compositions including one or more BP clarinets may give an overview about the potential of the BP scale and clarinet in music composition, and it may inspire the reader's own exploration of the scale.

### 6.2.1 Manfred Stahnke: Die Vogelmenschen von St. Kilda

In *The Bird People of St. Kilda* for two BP clarinets (2007), Manfred Stahnke uses the BP scale in the context of Just Intonation. Each of the 23 short scenes is composed on a virtual fundamental and uses the 3rd, 5th, 7th, 9th, 15th, 21st and 27th partial.

In his comment included in the score Stahnke suggests eight "figures", or chords, on which he bases the composition. These figures are series of odd partials, each figure based on a missing fundamental which is out of the range of the clarinet. Most of the figures that Stahnke gives in the score start on the 3rd partial; those which start on the 5th partial do so because the missing fundamental is so low that even its 3rd partial is out of the clarinet range (fig. 51, 52).

Stahnke's example no. 3 (fig. 51) is not used in *Die Vogelmenschen von St. Kilda*; but there are three more figures which Stahnke does not mention in his introduction and which shall be named a, b, and c (fig. 53).

The use of simple number ratios in his compositions creates what Stahnke calls *Meloharmonik*: he derives his compositional material from the natural overtone series which has a direct impact on the melodic gestalt of the piece [Stahnke 2005].

Beside his concept of *Meloharmonik*, Stahnke creates a collection of *hockets:*[50] both parts consist of wide leaps which are often not perceived as such by the listener because the parts intertwine in a way that the interaction between them reveals a melodic layer in which a latent melody can be heard. Towards the end of the piece the illusion of three clarinet players, playing on

[50]Hocket, a compositional technique with interlocking rhythms and melodies between parts/voices, cf. MGG Band 4, 1996, Kassel

three different melodic levels, occurs – in the altissimo register, in the middle register and in the low register. The middle voice may be perceived as the most present one, even though it is not played in this form (no. 23 of *Die Vogelmenschen*), but rather shared between the two players.

An interesting aspect about Stahnke's use of the scale is that, regarding the harmonic content, the music does not sound strange or foreign by any means. The author's experience in concert performances shows that audiences perceive Stahnke's piece very differently from, e.g. Hajdu's *Beyond the Horizon* which slingshots the listener to a completely different universe of harmonies. *The Bird People of St. Kilda* makes use of those intervals which are familiar from the 12div2 system, but appear in a more consonant, "softer" variant in BP. Many listeners do not even notice that Stahnke's piece uses a completely different scale system; it almost seems like Stahnke played a trick on the audience. The result is a particularly consonant music which obtains a great part of its charm from the "shaggy" style regarding rhythmic and melodic lines featuring far leaps.

Stahnke finds his inspiration for the piece in the history of a small and peculiar people, the inhabitants of Hirta, the main island in the St. Kilda archipelago, situated in the Outer Hebrides northwest of Scotland. Their nickname "bird people" originates from their habit of climbing over rocks to pick eggs and young birds of seagulls and puffins as their predominant food source and for trades good in St. Kilda's inhospitable climate and unpredictable weather. The St. Kilda people lived in isolation from the Scottish mainland, with hardly any contact with people on the mainland. When the conditions of living became unbearably difficult from diseases inflicted on them from visitors and from the fact that they were forced to base their way of living on money since the end of the 19th century, they abandoned the island in 1930 to live on the Scottish mainland [Rix 2012].

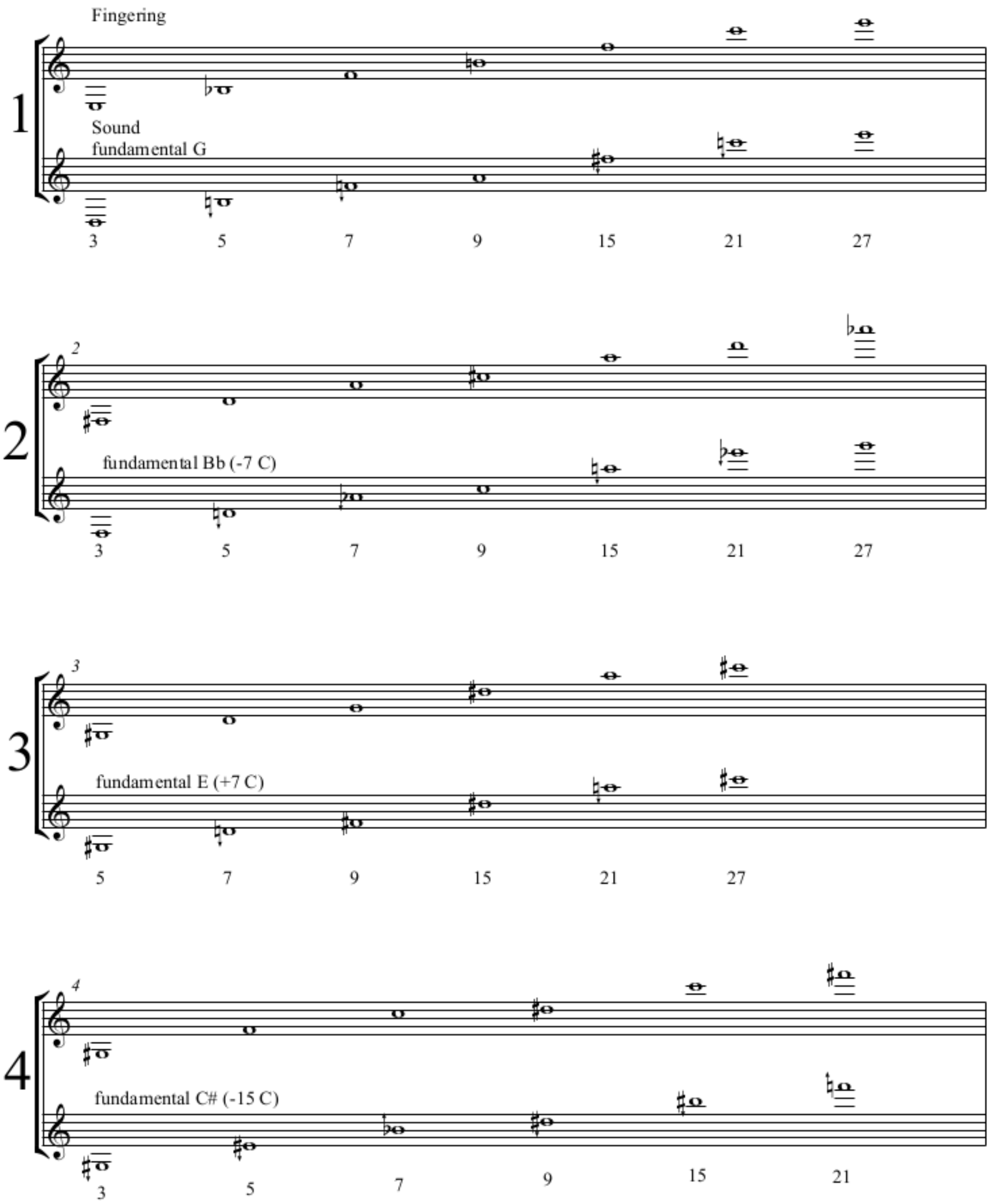



Figure 51: Stahnke's representation of pitch material in *Die Vogelmenschen von St. Kilda*. The score and composer's comment date from 2007, when MH notation had not yet been developed, and thus are based on eighth-tone and clarinet fingering notations.

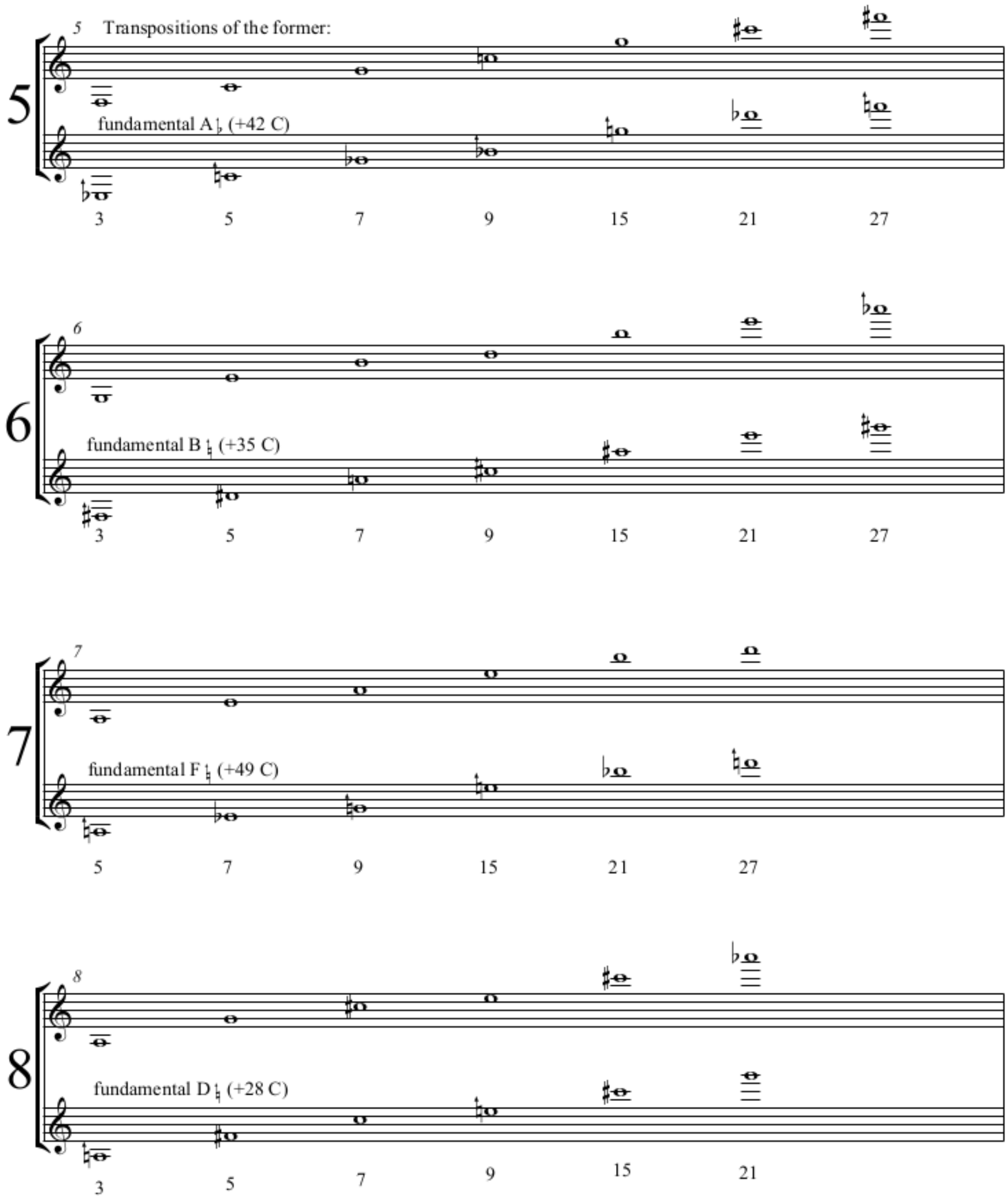



Figure 52: Pitch material in *Die Vogelmenschen von St. Kilda*.

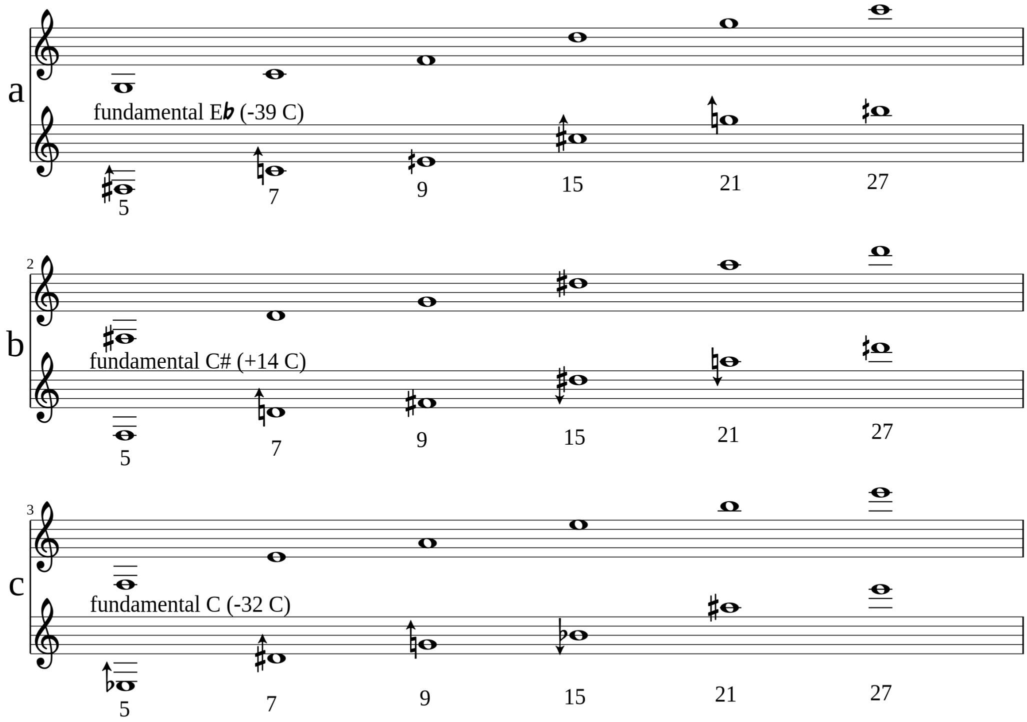



Figure 53: More pitch material used by Stahnke in *Die Vogelmenschen von St. Kilda*, not mentioned in the composer's comments about the composition.

### 6.2.2 Georg Hajdu: Beyond the Horizon

Georg Hajdu's composition *Beyond the Horizon* for two BP clarinets and synthesizer in BP (2007) can be seen as an introduction to the melodic and harmonic characteristics of the BP scale. Showcased are the BP scale, the 3/5/7 chord and a chord of BP 4ths and 3rds. Hajdu's motivation for this piece was "the purely hypothetical and philosophical question of what the world would look like, if it consisted only of odd numbers as it is the case with the clarinet spectrum."[51] Hajdu creates a synthesizer sound that perfectly matches the harmonic properties of the BP scale by the use of stretched spectra: the spectrum of the bell-like keyboard sound is adjusted in a way so that the harmonic series consists of only odd harmonics, matching the pitches of the BP scale.

After an introductory spoken text (an excerpt of a text written by cosmologists Lawrence M. Krauss and Robert J. Scherrer, *End of Cosmology?*) and a slow, low keyboard introduction in a space-like, spherical sound BP clarinet 1 plays the first theme of the composition (bars 13 -16).

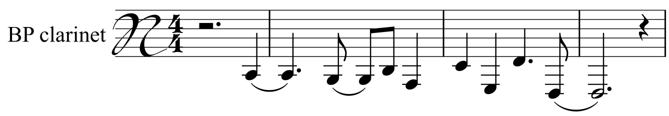



Figure 54: *Beyond the Horizon*, b. 13-16. This and the following excerpts of the piece have been transcribed into Müller-Hajdu notation by Nora-L. Müller.

The scale seems to be expanding from its starting note up and down, framing the interval of a BP 7th at the end of the phrase. To Western ears, this seventh raises expectations and requires resolution as it is an interval listeners are familiar with from the dominant chord of the seventh in Western music. When the second clarinet enters, the two clarinets creep up and down in a merging line, ending on a BP 8th, the "forbidden interval" (b. 19).

[51]Hajdu's program note to Beyond the Horizon, to be found on http://bohlen-pierce-conference.org/compositions/hajdu-beyond-the-horizon, last access: 30th July 2019

This may be seen, or merely heard, as an ear-opener to the first-time BP audience, due to its dissonant quality: an octave, or almost an octave – an octave which surprisingly seems to be so much out of tune that it cannot be used as a harmonic frame in this context, followed by a grand pause as if to give time to the listener to realise this dissonant, peculiar, almost idiosyncratic interval. The next phrase, in the contrary, goes straight up (first clarinet) and down (second clarinet) to achieve a tritave (b. 24). To complete the listener's transportation to the BP world, the BP wide triad is introduced in bars 25-26, showing not only its root position, but also its first and second inversion. At this moment, the audience has completed the trip from their usual musical planet to *Beyond the* (musical) *Horizon*. In the next part (b. 38-50), rapid arpeggios whirl up from the lowest register to altissimo notes speeding up the music as the universe is supposed to do in its expansion. The chords used here are built out of BP 3rds and 4ths, and used in a parallel movement. The two clarinets play these arpeggios in parallels of BP 3rds in their "edgy", slightly dissonant quality, doubled by the synthesizer. If any of the listeners have not been slingshot to a parallel musical universe yet, at this point the harmonic uniqueness of the BP scale becomes so obvious that everyone can hear the difference.

The piece culminates in BP scales, performed in virtuoso fashion, whirling up to the highest registers; the synthesizer supports the increasing density with fast clusters, rushing downwards from high registers into the depth with the clarinets (b. 60-72). Long, sustained *fortissimo* notes in the high registers of the two clarinets show some of those intervals that are familiar from 12div2, but differ slightly in BP, yielding strong combination tones when played in perfect intonation: BP 5ths, 7ths, 9th, 11th, 13th (b. 73-77). Even in this detail the composer stays with his concept of preliminary odd numbers in this new tonal world. After a second chase of scales (b. 84-86), the music calms down. While the second part of the above mentioned text is being spoken, pointing out that the time window of life and science is probably short, the two clarinets accompany with brittle multiphonics and *fluttertongue* effects to underline the fragility of life and universe; the synthesizer part moves back to a low register, similar to what it played in the beginning (b. 93-106).

Hajdu creates eleven minutes of exciting music, using the simplest compositional material. A large part of the peculiar charm of this piece is owed to the complex synthesizer sound, built from an artificial spectrum which perfectly matches the BP scale.

About the keyboard notation in Hajdu's original score of *Beyond the Horizon*: the notated c' in the keyboard part is mapped to the notated c' in BP clarinet notation and therefore a sounding c' +22 ct (U3). The a' (N4) consequently is located on the f"♯ key. To avoid confusion about notation, the given excerpts of the score have been transcribed into Müller-Hajdu notation by the author.


Figure 55: Georg Hajdu, *Beyond the Horizon*, b. 1-17 in Müller-Hajdu notation


Figure 56: Georg Hajdu, *Beyond the Horizon*, b. 18-29 in Müller-Hajdu notation

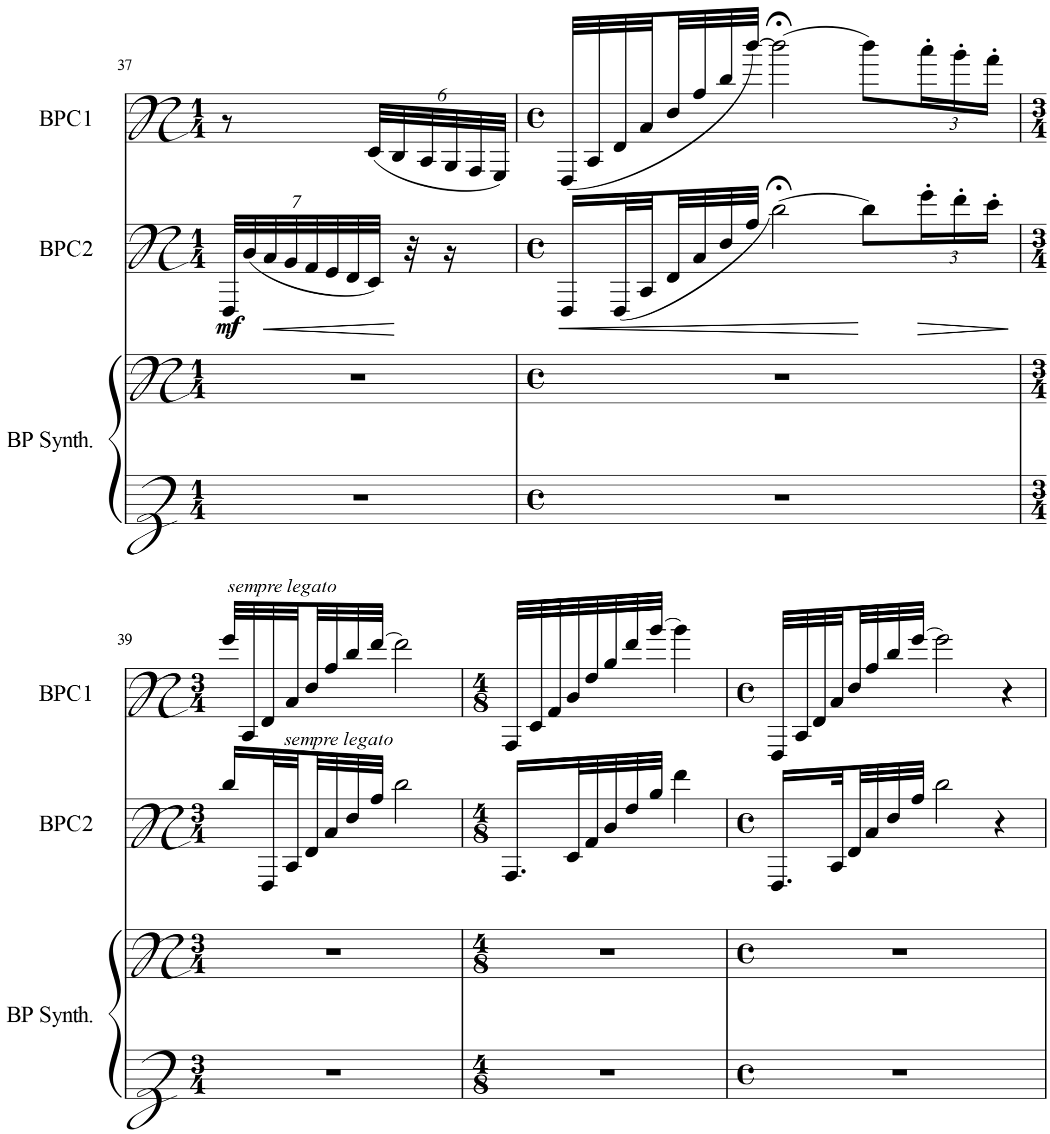



Figure 57: *Beyond the Horizon*, b. 37-41

### 6.2.3 Sascha Lemke: Pas de deux

The original score of *Pas de deux* dates the composition to 1997/98, which of course causes astonishment since this happens to be a mere decade before the first BP clarinets were released. Asked about this apparent "mistake" in an informal conversation, Lemke explained to me that one of the ideas behind the piece in fact dates back to 1997: the rhythmic air noises of the two clarinets in the beginning of the piece is an image of some sort of classic ballet or shadow dance etude without any "music", where no dancer is seen, but the sound of dancing feet and the two dancers' breathing can be heard. Given the opportunity to compose for these two different instruments, one of which had just been newly developed to play in a peculiar tuning system, Lemke creates music which makes good use of the clarinet's expressional range, including fluttertonguing, key noises and sporadic use of multiphonics. His natural approach to extended techniques may be owed to the fact that he is a woodwind (recorder) player himself. Lemke describes his concept in the pogram note:

> "*Pas de deux* combines the classical B♭ clarinet with a so-called Bohlen-Pierce clarinet. In contrast to the classical clarinet, which is designed for the usual chromatic scale, the Bohlen-Pierce clarinet also uses an equal scale, the steps of which are slightly smaller than a semitone plus a quarter tone. In *Pas de deux* I combine these two "chromatic" scales, mostly in the form of simultaneously descending lines. As the steps of the Bohlen-Pierce scale are slightly larger than the chromatic scale, the Bohlen-Pierce clarinet will descend faster than the traditional Clarinet. There are two lines that begin in unison, then diverge and eventually move towards each other again. I have supplemented these intervals with additional difference and summation tones to form strange chords. In addition to these chords, the deliberate beatings between almost identical notes of the two instruments also

> play a role, as does the opposite, namely pure overtone arpeggios."[52]

The piece starts with very quiet but lively hissing and swooshing noises. Now and then, an extremly high, short and quiet note pops out, first every few bars, then more and more often, creating an ascending line which gets denser by the time, and more and more recognizable both rhythmically and melodically. Pitches which are in unison or almost-unison between the two scales are held as long notes, featuring the beatings between them, enhanced by electronic effects such as perforation. Todd Harrop offers a detailed analysis of the opening part (b. 1-60) of *Pas de deux* [Harrop 2017].

He compares the pitches of both clarinets, transcribed into concert pitch (fig. 58). In the staff under the normal chromatic scale of the B♭ clarinet he notates the BP pitches in eighth-tone notation including cents deviations from regular chromatic pitches. It becomes clear that Lemke interweaves the scales of the two clarinets into a very peculiar, microtonal "hyper-scale". Some of the notes are marked with asterisks. Those are the ones that sound either in a longer, perfect unison of the two clarinets (e"', a' and d) or almost in unison with a deviation of only few cents so as to create the "deliberate beatings" mentioned in the program note.

In the following section, *Presto luminoso*, b. 62-73, electronic, cluster-like chords form a contrast to fast descending scales of the clarinets, to which a long delay effect is added, creating a kind of twittering. As in the beginning of the piece, a separate, descending microtonal scale is present, artfully interwoven with the runs which are by short extra-pitches. The descending line happens only in the middle registers of the clarinet and not, as before, covering the full pitch ranges of both clarinets.

The climax of the composition (b. 74-89) consists of arpeggiated clarinet chords which are electronically processed in such a manner that the strangeness of the given chords is underlined by extra peculiar sound colours.

[52] http://saschalinolemke.de/, last accessed: 1st September 2019

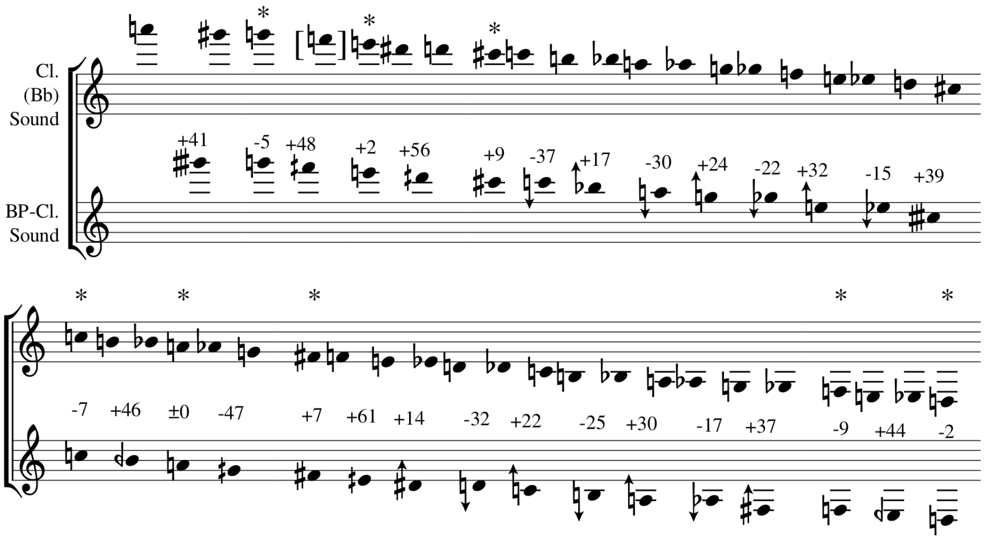



Figure 58: Descending lines of the two clarinets in Lemke's *Pas de deux.* Both parts are transcribed into concert pitch and show the microtonal hyper-scale which results from intertwining the traditional chromatic scale with the BP scale. Graphic by Todd Harrop.

In the closing section from b. 146 on, the piece returns to its own beginning in a kind of "reprise": hissing and swooshing noises, both live from the clarinets and electronically added, thereby creating an especially dense texture. As in the beginning, short and silent high notes show up now and then, but this time the microtonal scale goes upwards. The perceived effect is that the piece goes "backwards", and it ends on a long high note in a vibrantly beating almost-unison of the two clarinets.

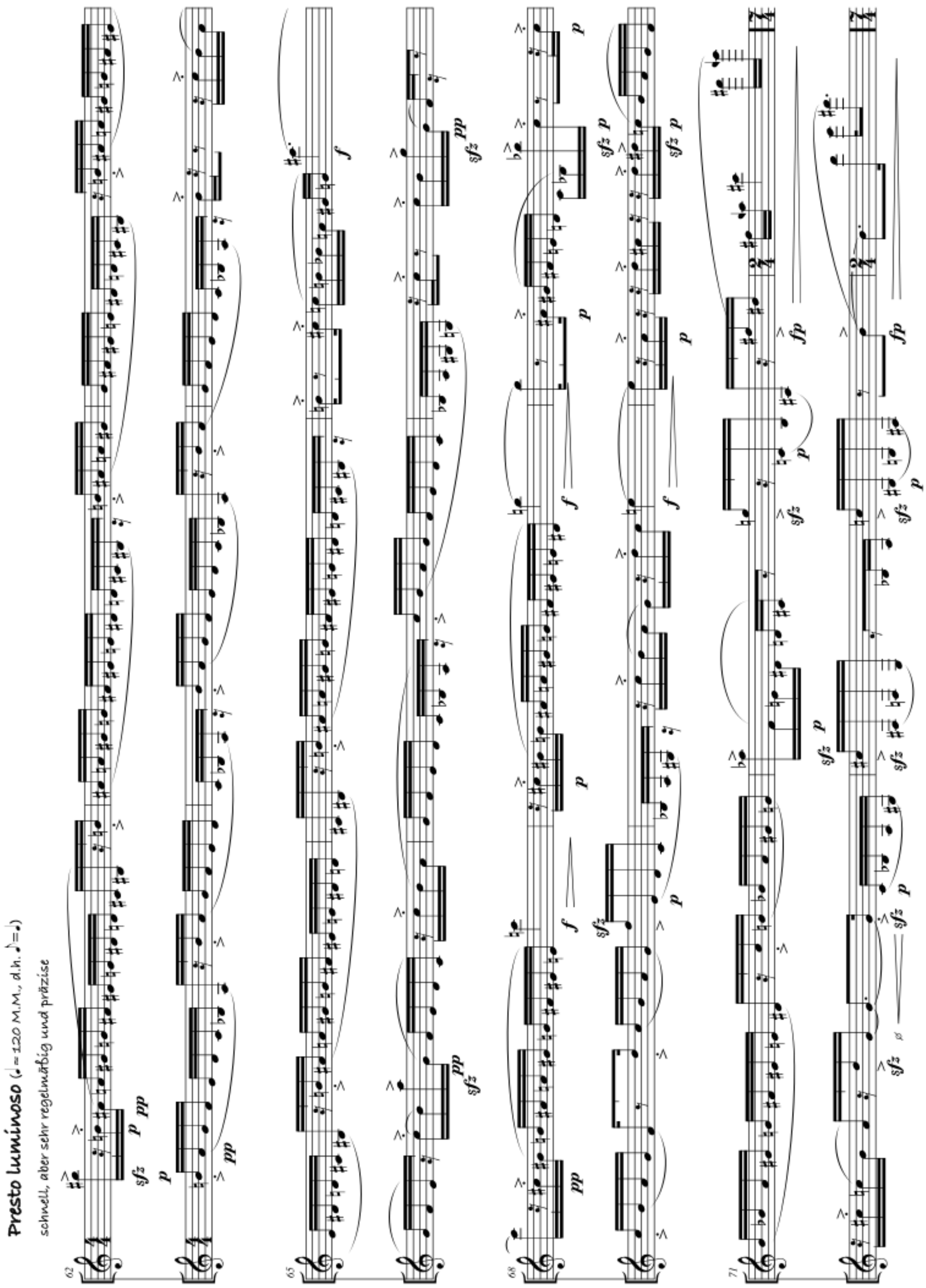



Figure 59: Sascha Lino Lemke, *Pas de deux*, clarinet parts, b. 62-73

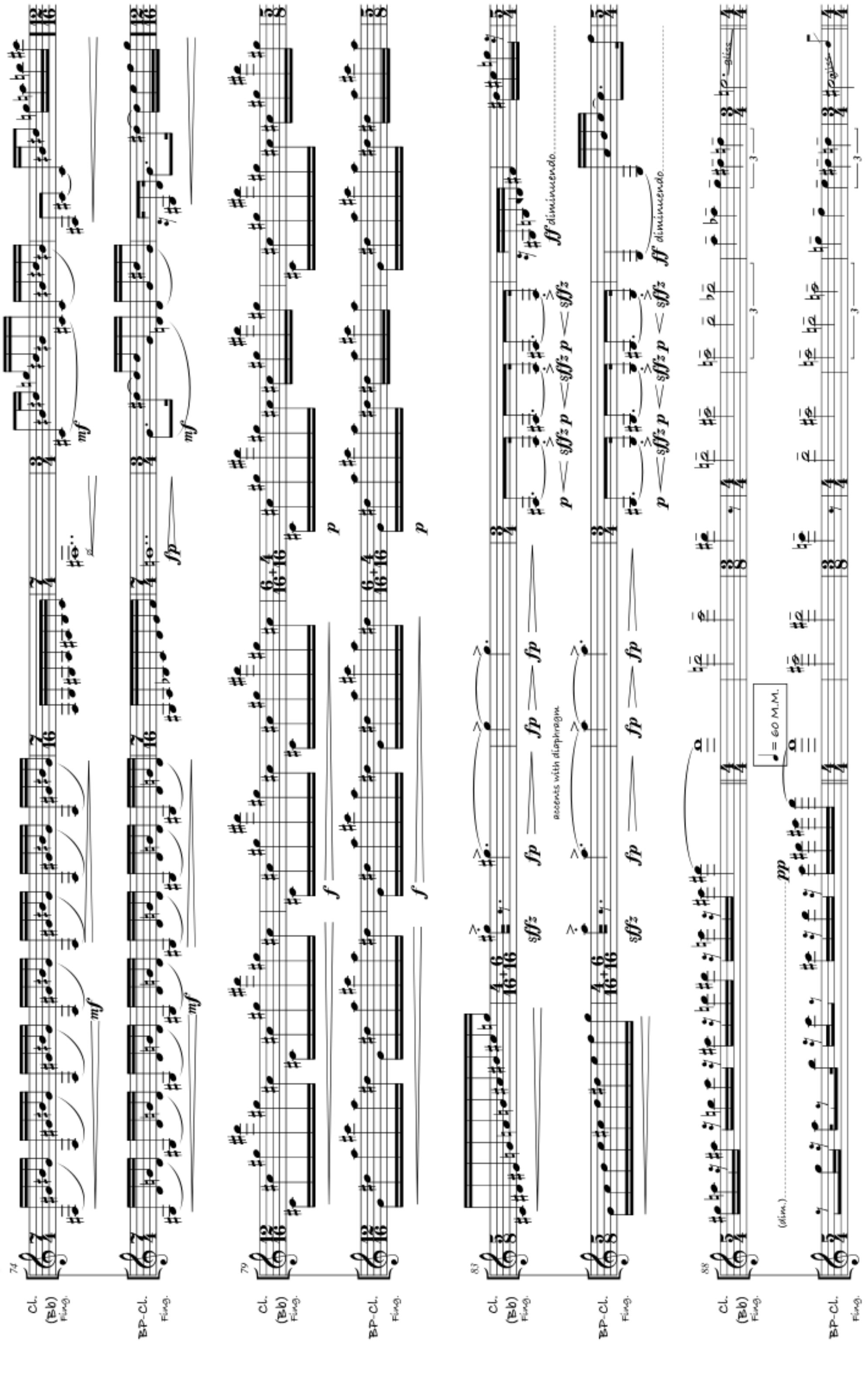



Figure 60: Sascha Lino Lemke, *Pas de deux*, clarinet parts, b. 74-95

### 6.2.4 Fredrik Schwenk: Night Hawks

> "Conceived for Bohlen-Pierce clarinet and B♭ clarinet, continues in principle the piece *Folsom Street* for alto flute and knocking sounds from 1994, at least in its atmosphere. In both cases, short developing motivic elements represent the dark and shady wastelands of abandoned industrial terrains as we know them from the film *Stalker* by Andrej Tarkowsky. In *Night Hawks*, the light spheres of dim, sooty gas lanterns gutter by way of the intonation of the two clarinets, playing in different tunings. With agitated gestures reminiscent of a dancing dervish, suddenly an argument breaks out as if two moths were competing for the favor of the sordid light.
>
> The harmonic basis for the composition are two 'whole-tone scales': one in the 12-tone equal tempered system, i.e. six whole-tone steps, and the other in the sense of the tuning developed by Bohlen-Pierce, whose steps are a quarter-tone shy of the whole step. Hereby, the piece always starts and falls back onto common, minimally deviant tones just to start rasping again in terms of intonation."[53]

*Night Hawks - dark scene for two clarinets* by Fredrik Schwenk is a duo for BP clarinet and B♭ clarinet. As the compositional material Schwenk chooses the BP scale vs. a traditional whole-tone scale and sticks to this material throughout the piece. A pulsating, heartbeat-like rhythmic motive is always present, except in the lyrical middle part. The piece starts with both clarinets in the lowest register only: the B♭ clarinet part stays in the lowest octave of the instrument, and the BP clarinet stays in the range of its lowest BP 6th. An exception are only the grace notes in both parts (a'/N4) which enter the scene for the first time in bar 11. A short "breakout" from this lowest BP 6th in this very beginning of the piece only happens in bar 37 by expanding to a BP 9th for a moment. The two clarinets take turns in playing a run and

[53]Program note by Fredrik Schwenk, to be found on http://bohlen-pierce-conference.org/compositions/schwenk-night-hawks, last access: 6th August 2019

a long tremolo. The tremolo is the same for both clarinets, a minor third / BP 2nd footing on the lowest note, a sounding d/N3.

From bar 49 onwards the range of the runs expands *peu a peu* to a higher register; the shakes vary regarding their pitches.

In bars 85-96 the piece culminates: both clarinets play in a very high register, loudly and in a virtuoso fashion, which leads to the effect of flickering combination tones. The pulsating rhythmic "heartbeat" motive is still present, while both clarinets restlessly play runs through all registers, emphasising the highest notes, a notated c"" (sounding b♭"') in the B♭ clarinet and a notated a♭"' (sounding a♭ +40c) in the BP clarinet. In bar 120 the piece calms down and comes to rest in the lowest register, followed by a slow, silent lyrical part (b. 121-162) composed of long notes. Harrop offers an in-depth analysis of this part of the composition [Harrop 2017] and points out, beside the symmetric echoing character between the two voices, that the harmonic structure here is unique since it is based on drone notes, some of which are chosen so that they are not contained in the respective other scale. Consequently, the dyads heard are neither part of the 12div2 nor of the BP scale, giving this part a peculiar harmonic flavour.

Bars 163-186 form a "backwards reprise": trills, runs in the lowest register, a pulsating motive as in the beginning, fading out in a decrescendo al niente, as if one were falling asleep and waking up the next morning, not remembering anything.


Figure 61: Fredrik Schwenk, *Night Hawks*,b. 1-14. Both clarinet parts are notated in concert pitch, transcribed by Nora-L. Müller.


Figure 62: Fredrik Schwenk, *Night Hawks*, b. 15-22, transcribed to concert pitch

### 6.2.5 Peter Michael Hamel: Umkehrung der Mitte

*Umkehrung der Mitte* by Peter Michael Hamel is a composition for 2 Bohlen-Pierce clarinets, viola, marimba and vibraphone.

His knowledge about and experience in musical styles from all over the world gives inspiration to Peter Michael Hamel's works. He draws from a well of performance and improvisation techniques as well as his own research in music and sociology (e.g. P.M. Hamel, *Durch Musik zum Selbst*, 1976). In *Umkehrung der Mitte (Reversing the Centre)* Hamel resorts to musical forms of Indian raga music.[54] The piece starts on a unison sound of a' (N4) for all four performers. Viola and marimba/vibraphone sustain this note throughout the first part of the piece, taking turns in their tremolo.

NB: In his autograph Hamel notated the BP clarinets in fingering notation. For the comfort of the reader, the score has been transcribed to concert pitch notation using eighth-tone accidentals for the BP pitches. Towards the end of the first part (b. 31-36) they move up to N5 (vibraphone) and down to N3 (viola, respectively). The clarinets, meanwhile, introduce the tonal material note by note, following the North-Indian Alap style, as Hamel explains in his program note to the piece. Starting from N4, all BP pitches up to V4 (a" -30 cents; clarinet 1) and down to S3 (a +30 cents; clarinet 2) come into the game, the second clarinet mirroring the first clarinet one bar

[54]Program note by P. M. Hamel:

"Drei Basistöne scheinen diatonisch dem 'alten' System nah und etwa am Klavier spielbar: das kleine d, tiefster Ton D der Bratsche, tiefstes D auf der Marimba – das hohe e, zweithöchster Ton auf dem Vibraphon. Alles ist vom sogenannten Kammerton A aus nach oben und unten gespreizt/gespiegelt. Das (...) klingend[e] a als Mitte. Entfaltung der Tonschritte wie im (nord-)indischen Ragavortrag (Alap), Umkehrung der auf- und absteigenden Phrasen. Der Mittelteil als ein heterogenes Gewebe. Der dritte Teil als Rekurs und formale Umkehrung: Aufstülpung des gespiegelten Raumes."

English translation:

"Three basic tones seem diatonically close to the 'old' system and playable on the piano, for example: the lowest D on the viola, lowest D on the marimba - the high e, second highest tone on the vibraphone. Everything is spread upwards and downwards/mirrored from the so-called *Kammerton* A440. (...) The sounding A forms the center.

Development of the pitch steps as in the (northern) Indian raga performance (Alap), reversal of the ascending and descending phrases. The middle part is woven heterogeneously. The third part as a recurrence and formal reversal: turning the mirrored space inside out."


Figure 63: Peter Michael Hamel, *Umkehrung der Mitte*, b. 10-18

apart, so that in b. 23 the "non-octave" is featured by all four instruments, vibraphone and viola still sustaining N4/a', the viola adding the 5/7 BP 4th below. Despite using a very different approach, Hamel comes to a similar musical idea as Hajdu does in *Beyond the Horizon*, slowly spinning out the BP pitches and at one point making the twist of the BP non-octave (i.e. the BP 8th) obvious for the audience. In b. 23-36 the ambitus of the two clarinets is spread out downwards, reaching N3 and ending the section in a double tritave sound (N3-N4-N5) of all four instruments.

The following section (b. 37-56) is a conversation between viola and vibraphone in the conventional 12div2 tuning, sporting tiny motifs of not more than a few notes. The time signature changes from a generous 4/2 of the initial section to a "rugged", unequal 5/8, letting the rhythmic component dominate the whole section, instead of a melodic flow as was the case before.


Figure 64: Peter Michael Hamel, *Umkehrung der Mitte*, b. 19-23

This idea can be characterised as a kind of *jor* or *jhala* in Indian raga music, and again shows Hamel's affection for this style.

The melodic aspect steps more and more into the background, until in b. 51 the melody is totally static: b' - a' sextuplet tremolo in vibraphone versus g' - a' in the viola part, resulting in a g-a-b mini "cluster", opening up to an f♯ minor sextuplet tremolo. The two clarinets re-enter in b. 58/60. While viola and mallets step back to their original a'/N4 tremolo, the clarinets develop a similar duo game as their counterparts have done before, but playing in BP tuning.

The last section from b. 73 onwards returns to 4/2 time signature and recalls the character and form of the beginning of the piece. In b. 89/90 the first clarinet achieves N5, while the second clarinet descends to N3. Viola and


Figure 65: Peter Michael Hamel, *Umkehrung der Mitte*, b. 28-36

vibraphone join in. This final double tritave sound is sustained and played upon for several bars, again giving the ending an Indian touch by remaining on the drone pitch for a relatively long time.

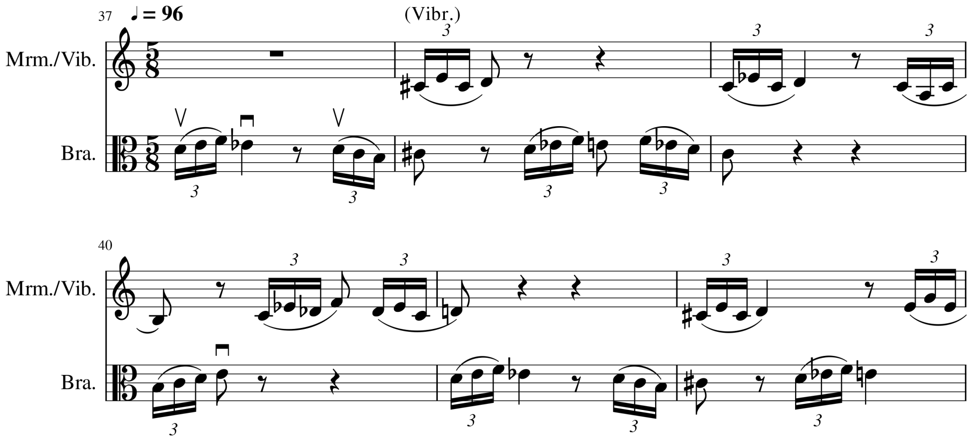



Figure 66: Peter Michael Hamel, *Umkehrung der Mitte*, b. 37-42


Figure 67: Peter Michael Hamel, *Umkehrung der Mitte*, b. 54-61


Figure 68: Peter Michael Hamel, *Umkehrung der Mitte*, b. 88-97

### 6.2.6 Todd Harrop: Bird of Janus

*Bird of Janus* for BP clarinet solo (2012) refers to the ancient Roman god who presides over beginnings and passages, with one face gazing at the past and the other peering into the future. The composition uses two modern tuning systems, Bohlen-Pierce and Carlos Alpha, and modulates between them via tones around an imperfect octave which they have in common. The work concludes with a rhythmic tiling canon, a 21st century technique which alludes to the ars nova of the 14th century[55].

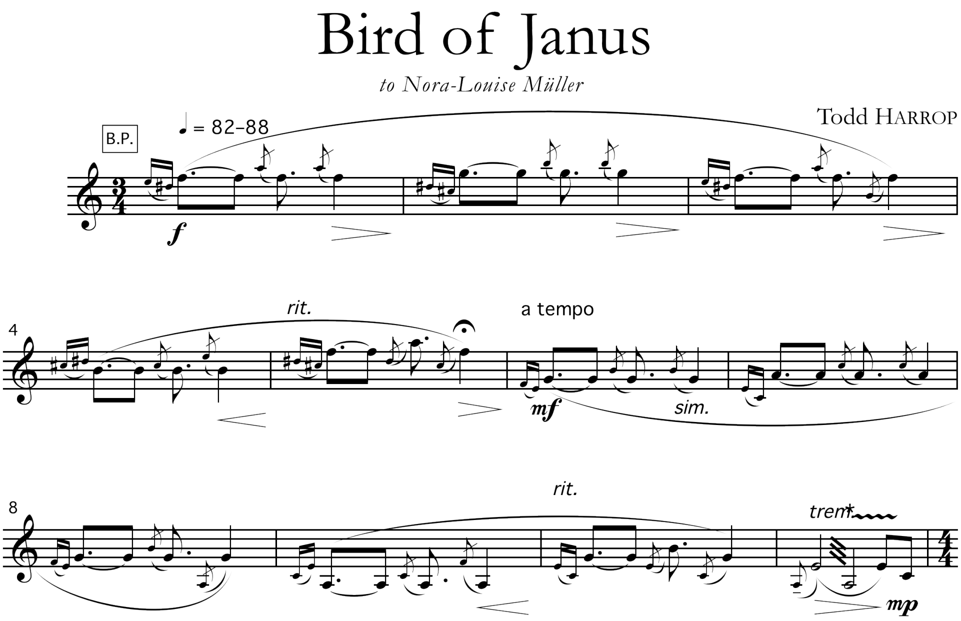



Figure 69: Todd Harrop, *Bird of Janus*, b. 1-11

The composition process of *Bird of Janus* was cumbersome. Harrop had found that the BP scale and the Carlos Alpha scale[56] share a characteristic interval, the non-octave / BP 8th of 1170 cent (interval ratio 25/49). This fueled his interest, and he developed a concept to combine the two scales in a

[55]Harrop: program note to *Bird of Janus*

[56]9div3/2, i.e. the perfect fifth divided into nine steps as proposed by Wendy Carlos in 1986. The resulting step size is 78c.

piece. He asked the author if she could figure out how to play the Carlos Alpha scale on the BP clarinet. She succeeded in a satisfactory manner, using c' = 261 Hz as a root note. (Using a'/N4 = 440 Hz as a reference note proved to be more complicated.) It was possible to play most notes of the Carlos Alpha scale by the use of special fingerings; sometimes embouchure corrections were necessary; the 11th scale step of 858 cents needed the tongue put on the reed to make the note flatter. This scale degree is close to a'/N4 but significantly flatter, and since this note is not flexible regarding intonation it had to be corrected in this unusual (and uncomfortable) way. The sound quality differed from tone to tone; some tones had a good sound quality with easy fingering, others sounded muffled or noisy and had very complicated fingerings. During the cooperation between Harrop and Müller in the composition process, more and more difficulties regarding practicability of the Carlos Alpha (CA) scale on BP clarinet turned up, so that Harrop had to modify the CA parts of the piece several times. From the composer's point of view, notation was a big practical issue, although Harrop had already been experienced in composing for BP clarinets (*Calypso*, 2008; *Der Zauberzephir*, 2011). Notating both scales, BP and CA in a way that supported the composer's work was difficult. Müller-Hajdu notation was still in development and not in practical use yet; Harrop was using a MIDI keyboard in the composition process and thus used keyboard notation. The transcription of the music to BP clarinet notation turned out to be hard work, especially regarding the Carlos Alpha parts.

Harrop makes extensive use of the dissonant BP 8th (25/49). He uses it as a frame for scales and as an interval of transposition, just as the octave is used in octave-based music.Thus, the BP 8th in this context is referred to as a "non-octave".

Bars 1-20 represent the BP scale. Bars 1-5 and 6-11 each consist of the same pitch material, but in non-octave distance. The pitch material covers the range of eight BP steps or a non-octave.

Bars 12-20 use a combination of both scales, mostly in the original pitch, some in tritave transposition. In b. 20, the notated e" (sounding e" +32 c) functions as a pivot point between the two scales: at this note, a common

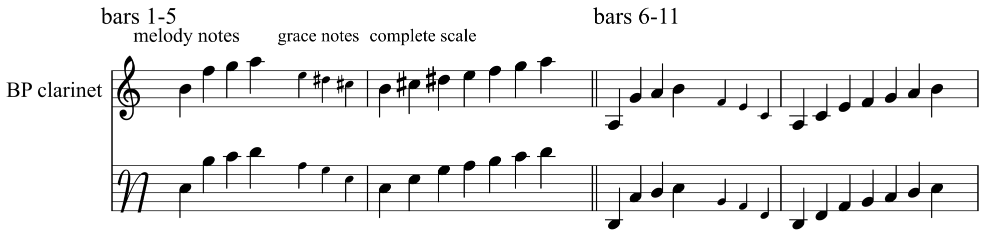



Figure 70: BP scales in *Bird of Janus* by Todd Harrop

pitch between the BP and Carlos Alpha scales, the music switches to Carlos Alpha. The other "pivot note" where the switches back to BP in bar 24 is the notated f' (f' -39 c).


Figure 71: Todd Harrop, *Bird of Janus*, b. 12-24

T. 71-82: In this part, Harrop uses a rhythmic tiling canon, a complex rhythmic structure with strong mathematical aspects: all three voices of the tiling canon – high, middle and low – have the same rhythmic structure but are augmented by factor 2 (high voice), 3 (middle voice) or 4 (low voice). A tiling canon requires a rhythmic pattern and augmentation such that no two notes sound at the same time. In notation example in fig. 72 the rhythmic structure of the tiling canon is shown in Müller-Hajdu notation, the three voices split up to three staves. In the original score, the clarinet part is notated in one staff throughout, in clarinet fingering notation, as can be seen in fig. 73.

Figure 72: Todd Harrop, *Bird of Janus*, b. 71-76, tiling canon, transcribed to three parts and to Müller-Hajdu notation

The piece ends by a short recall of both Carlos Alpha and BP scales. In the last four bars (86-90, fig. 72) the clarinet makes tremolos and fluttering noises, as if the bird were flying away.

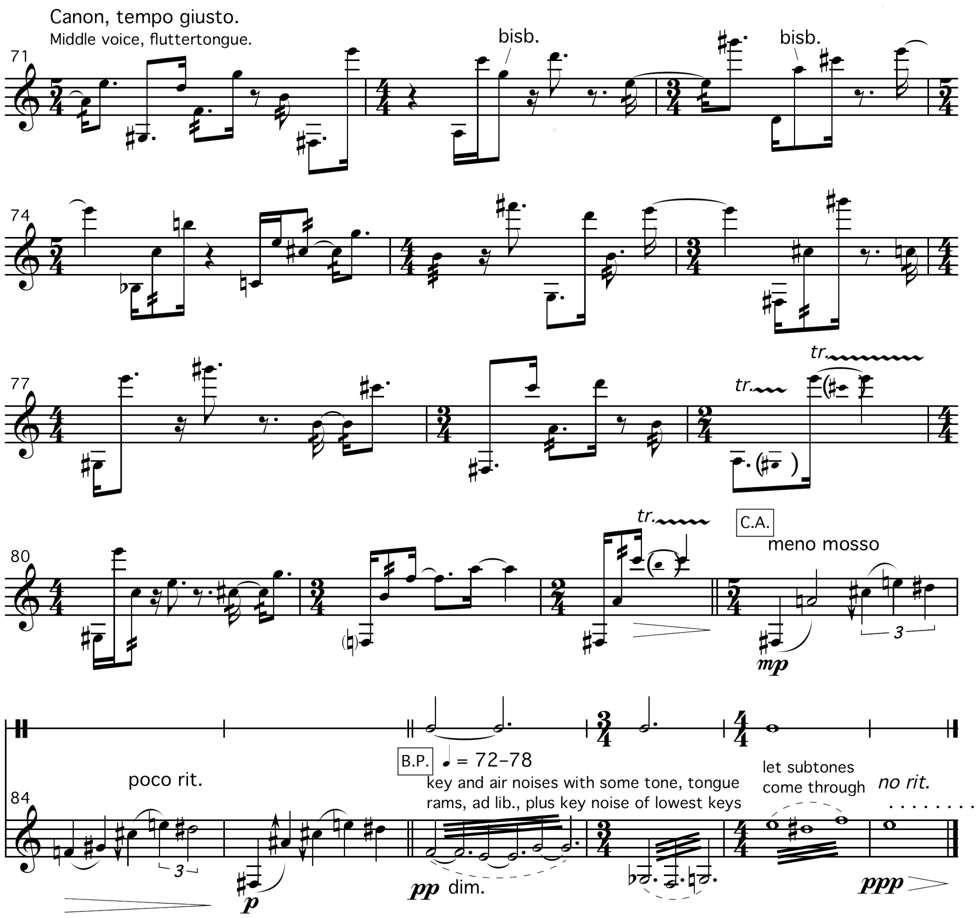



Figure 73: Todd Harrop, *Bird of Janus*, b. 71-90

### 6.2.7 Benjamin Helmer: Preludio e Passacaglia

In *Preludio e Passacaglia* (2015) for BP tenor clarinet, viola, kalimba and guitar (41div2) Benjamin Helmer combines his interest in ancient musical forms with the novel tonality of the BP scale. Wondering what a "hard-hitting collision of the ancient form with the new world of BP could look like – an almost child-like, naive question"[57], Helmer creates a tonal composition which could be defined as N minor, due to the finalis chord on the piece's main note N plus a BP 2nd.

As one of the first composers, Helmer consistently uses Müller-Hajdu notation for all instruments except the Kalimba part. Tenor clarinet and viola are notated in U clef, while the guitar part is notated in two systems featuring N and Z clefs. The notation of the kalimba is shown in figure 74.

A Hugh Tracey alto kalimba with nine tines, retuned to BP has been used since the premiere of the piece.The middle tine of the kalimba, the longest one, is notated on the middle line of the staff in alto clef. It is a sounding U3. The tines right from the middle one are notated above the middle line; the ones left from the middle below, accordingly. This results in a kind of tabulature notation, easy to read for the kalimba player. The original score, though, uses a traditional alto clef for the kalimba part which might be misleading in this context.

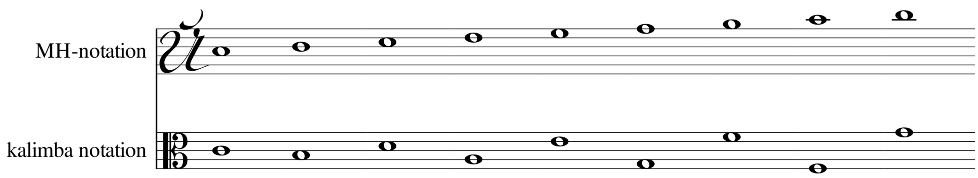



Figure 74: Kalimba notation in *Preludio e Passacaglia* by Helmer. The kalimba part is notated in tabulature, but uses a traditional alto clef which might be misleading in this context.

Helmer makes use of BP microtonality, in this case BP fifth tones, because he felt that the BP scale lacks steps of smaller sizes, but he wanted leading

[57]Email from Benjamin Helmer, 12th October 2017

tones in his melodies. Fortunately, guitarist Melle Weijters (Amsterdam) was involved in the project for which the piece was composed, and he played a 41-tone electric guitar (i.e. 41 tones per octave). BP can be played on this instrument as a subset: playing every fifth step results in the BP scale. The original 41 tone steps, on the other hand, can be defined and notated as BP fifth tones in this context. Helmer gladly took the occasion to use these BP microsteps.

**Preludio** The *Preludio* starts with a unison N, determining the tonic of the two movements. Helmer follows tradition and uses the same tonic for both *Preludio* and *Passacagalia.* The subject of the *Preludio* first appears in b. 1-3 of the viola part, a cross motif in BP fifth tones which can be considered a *pathopoeia*[58], due to the use of those very small-scale "chromatic" steps.

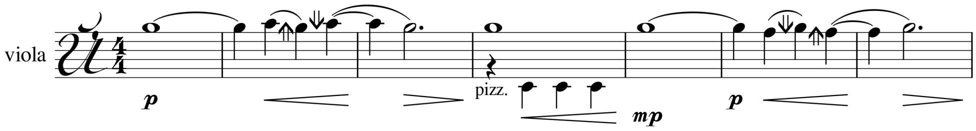



Figure 75: Bars 1-7 of the viola part, representing the cross motif and its inversion. Arrow symbols with two stems indicate two BP fifth steps up or down, respectively. (One BP fifth step = ca. 30 cents, two steps = ca. 60 cents.)

The same motif is played by the guitar, shifted by one bar, and in b. 5-8 returns as an inversion in both instruments. The "knocking" motif, shown as a tone repetition of quarter notes in pizzicato notes in b. 4, i.e., occurs in both parts and is later (b. 13, 16) imitated by the kalimba. The BP tenor clarinet remains accompanimental. In b. 15 the cross motif appears one more time before the Preludio ends on a chord made from the pitches T – Q – W – N – O. In the centre of this chord are the notes Q – W – N, a BP wide triad, framed by the dissonant interval T – O (BP fifth and eighth resp.), a slightly unstable chord of open character which can be interpreted as a

[58]Pathpopeia, a rhetoric figure in music which expresses grief and pain by the use of chromatic steps with accidentals.

kind of *Halbschluss* (imperfect cadence), leading the way into the following *Passacaglia*, which again starts on the note N – and in the key of N.

**Passacaglia** In 19th and 20th century music, a passacaglia is "a set of ground-bass or ostinato variations, usually of a serious character" [Silbiger 2017]. Most of the time, a passacaglia is a composition in a minor key. Helmer uses a simple four-bar ostinato in the guitar which is being ornamented and varied in the course of the piece (figure 76).

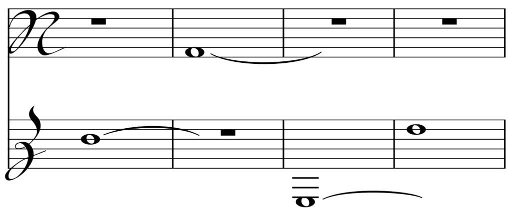


Figure 76: Four-bar ostinato of Passacaglia

The ostinato (b. 18-21) consists of the notes N3 – W3 – N2 – P3 and is repeated two times as is, before a subtle metamorphosis starts in the 3rd and 4th cycle: the N2 is alternated microtonally and appears a 1/5 BP step (about 30 cents) higher in bar 28; during the next cycle, in bar 32, it is sharpened by another 1/5 step. The notated O -2/5 in b. 36 is an enharmonic of N +3/5; the following P (b. 37) is alternated by -2/5 BP steps. These minimal changes may be perceivable only by the most attentive listeners. Greater variations of the bass line happen from b. 38 onwards (6th cycle of the bass line). While the original note of the bass line appears on the first downbeat of each bar – though often microtonally alternated, so as if wandering about – rhythmical changes, melodic ornamentations and an increase of harmonic density are added. All of the original pitches of the bass line move in microtonal ranges during the course of the piece; the N2 as the third original note, however, goes through greater pitch changes toward the middle of the movement. While its metamorphosis starts in small 1/5 tone steps, it leaps higher and higher by the time until appearing in b. 59/60 as an early downbeat on N4. This happens in the 11th cycle of the bass line.

After this point, it regularly stands on its original position as an N2 on the downbeat of the third bar, while the whole bass line gradually returns from a rhythmically vivid, ornamented form to a very plain form, similar to the beginning. The 15th cycle (b. 75-79) is stretched to a five bar phrase by lengthening the P. The piece ends with the 20th bass line cycle.


Figure 77: Benjamin Helmer, *Preludio e Passacaglia*, b. 26-33

Characteristic for the guitar part are microtonal passages in BP 1/5 steps between the ostinato tones which appear from b. 46 (6th cycle) onwards. It could be interpreted in the sense of a *Passus duriusculus*, a chromatic passage which in the baroque era symbolised sorrow and grief. It is repeatedly imitated by the viola, thereof only twice in the form of an ascending line. The fifth-tone steps are a character connection between guitar and viola, which in turn is oriented more towards the clarinet regarding themes.

The sequenced clarinet theme in b. 42-49 is imitated by the viola at a distance of two bars. The two parts intertwine so that the theme (most obvious motif here: the quarter note triplet) appears four times in total, sequencing one or two BP steps upwards each time. In addition, there is the guitar, which on the first beat of bars 42-45 plays quarter note triplets. This broken triad thus appears eight times in total, six of them as BP Wide Triad (3/5/7). (The second time in the guitar (b. 43) it is 3/5/5, repeating the middle note and omitting the upper one. This is simply due to technical issues in Melle Weijters's 41-tone guitar which is a very challenging instrument to play.)

Descending thirty-second note runs in viola (b. 62-63) and clarinet (b. 70-71) are a feature of the middle section, alongside the percussive use of the kalimba, which is played by knocking (with knuckles or a mallet) on the back of the instrument. Hereby the kalimba joins the guitar in the syncopated sixteenth notes. This marks the climax of the piece (b. 65-74) with the highest rhythmic density and relatively high pitches in the clarinet part. When the piece calms down at its very end in favour of longer tones, the kalimba (b. 86-92) plays a rhythmic diminution of the short clarinet motif of b. 29-34. The final sounds are N3 in the guitar and N4 in the viola and kalimba, as was in the beginning of the piece, with the tenor clarinet adding a P3. This creates a kind of final chord in "N minor" since the tritave N3 – N4 can be perceived as a pure fifth an octave apart, interpreting the sound in a context of octave-based music, with P3 as an additional minor third, as Helmer confirms:

> "N-Moll, genau! Vielleicht ist das ein wenig frech gewesen, auf einmal in Moll zu landen, obwohl wir nicht mehr in 12EDO sind, andererseits ist es eine klare Assoziation meiner Ohren: Die Tritave ist äußerst dominant, ebenso die BP-Terz, die man sich (man = ich in dem Fall) sehr schnell als unsere Mollterz zurechthört."[59]

[59]Personal email from Benjamin Helmer, 12th October 2017. English translation: "N minor, exactly! Maybe it was a bit cheeky to suddenly land in a minor key, although we are no longer in 12EDO, on the other hand it is a clear association of my ears: The tritave is extremely dominant, as well as the BP 3rd, which one (one = me in that case) can very quickly be identified as our minor third."


Figure 78: Benjamin Helmer, *Preludio e Passacaglia*, b. 65-66


Figure 79: Benjamin Helmer, *Preludio e Passacaglia*, b. 67-70


Figure 80: Benjamin Helmer, *Preludio e Passacaglia*, b. 71-75

### 6.2.8 Georg Hajdu: Burning Petrol

*Burning Petrol* is an arrangement of Scriabin's piano piece *Vers la flamme*, for three BP clarinets (soprano, soprano, tenor), BP guitar, double bass, keyboard, kalimba / tam-tam (one player) (2014).

The compositions of Alexandr Scriabin (1871/72-1915) still sound very fresh even to the contemporary ear. His music hardly fits into analytical concepts of keys and major/minor triads. Instead, Scriabin develops his personal harmonic language, with his famous *mystic chord* (also referred to as *Prometheus chord*) giving flavour to a huge part of his oeuvre.

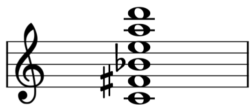


Figure 81: Mystic chord from bottom to top: tritone – maj3 (dim 4) – tritone – 4th – 4th

The many attempts to interpret the mystic chord include the association with higher tones of the harmonic series. Russian musicologist Leonid Sabaneyev for instance, a close friend of Scriabin, interprets the chord as a representation of notes 8-14 of the harmonic overtone series [Sabaneyev 1927]. This interpretation inspired Hajdu to have a closer look at the works of Scriabin in terms of BP harmony. He found that harmonics 8-14 are represented by BP intervals with a considerably better approximation than in 12-tone equal temperament [Hajdu 2015].

In *Vers la flamme* (1914), the mystic chord can be found for the first time in b. 19 with a low B♭ as the bass tone.

The first impression when listening to the original *Vers la flamme* is that of a soft, mellow piece in character of a minor key. The soft chords are held over a long time and are repeated often. There is almost nothing which could count as a melody; the only melodic motif in *Vers la flamme* is a short, fanfare-like two-note motif, moving downwards by a half-tone step, and its expansion which returns as an idée fixe throughout the piece. Soon the

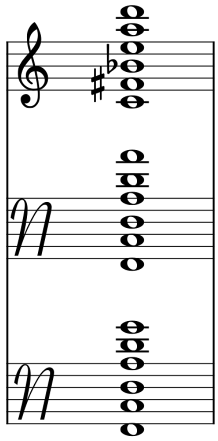


Figure 82: Scriabin‘s mystic chord as written in b. 19 of *Vers la flamme* (top); representation of the same chord in BP (center); Hajdu slightly modifies the chord structure in order to match the BP scale better: he chooses two BP3rds as the top two intervals instead of the two pure 4ths of the original chord.

magic of Scriabin's music appears: from b. 41 onwards the piece lives of an overlap of metrics, giving the music a complex texture. The most dominant of these layers is a kind of fast tremolo in the middle range of this (from b. 77 onwards), and it may be associated with the radiant tongues of fire.

With *Burning Petrol* Hajdu offers a unique arrangement of *Vers la flamme*. Many of the chords Scriabin uses contain tritones, minor sevenths and ninths, all of which are intervals that find smooth reprentations in the BP system. Despite the similarity of Scriabin‘s harmonies to the BP universe, he still composes within the octave-based 12-tone system, which makes adaptions necessary when transcribing the composition to BP [Hajdu 2015].

Hajdu's instrumentation is unusual, but on the other hand goes with what instruments and musicians were available at the time of the premiere in early 2015: three BP clarinets (two sopranos and one tenor), electric guitar (to be more specific, Melle Weijters and his 41-tone guitar), kalimba and tamtam (one player), keyboard, and double bass. The three clarinets play a central role in the arrangement. They are assigned to play the sparse melodic motifs which the original composition provides. The kalimba enters in bar 77, representing the flickering flames as Scriabin writes them in the middle of the pitch range. The double bass creates the harmonic fundamental by playing preferably long tones. Tasks of the guitar are to double the second and third clarinets at times (b. 41-69 and 81-94), as well as adding sustained harmonies, e.g. b. 23f. and 70f. Please note the BP wide triad in b. 72! The keyboard serves as a harmony instrument playing low sustained chords throughout the piece. Later on, beginning in b. 101 the keyboard is assigned the high repetitive chords which appear more and more frequently towards the end of the piece.

*Vers la flamme* ends with an ascending chord from the lowest to a very high register, covering almost the entire pitch range of the piano from E/,E through c””♯. This chord can be interpreted as Emaj ♯7 ♯11 ♯13. Hajdu, on the other hand, decides to transfer the chord into a narrower form by omitting the bass note, thereby starting on Y1. The effect, though, is surprisingly similar to Scriabin's version.

The way Hajdu deals with issues regarding notation is also remarkable: he uses an instrument-specific notation for almost each instrument, as several members of the ensemble performing the premiere were unfamiliar with notation on six lines. The three clarinets are written in clarinet fingering notation; the guitar part in T clef in Müller-Hajdu notation; the double bass uses tablature notation; the keyboard is notated, as in Beyond the Horizon, for a keyboard with standard layout; for the kalimba Hajdu also gives a tablature (see 6.2.7 for explanation).

Overall, Hajdu's re-creation in a modern (acoustic/elctronic) ensemble setting would probably get Scriabin's placet: the *mystic* effect of the piece is even greater in this unusual instrumentation, and since Scriabin himself was constantly searching for novel and eccentric harmonies, we may have the vision that he would have been an admirer of Bohlen-Pierce instruments.

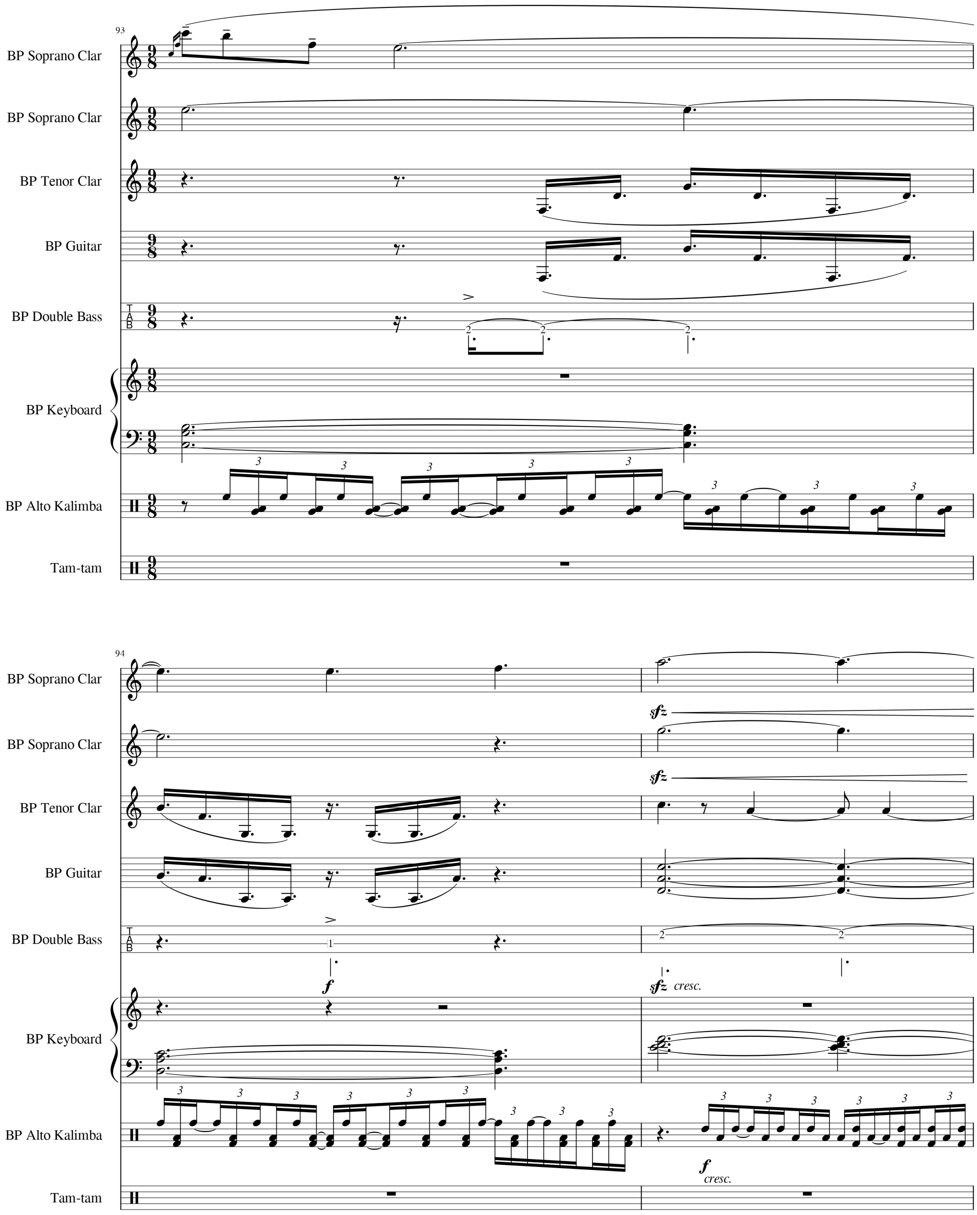



Figure 83: Georg Hajdu, *Burning Petrol*, b. 93-95

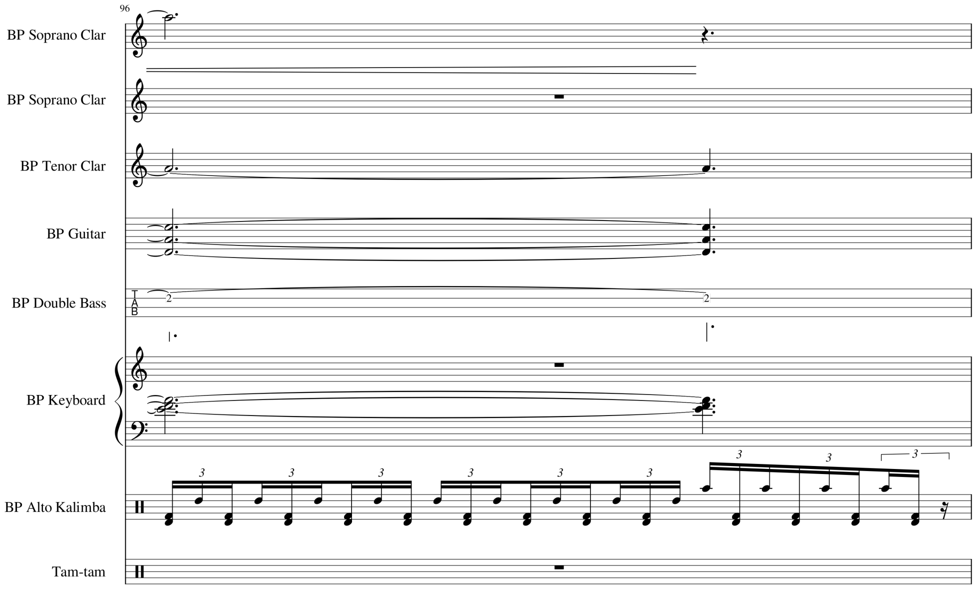



Figure 84: Georg Hajdu, *Burning Petrol*, b. 96

### 6.2.9 Todd Harrop: Maelström

The initial idea of his composition for two BP clarinets (soprano/tenor) and 41-tone guitar (2015) is based on Edgar Allen Poe‘s short story *A Descent into the Maelström* (1845) and dates back to 2011: an improvised piece for BP tenor clarinet and kalimba/cymbals (plus samples of dripping water, Eider ducks, ship horns and a giggling baby), based on a chord progression in a "found scale" (Harrop) to which the kalimba was tuned to. Following the form of Poe's short story, the ever-repeating chord progression moves forwards in the first part of the piece, and backwards in the second part. This symbolises the trip down into and up from the Maelström. After the concept proved promising in a festival performance in Hamburg in 2011, Harrop picked up the idea again in 2014 when asked to compose a piece for two BP clarinets and BP electric guitar, to be premiered on occasion of the 10th anniversary of the multimedia department at HfMT Hamburg in February 2015. This new version of the piece was partly improvised with given elements to be played by the interpreters in a free time frame, cueing each other for the changes of harmony in the underlying chord progression. In preparation for the recorded version, Harrop decided to give the piece a deep compositional overhaul in 2017, away from a partly improvised piece towards an exactly notated composition. Although written out rhythmical accuracy and with bar lines, it is the composer's intention that the three instrumental parts shall "float", i.e. not exactly together as written, but to be played in a fluid rubato, to some extent independent from each other. Looking back, the idea moved from a structured improvisation to a notated piece with certain freedoms.

The harmonic progression of *Maelström* is based on a mode of BP scale steps 0-3-6-7-9-10-11-12-0'. It is important to note that in contradiction to common practice, Harrop declares the starting note of his mode step 1. Hence, step 8 is the ast step of the mode, followed by the repetition of the starting note a tritave above which Harrop names 1'.

Harrop's mode and chords are here transcribed into MH-notation. In his own writings about *Maelström*[60] Harrop uses a nomenclature based on the classic Roman numeral analysis, including upper-case and lower-case letters as Roman numbers to indicate whether he considers a chord a "wide" or "narrow" triad, speaking in BP terms. For example, I symbolises a BP wide triad on the first note (the starting note) of the mode; ii symbolises a narrow chord footing on the second note of the mode. Harrop chose to build each chord on the note three mode steps below the preceeding one, aiming to symbolise Poe's descent into the Maelström. The single chords are made by skipping two steps of the mode : 1–4–7; 6–1'– 4'; and so on. This chord structure enables smooth voice leading between chords, such as 1–4–7 / 1–4–6.

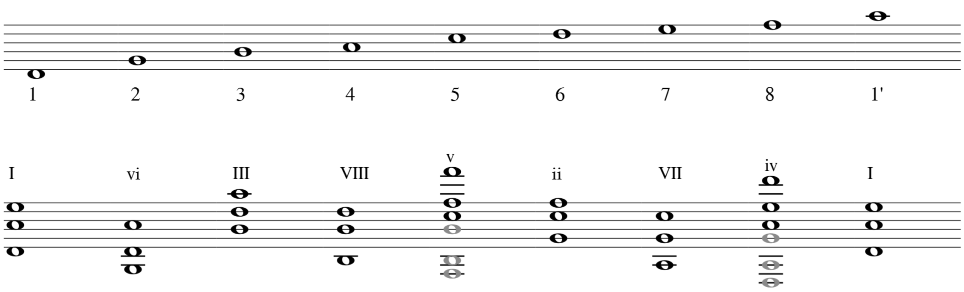



Figure 85: Chord progression in *Maelström* by Todd Harrop

The original score, from which excerpts shall be shown in the following, uses Müller-Hajdu notation for the guitar part and clarinet fingering notation for the two clarinets. As an experienced composer for BP clarinet – Harrop had composed several BP clarinet pieces since 2008, long before Müller-Hajdu notation was developed – he was able to handle both notations at a time. The form of the piece can be described in terms of free forms of the romantic era, such as a rhapsody. Harmonically, Harrop follows a very classic idea: b. 1-18 use the harmonic chord progression based on U. Each chord is maintained through two bars.

In b. 19-27, the chord progression is transposed to R (3rd below / 10th above), which can be considered a kind of "dominant" key. The harmonic

[60] https://thmuses.wordpress.com/2011/11/13/bohlen-pierce-kalimba-part-3/, last access: 30th July 2019

Figure 86: Todd Harrop, *Maelström*, b. 1-6

speed is faster than before, each chord is maintained through one bar; the tempo is slightly faster.

In a short interlude, the three instruments play a homophonic ascending line, adumbrating a harmonic series (b. 28-30).

While the guitar effect is still fading, a new section begins, to be played in time (b. 31-49). It modulates through various „keys“, in the character of a minuet: a light melody in 3/4 time signature (occasionally changing to 4/4). The section includes a small "modulation" to BP fifth-tone harmonies in bar 39, notated with sagittal accidentals as proposed by guitarist Melle Weijters who premiered and recorded the piece with us.


Figure 87: Todd Harrop, *Maelström*, b. 19-20

Exactly in the middle of the piece and like an echo from another world, lies the most catching part of the piece (b. 50-52): again, it is a simple harmonic series, enchanted by the two clarinets playing multiphonics which perfectly (or almost perfectly) match the guitar's notes. In the given excerpt, straight lines between notes are added to show correlation of pitches.

One may imagine here the node inside the Maelström where movement (and time?) stands still, deeply underwater (instruction for guitarist: underwater reverb), the moment when the direction changes and the journey up the Maelström begins. And literally: in the following, the piece turns around.

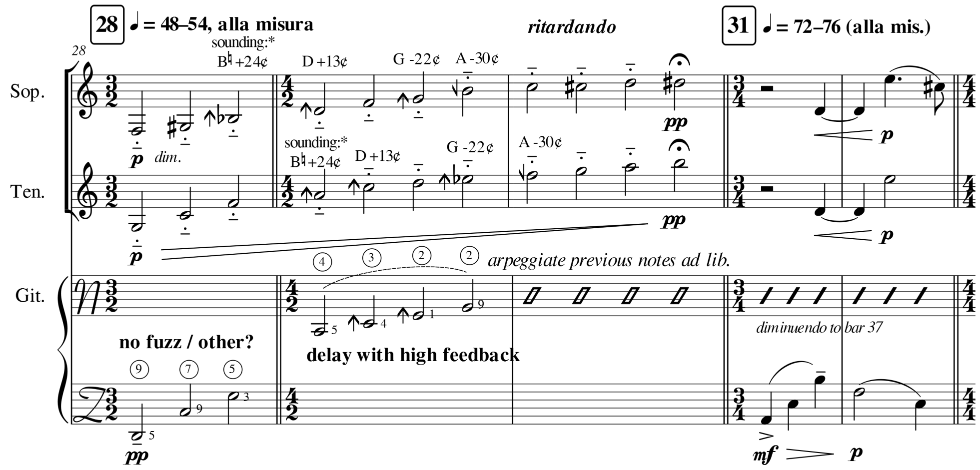



Figure 88: Todd Harrop, *Maelström*, b. 28-32

The initial key, based on U, returns (b. 53-79). The harmonic progression, however, now flows backwards. The broken chords in the guitar part, which have been played downwards in the beginning of the piece, are now being played upwards, symbolizing the ascent back up from the depth of the Maelström. Each chord lasts through one bar, and the progression is done twice until the piece is ended by a harmonic series again.

For several years, Harrop stuck to his idea of a chord progression, just as Jonas Rasmus in Poe's story tightens himself to a barrel and safely travels through the Maelström on it, until the force of the vortex decreases. The narrator's brother, who had grasped a ring-bolt on the large ship's deck, died in the force of the Maelström.[61]

[61] Regarding Harrop, it is certain that he survived the Maelström and at the time of publication of this work is of good health. Since he learned to navigate non-octave oceans, more works for BP clarinets may be expected from him in the future.

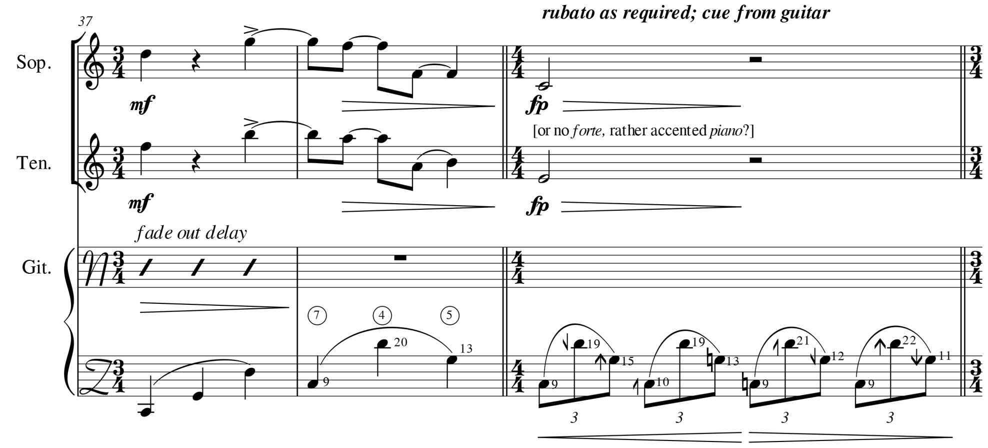



Figure 89: Todd Harrop, *Maelström*, b. 37-39

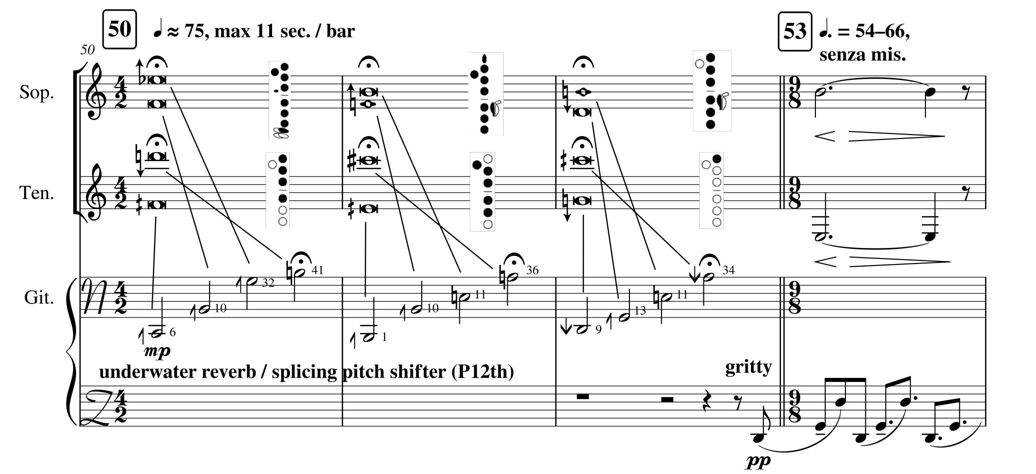



Figure 90: Todd Harrop, *Maelström*, b. 50-53. The connective lines between notes have been added by the author to indicate pitch correlations.


Figure 91: Todd Harrop, *Maelström*, b. 80-88

### 6.2.10 Nora-Louise Müller: Morpheus

The miniature piece *Morpheus* for two BP soprano clarinets and BP tenor clarinet (2015) has a free form and is dedicated to rather unusual sounds such as long glissandi and multiphonics. Interestingly, the piece almost lacks consonant intervals and triads. The double tritaves in bars 2 and 11/12 are the only perfect consonances in this three-minute piece. The composition seems to exist for the sake of pulsations and beatings. Dark colours and colour fingerings shape the atmosphere.

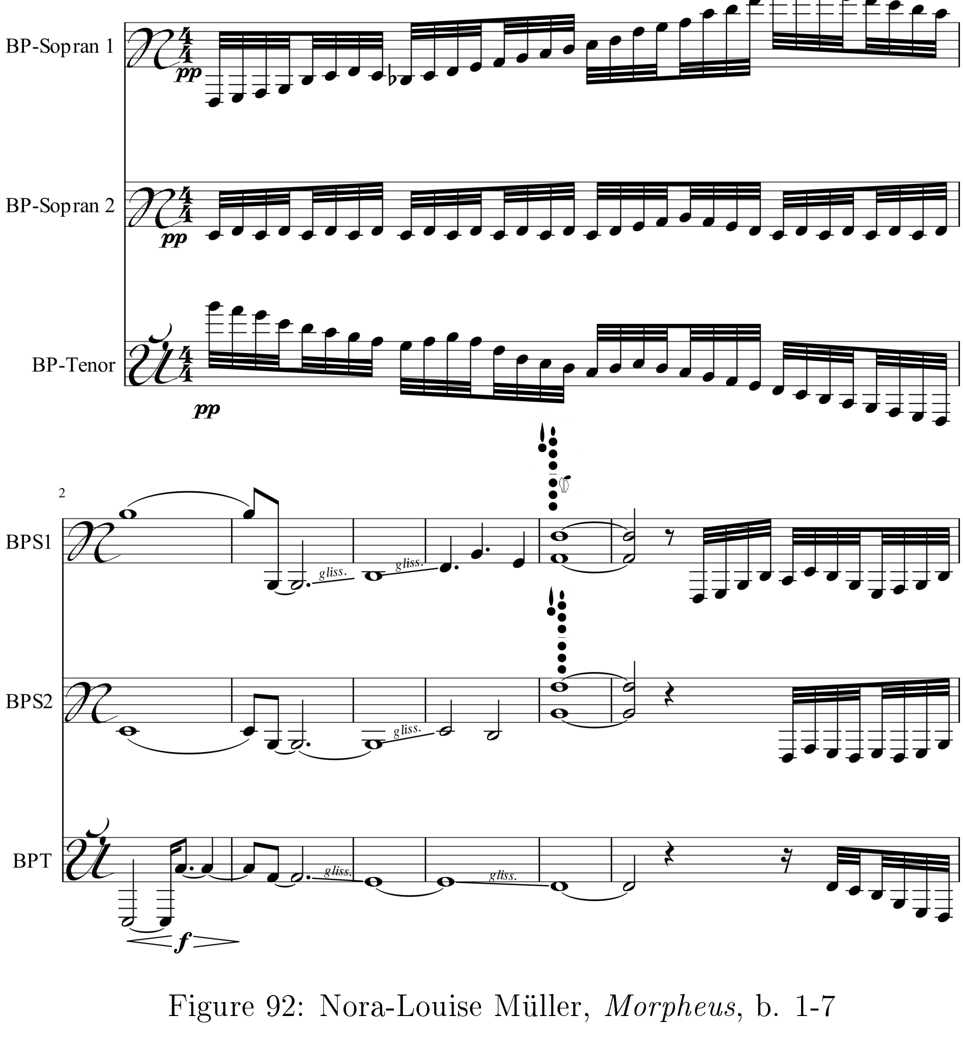



Figure 92: Nora-Louise Müller, *Morpheus*, b. 1-7

After a *pianissimo* initial run which likewise sounds as if it was "held under the blanket", the BP clarinets show one of their particular abilities: sliding through a long glissando. The following harmony is made of one dyad in each of the soprano clarinets, creating a specific sound of BP multiphonics. The motif of a fast, silent run in the lower registers – an atmosphere like running through a tunnel, then the tunnel opening up to a multiphonic woooaaaa-sound is repeated two more times, each time using different pitch material. The middle part (b. 13-27) is a low, dark globbery mass like a "slime monster" evolving from the catacombs, and there are even four microtones in the first and second clarinet. They do not have a sophisticated microtonal function, they are just there for the fun of it and for their airy, "grey" sound colour.


Figure 93: Nora-Louise Müller, *Morpheus*, b. 13-27

Predominant intervals are 1sts, 2nds, 6th, 5ths and 8ths. Typical BP triads such as 3/5/7 are avoided throughout the piece, and even the final chord, aimed upon by large and long glissandi of the two soprano clarinets, is not quite consonant.

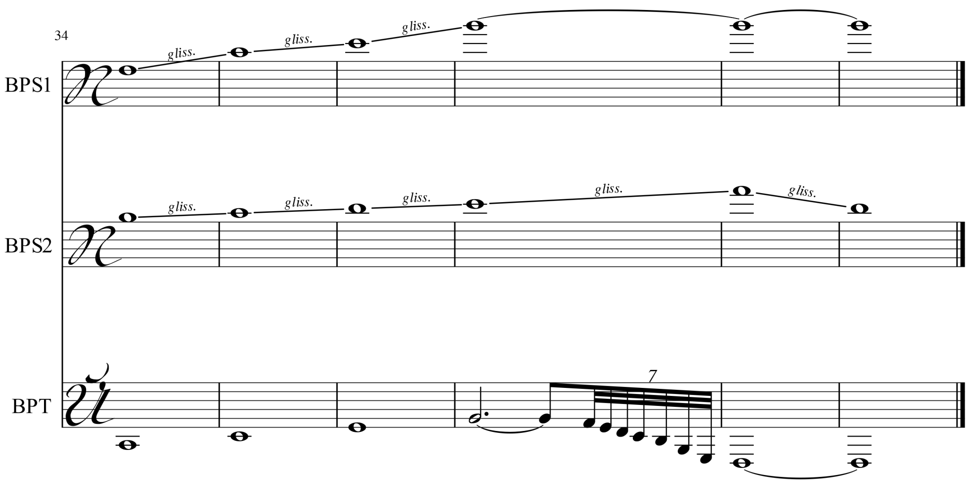



Figure 94: Nora-Louise Müller, *Morpheus*, b. 34-39

The tenor clarinet ends on U2, the second clarinet plays V4 a BP 2nd plus a tritave above the tenor, and the first clarinet plays N5 in a distance of a BP 5th distance from the second clarinet. In practice, however, it is likely (and expected) that the clarinettists choose to tune the interval V4-N5 as a pure fifth by flattening N5 (e"' +2c) by about 25-30 cents, at the same time achieving a pure octave between U2 (E-26c) and N5.

### 6.2.11 Ákos Hoffman: Duo Dez

The fact that Ákos Hoffmann's six-minute work for two BP soprano clarinets and BP tenor clarinet (2015) is a humouristic piece of music, can already be seen from the title. *Duo Dez* is a parody of *Duodezime*, the German word for perfect twelfth. By cutting the word into two, it pretends that this piece is a duo, which it is of course not, but rather a trio for two BP soprano clarinets and a BP tenor clarinet.[62] The opening of the piece resembles a kind of Eastern European / Jewish *doina*: against a ground of long notes, an ornamented improvised tune, here played by the first clarinet, catches the attention of the audience. The accompanying motif, played by the second clarinet and tenor clarinet, is based on a tritave, and the few and small melodic changes in the second clarinet are mirrored by the tenor clarinet (b. 1-16).

The following part (b. 17-28) is a lively 7/8 tune on the basis of an ostinato which can also be interpreted as an hommage to Eastern European traditional dances. Hoffmann, having Hungarian roots, allows his own Eastern European musical genes to enter his music.

The first and second clarinets play a triad motif of the intervals 4th – 5th – 4th, repeating a tritave higher, while the tenor clarinet plays a perpetuum mobile ostinato, spanning the interval of a 7th; at some point, it is taken down by a BP 5th (!) for two bars (b. 23-24), so as to show a harmonic progression, creating a traditional subdominant effect. Additionally, the ostinato motif is doubled by the second clarinet during these two bars. On the downbeat of the bars the two instruments play the dissonant interval of a 5th which gives the section an extra twist; for the rest of these bars, it is a consonant 6th. This short part ends by an "augmented" chord built from BP 3rds, played by the two clarinets, anticipating the main motif of the next passage (b. 30-36): chords of BP 3rds (not tritave repeating) on different starting notes, connected by a short chromatic run of the soprano clarinets at BP 4th distance.

[62]The term *duodez* also describes a very small book format. A personal conversation with Ákos Hoffmann, however, reveals that he was not aware of this meaning of the word. Thus, it may be ignored in interpretation and analysis of the composition.


Figure 95: Ákos Hoffmann, *Duo Dez*, b. 1-11

After a short reminiscence of the ostinato part in bars 37-41 the two clarinets play a lively up and down of "augmented" chords consisting of BP 3rds before the tenor accompanies a somewhat slower, unhurried clarinet melody in a bluesy walking bass fashion (played in straight eighths, though), each bass "chord" spanning the interval of a BP 7th.

The lively up and down movement of thirds is picked up again by the clarinets in b. 68-75. The piece ends with a slight variant of the beginning *doina* theme, the tenor clarinet doubling the first clarinet at a distance of two tritaves, the second clarinet mirroring the other two. A soft, pure unison (i.e. double tritave sound) marks the end of this humorous, entertaining piece.


Figure 96: Ákos Hoffmann, *Duo Dez*, b. 17-24


Figure 97: Ákos Hoffmann, *Duo Dez*, b. 30-34

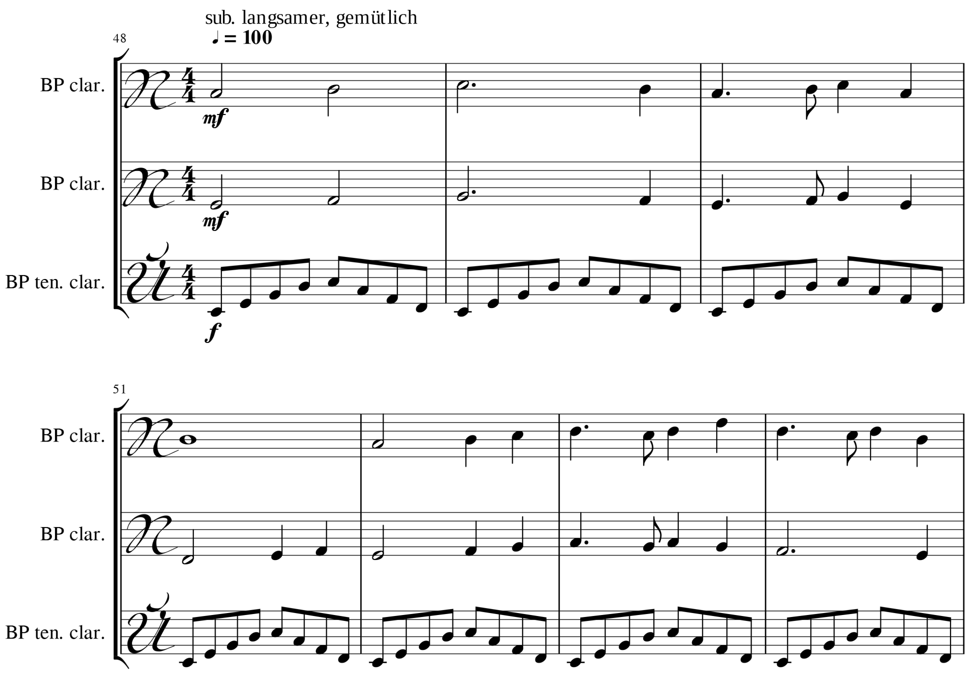



Figure 98: Ákos Hoffmann, *Duo Dez*, b. 48-54

# 7 The BP Triple Scale

Despite the high harmonic value of the BP scale and its great number of consonant intervals, there is one implicit disadvantage to the scale: the big step size. One BP step is bigger than a traditional half-tone step. Two BP steps are perceived – be it by habit or by any other reason – as a (small) leap rather than as a step. In Western traditional music (12div2), the half-tone step fulfills an important function as a leading tone, the penultimate tone which gently forces the melody to its *finalis* tone. Although there may be modal melodies in which the last tone is approached by a whole-tone step, an ascending half-tone step has often been preferred in the past centuries. For pieces in minor keys for instance, the melodic and harmonic scale variants of the minor scale are representative for this preference.

Taking this into account, it appears reasonable that some composers and music theorists would think of smaller step sizes within the BP scale, keeping its characteristics and at the same time adding new material. A division of the tritave into smaller step sizes than 146.3c can be considered BP microtonality.

Paul Erlich suggested the BP triple scale in 2010 [Sword 2010]. The subdivision of each BP step into three micro steps results in a division of the tritave into 39 steps. By this, a number of JI intervals containing prime numbers 11 and 13 are added to the original fundament of BP intervals from prime numbers 3, 5 and 7. Manfred Stahnke tells that "the BP triple scale has been interesting for me from the beginning, and it still is by today. (...) In endless discussion, thoughts like this just come ... it seemed so natural to me, easy to understand for a simple thinking composer since sixth tones [of 12div2] had been known to me for a long time."[63].

Step size in the equally tempered version of the BP triple scale is 48.8 cents. One could argue that this step size is so close to a quarter tone step in 12div2 that there is hardly any difference between 39div3 and 24div2. There are conceptual differences indeed. Many of the intervals in the BP triple scale can be considered consonant due to their relatively simple ratios,

[63]Email from Manfred Stahnke, 28th Sept 2017, translated by the author.

and thus can be seen as an enhancement or refinement of the BP scale in some respects. Interval ratios remain containing odd numbers only, as in the original BP scale. One of the main characteristics of the BP scale is supported by the triple steps: there are still no pure fifths (2/3) or octaves (1/2).

**Intervals in the BP triple scale** In the following table, a description of some of the BP triple intervals is given, including the interval ratio, step size in cents (equal-tempered steps only), and a characterization of the interval. The table may help understand the harmonic content of the BP triple scale[64].

| step no. | ratio | cents value | description |
|---|---|---|---|
| 1 | 653/65 or 75/77 | 48.8c | |
| 2 | 33/35 | 97.6c | |
| 3 | 25/27 45/49(Haj) | 146.4c | BP 1st |
| 4 | 49/55 or 35/39 | 195.2c | |
| 5 | 13/15 | 243.8c | Right in the middle between 12tet[65] major 2nd and minor 3third |
| 6a | 21/25 | 292.6c | BP 2nd. This equally tempered interval is one of those in the original BP scale which deviates most from the just version (301.8c) of the BP scale. It may be the relatively strong defect of -9.2c that inspired Erlich's variation of this scale step as described below. |
| step no. | ratio | cents value | description |

[64]Ratios have been calculated using Todd Harrop's *ratio finder* which he programmed in matlab.
[65]12-tone equal temperament, i.e. a step size of 100c.

| step no. | ratio | cents value | description |
|---|---|---|---|
| 6b | 11/13 | 289.2c | A variant of 21/25. The just interval 11/13 has a step size of 289.2c and approximates the equally tempered step of 292.6c very well. When thinking about 39div3, Erlich had JI ratios of 11 and 13 in mind, so it makes sense that he takes the opportunity to double the 6th step. This interval is also called a *tridecimal minor third.* |
| 7 | 9/11 | 341.4c | Being ~45c short of 4/5 (major third) and ~26c sharp of 5/6 (minor third) it can be considered a *neutral third.* |
| 8 | 39/49 | 390.2c | Major third, 390c, and thus very close to 4/5 (386c).<br>Major third, 390c, and thus very close to 4/5 (386c). |
| 9 | 7/9 | 439c | BP 3rd |
| 10 | 49/65 or 25/33 | 487.7c | |
| 11 | 11/15 | 536.4c | A sort of tritone. Or a very large 4th, long by ~40c, and ~45c short of 5/7, 48.8c short in ET respectively. Rough sound, strong beating. NB: just one triple step below 5/7. Difference tone: major 7seventh + octave below upper note; 1200+551c below lower note, i.e. exactly between 12-tET fourth and tritone. |
| 12 | 5/7 | 585.2c | BP 4th |

| step no. | ratio | cents value | description |
|---|---|---|---|

| step no. | ratio | cents value | description |
|---|---|---|---|
| 13 | 9/13 | 634c | Another kind of tritone possibly, a triple step above 5/7. Appears dissonant due to its roughness and strong beatings. Dissonant difference tone as well. Still interesting though. |
| 14 | 33/49 | 688.1c | |
| 15 | 49/75 | 731.5c | BP 5th |
| 16 | 7/11 | 780.3c | Two times 390.2c; so-called *undecimal minor sixth* or *undecimal augmented fifth*. May be interesting to those working in Fibonacci numbers. |
| 17 | 13/21 | 829c | Simple ratio, and almost perfect regarding deviation in ET version. Minor sixth. |
| 18 | 3/5 | 877.8c | BP 6th |
| 19 | 45/77 | 926.6c | |
| 20 | 77/135 | 975.4c | |
| 21 | 5/9 | 1024.1c | BP 7th |
| 22 | 7/13 | 1072.9c | A major seventh, very close to the 8/15 (just major seventh), i.e 12-tET maj7 but smaller, as it should be following the harmonic series. |
| 23 | 11/21 | 1121.7c | Comparable to an equal tempered major seventh (1100c). |
| 24 | 25/49 | 1170c | BP 8th |
| 25 | 45/91 or 49/99 | 1219 c | Slightly sharp from an octave, this interval may still be perceived as such, with a strong beating. |
| 26 | 13/27 | 1268c | |
| step no. | ratio | cents value | description |

| step no. | ratio | cents value | description |
|---|---|---|---|
| 27 | 7/15 | 1316.8c | BP 9th |
| 28 | 5/11 | 1365.5c | In a 3/5/7 triad, this interval is consonant to the root and serves nicely as a retardation: 1/1 - 3/5 - 5/11 → 1/1 - 3/5 - 3/7 |
| 29 | 11/25 | 1414.3c | |
| 30 | 3/7 | 1463c | BP 10th |
| 31 | 49/117 or<br>27/65<br>225/539<br>(Haj) | 1511.8c | |
| 32 | 11/27 | 1560.6c | Neutral tenth; may serve as a suspension: 1/1 - 3/5 - 11/27 –> 1/1 - 3/5 - 3/7 |
| 33 | 25/63<br>13/33(Haj) | 1609.3c | BP 11th |
| 34 | 13/5 | 1658c | |
| 35 | 13/35<br>63/169(Haj) | 1706.8c | |
| 36 | 25/9<br>135/49 (Haj) | 1755.6c | BP 12th |
| 37 | 35/99 | 1804.4c | Due to their similarity to quarter-tone and half-tone steps (resp.) in 12div2, these two intervals may serve as melodic leading tones. |
| 38 | 49/143<br>77/225(Haj) | 1853.2c | |
| 39 | 1/3 | 1902 | tritave |
| step no. | ratio | cents value | description |

The ratios marked (Haj) are suggested by Georg Hajdu. Despite being complex ratios, they still provide a good stability profile, as he explains: "Some of the ratios I calculate for the triple scale I calculate differently from yours. This is particularly obvious in the BP 1st, since we are not limited to

7sans2-limit JI but instead are allowed to go up to 13 (i.e. 13sans2-limit JI). It is not necessary to derive the BP 1st as an interval between 5/3 and 9/5; I am free to choose the next stable interval from odd numbers near 146.3 cents, as long as it is within 13-limit; thus 49/45 (= 147.43 ct) instead of 27/25 (= 133.24 ct)."[66] However, in a later email from the same day Hajdu admits that steps 31, 35 and 36 may be at least as good in their smaller numbers ratios.

Hajdu[67] points out the lack of small steps in the original BP scale and welcomes the smaller step size in the triple scale due to the possibility of implementing melodic leading tones. Depending on personal taste and perception, either a small step of 48.8c can function as such, or a bigger step (two BP triple steps) of 97.6c, both in an upward or downward movement. Paul Erlich, on the other hand, skips these small intervals in his original research about the scale, concentrating on JI intervals up to the limit of 13.

One of the most consonant intervals in the BP scale is 5/7, the *Huygens tritone*. Interestingly, the BP triple scale adds two more kinds of tritones to enrich the harmonic possibilities of the scale: 11/15 and 9/13, a BP triple step above and below 5/7. While 11/15 has a soft, consonant character, 9/13 offers more of a twist. The various tritones make nice melodic and harmonic progressions, particularly in respect of their difference tones which can be heard when listening closely, or maybe even doubled by a low instrument in a composition.

## 7.1 About the Notation

After thorough experimentation and consideration, I propose the following notation of the BP triple scale by borrowing third-tone accidentals as used by Xenakis [Gould 2011]:

Figure 99: Suggestion for notation of BP triple pitches

[66]Email, 7th Oct, 2017; translated into English by the author.
[67]Email, 1st Aug 2017

The standard BP pitch is notated without an accidental. One BP triple step up (48.8c) is notated by Xenakis's third-tone accidental, two triple steps up by the respective two-third-tone accidental. As for the BP clarinet fingering notation, some more explanation is needed. The BP fingering notation makes use of standard ♯ accidentals with some pitches, as well as a standard ♭ with notated b♭ below staff. The given third-tone accidentals are used additionally to the standard accidentals:

Figure 100: BP clarinet fingering notation with additional third-tone accidentals

Although uncomfortable for composers, this notation is still easily understandable for a BP clarinettist. It should be pointed out that this way of notation is different from Xenakis's use of the accidentals where the standard ♯ should be between the two third-tone accidentals since they are indicating the progression 1/3 tone – 1/2 tone – 2/3 tone. Due to the peculiarity of the BP fingering notation, the third-tone accidentals are simply attached to the given standard BP note, regardless whether in clarinet fingering notation it is a natural pitch without an accidental or one wearing a ♯ or ♭. Downward accidentals may be borrowed from Wyschnegradsky, as suggested by Georg Hajdu:[68]

[68]Email, 27th October 2017

Figure 101: Downward accidentals borrowed from Wyschnegradsky

In the fingering charts (→ 9.4 and 9.5) standard BP pitches at the beginning of each staff line are not indicated by fingering suggestions. Not all of the triple pitches marked with the Xenakis accidentals are possible to produce. If there is no fingering suggestion for a pitch it means that there is no way known of producing a note of this pitch. It is not advisable to use these pitches in a composition, unless the collaborating clarinettist has found a fingering for it and agrees to its use.

## 7.2 About Sound Colours

Microtones on the BP clarinet are of various sound colours and qualities, as it is the case on almost any wind instrument (except maybe trombones – and slide whistles). Generally it can be said that fork fingerings[69] give a darker and mellower sound colour than linear fingerings.[70] Tones generated by fork fingerings may contain more noise than other notes, and their dynamic range may be limited. The following fingering chart includes very few comments about timbre; only extremely mellow, sallow, almost "dead" sounds are indicated by a sign. A very cautious use is recommended for these notes since they are out of the ordinary timbre range and may disturb melodic lines. On behalf of their "dead" timbre these notes can be considered useless; on the other hand they may be wanted just for the sake of this effect and have been included in the collection of fingerings nonetheless. Four of the given fingerings for the BP tenor clarinet and one for the soprano are marked having a "multiphonic tendency". This means fingerings which result in the required pitch but can at the same time function as fingerings for multiphonics. In

[69]A fork fingering – or cross fingering – is a fingering which covers tone holes in the upper part of the tube, then leaves one tone hole open, and covers one or more ton holes below the open tone hole.

[70]This phenomenon is due to a low cut-off frequency and the acoustic impedance. http://newt.phys.unsw.edu.au/jw/clarinetacoustics.html#cross explains both phenomena in detail.

practice this means that the "pure", monophonic pitch can be achieved only in piano, while at a higher volume level or with appropriate modulation of embouchure the given multiphonic will sound.

## 7.3 When writing in Triple for BP clarinet

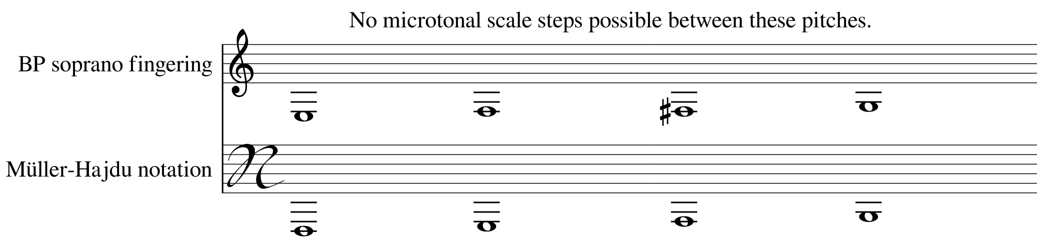
At the time of publication of this book, the BP triple scale is still rarely in use in compositions. For this reason, a composer writing in BP triple is advised to always collaborate closely with the clarinettist who is going to premiere the piece to make things practical for both – composing and performing – sides. It needs to be kept in mind that some fingering combinations are acrobatic. It is cumbersome to play in BP triple, and it is strongly recommended not to write virtuoso passages without consulting a BP clarinettist. For example, it is possible to play upwards from d"+ 1/3 to d"+2/3 (Q4+ 1/3 to Q4+2/3). The movement is complex, the left little finger jumps from the left e/b' key (N3/N4 key) to the left f/c" key (O3/O4 key). For this reason, the step cannot be played very fast but in relatively slow movement only. The reverse step, from d"+2/3 down to d"+ 1/3 is not possible to do because the left f/c key (O3/O4 key) is situated significantly lower than the e/b key (N3/N4 key) which makes sliding from one key to another impossible. The same applies to movements between d"+ 1/3 (Q4+ 1/3 ) and d"♯+ 1/3 (R4 + 1/3 ). As for tremoli in high registers, it may always be the case that a specific tremolo is not possible although comfortable in fingering. If the tremolo crosses a register break in the high register, it is usually not possible to perform, or in very slow tempo only. The collaborating clarinettist will let you know if this is the case. As mentioned earlier, some notes sound very different in timbre from others and are limited in terms of dynamics. Microtonal scales in general and the still rarely used BP triple scale in particular are ones which the performer is probably not used to playing. Thus it requires a lot more time than usual to prepare a new work for a performance. BP triple offers a field of possibilities yet to be researched. Practical guidance in its use on BP clarinets has been given in this chapter. I hope that the information I give encourages you to compose and play new music in BP triple. Explore the next musical horizon!

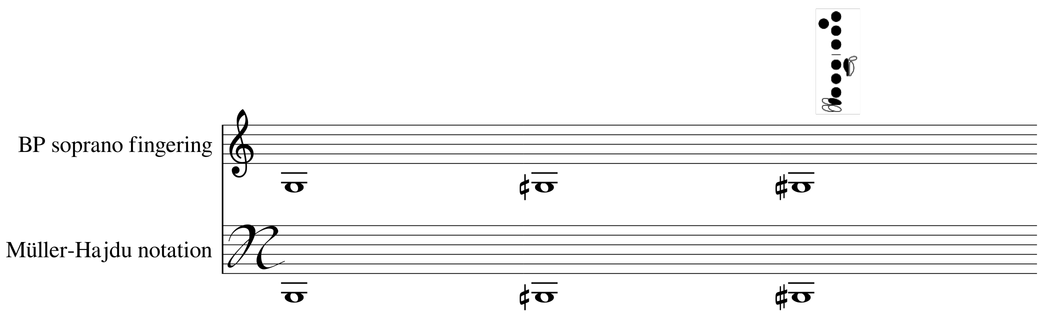
## 7.4 The BP Triple Scale on BP Soprano Clarinet

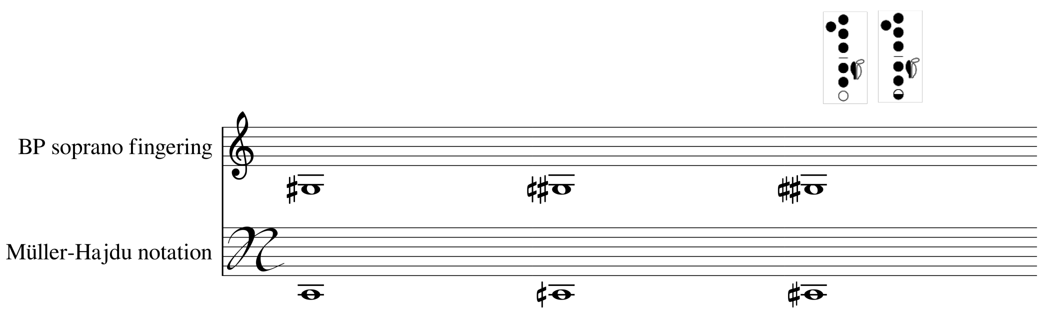
indicates a "dead" sound quality, a damped pianissimo sound containing much noise

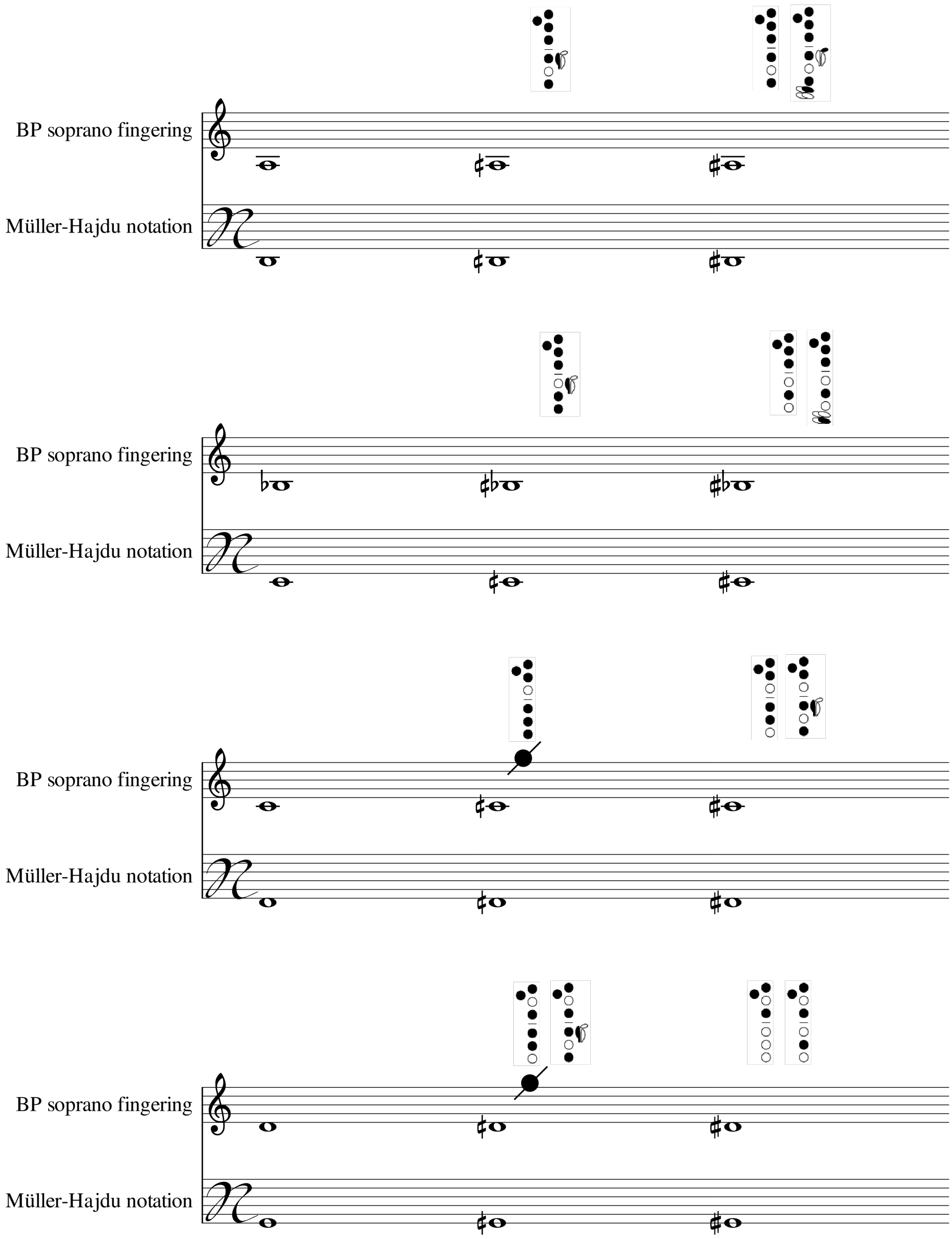
↓ sharp note, to be flattened by embouchure

↑ flat note, to be played as high as possible




BP soprano fingering
Müller-Hajdu notation
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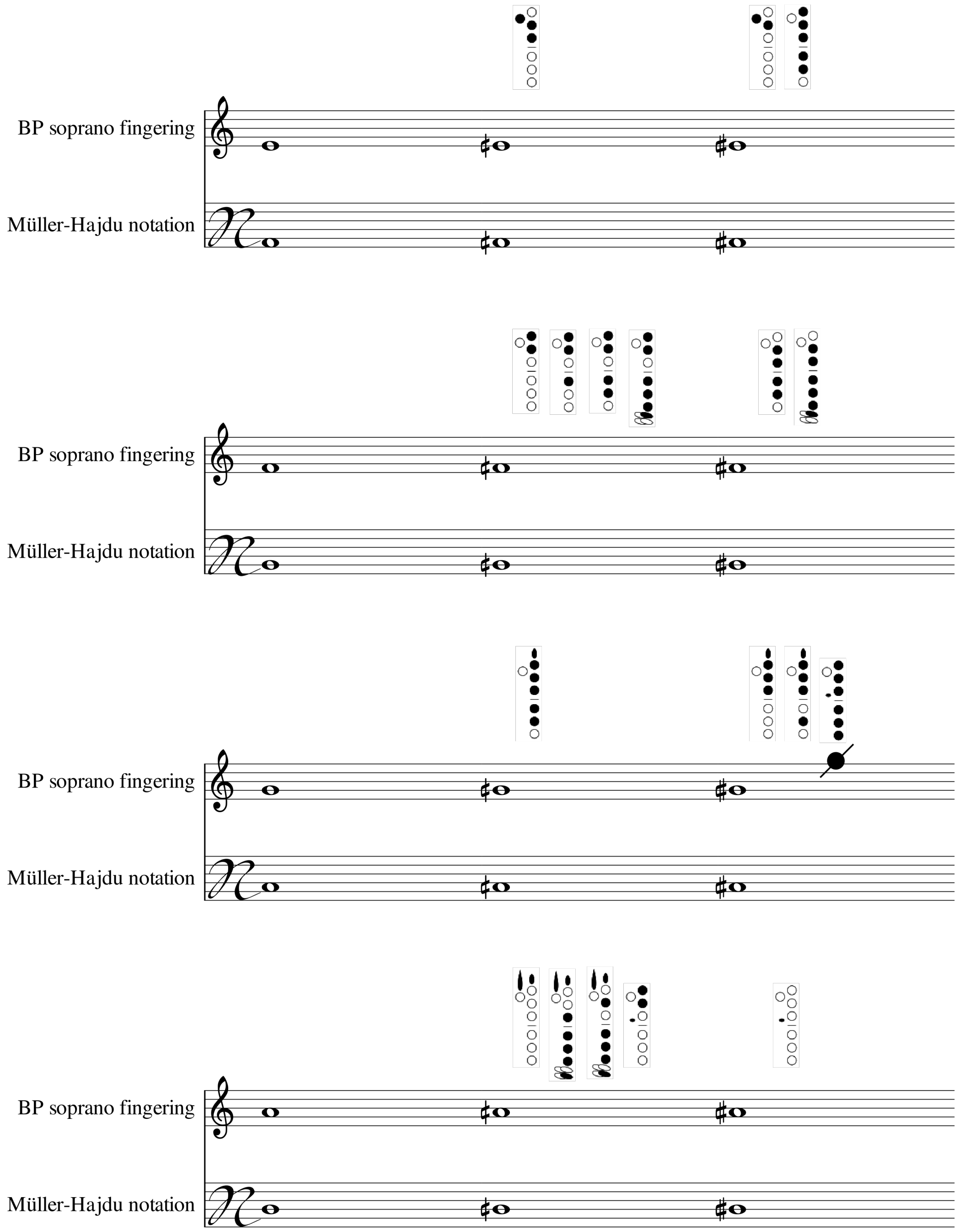
Müller-Hajdu notation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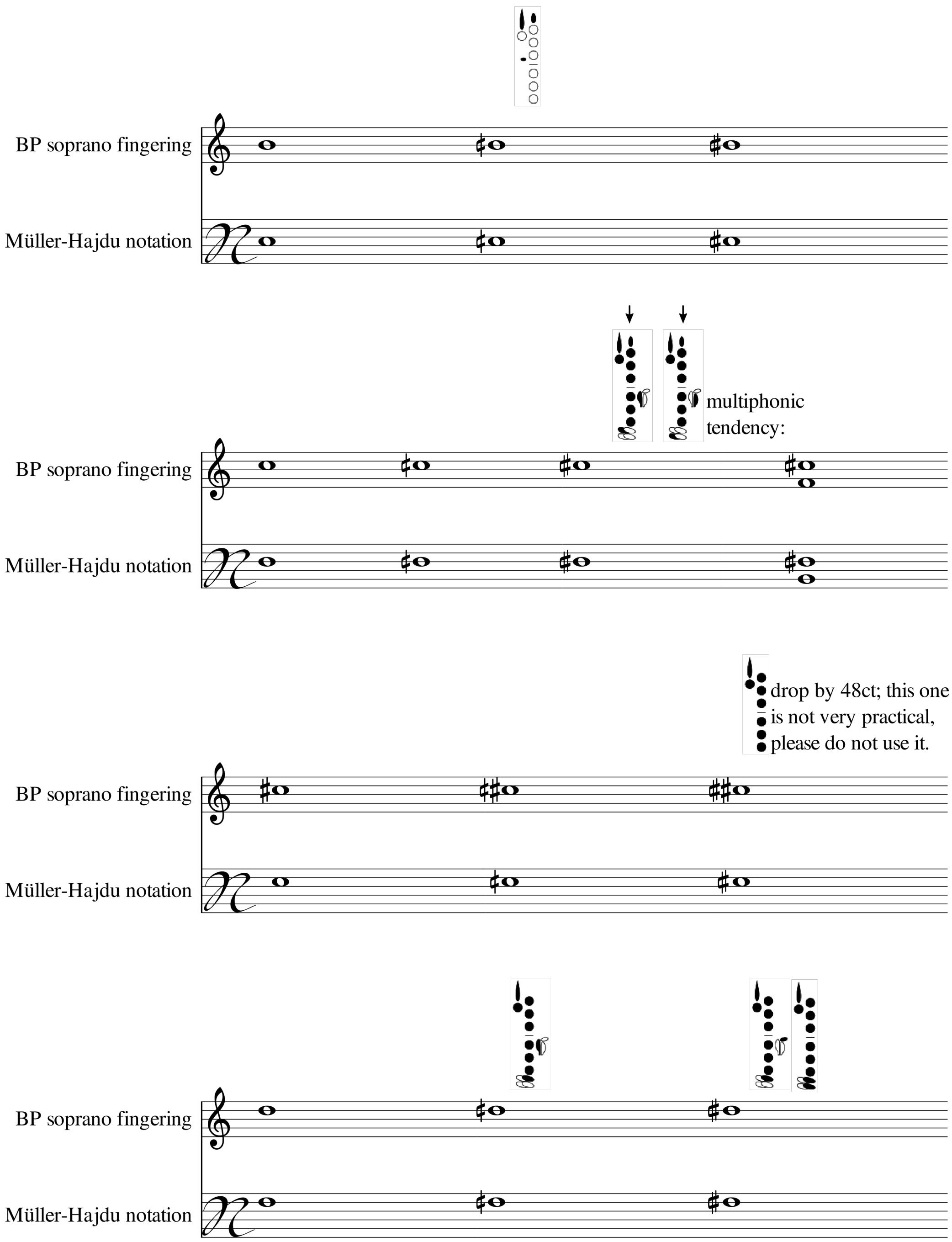
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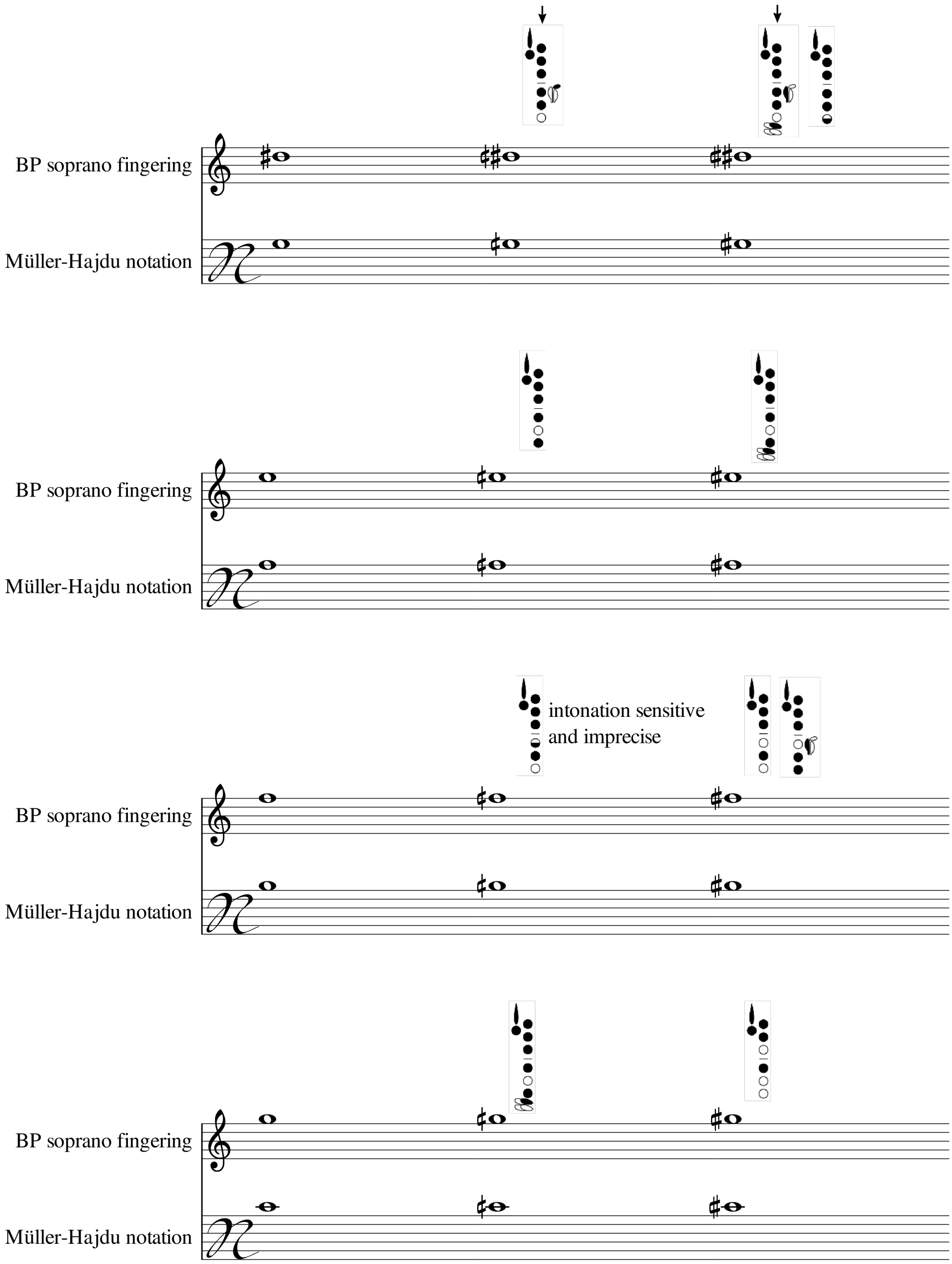
Müller-Hajdu notation
multiphonic tendency:
drop by 48ct; this one is not very practical, please do not use it.


BP soprano fingering
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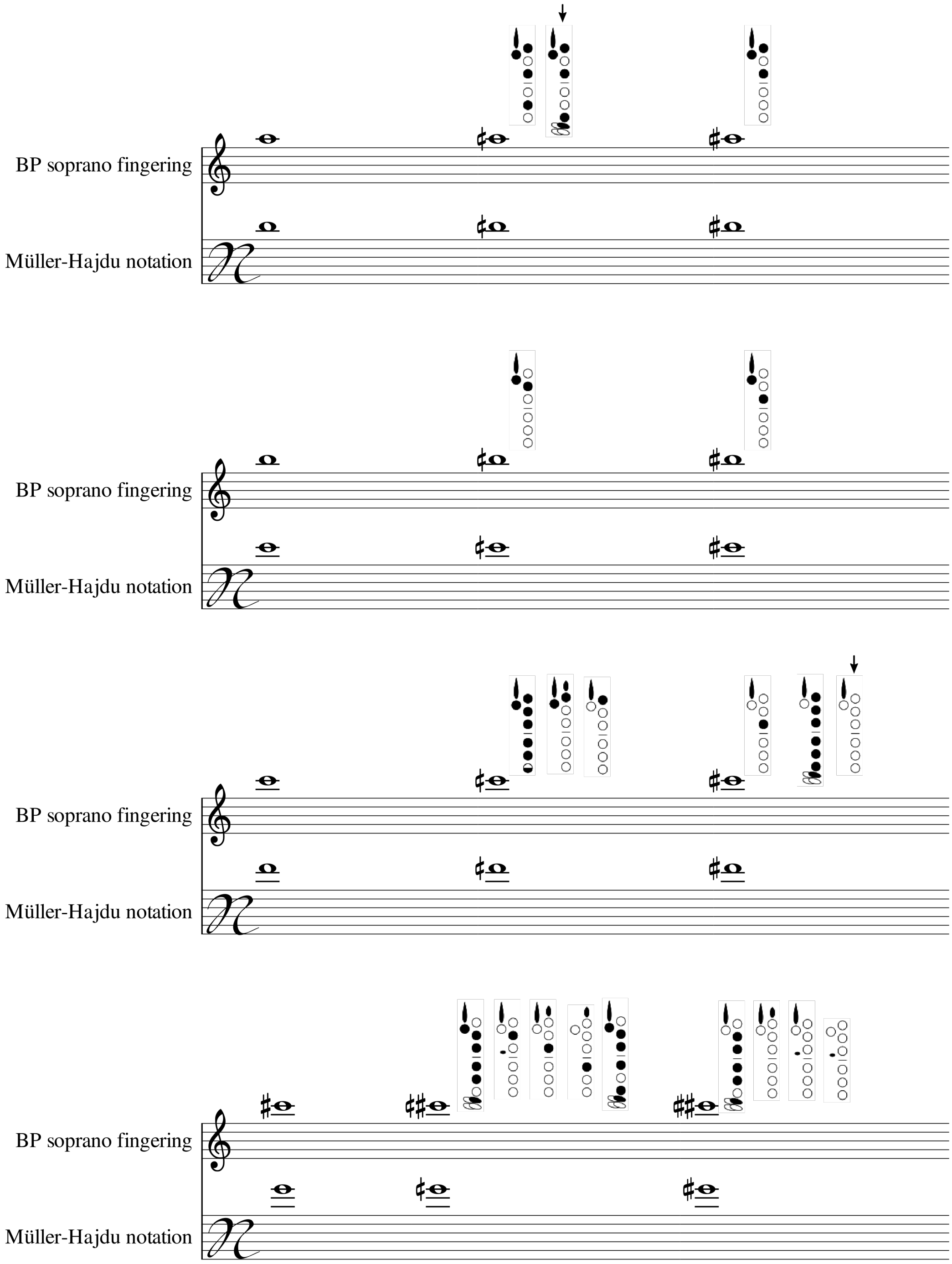
BP soprano fingering
Müller-Hajdu notation


BP soprano fingering
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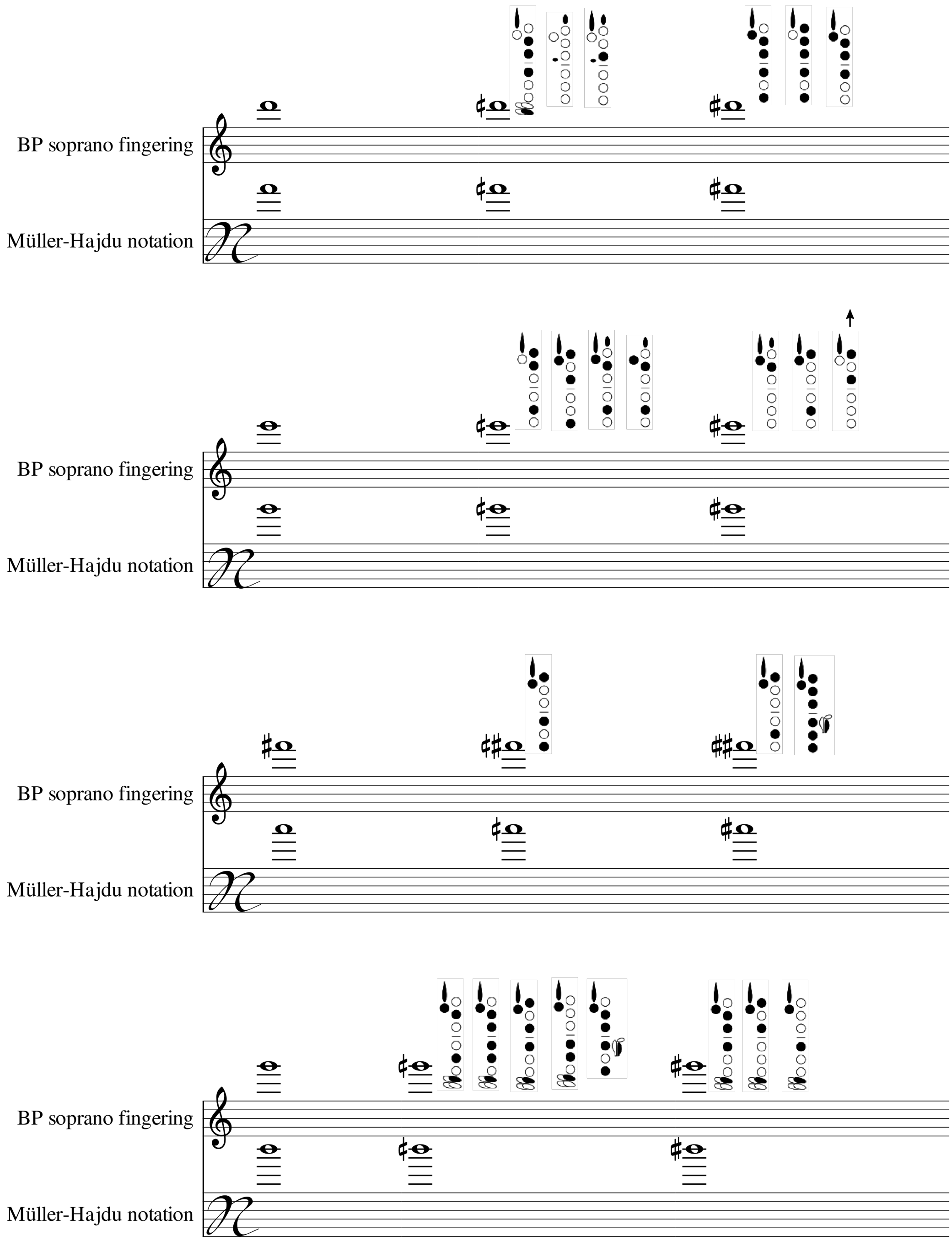
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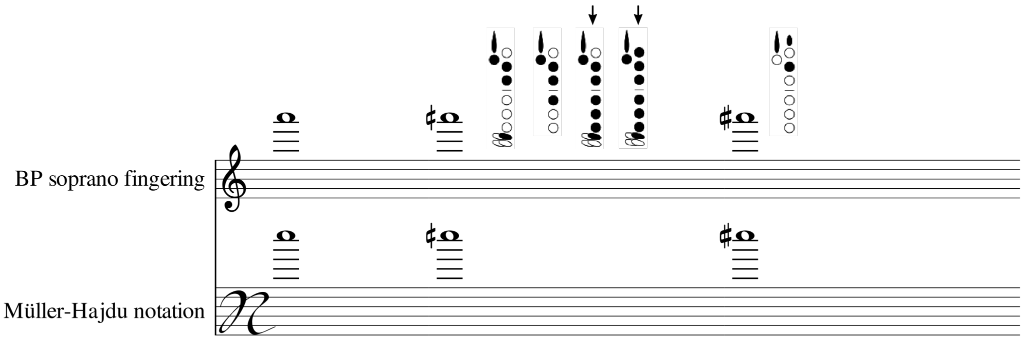


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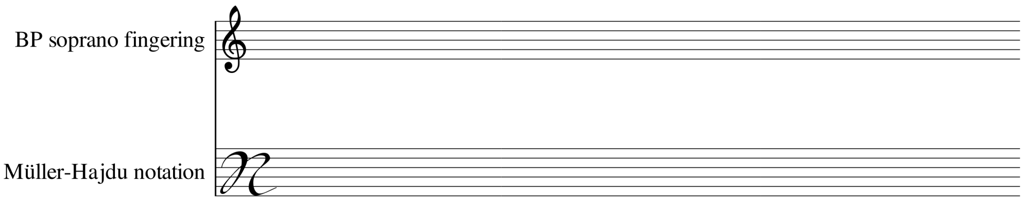
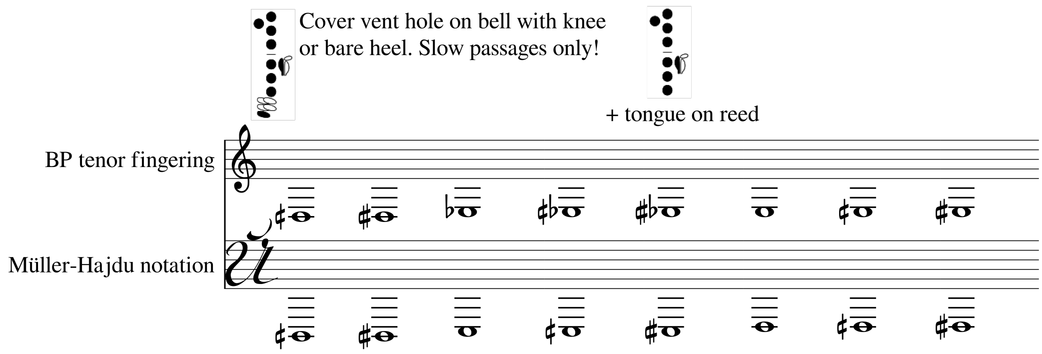


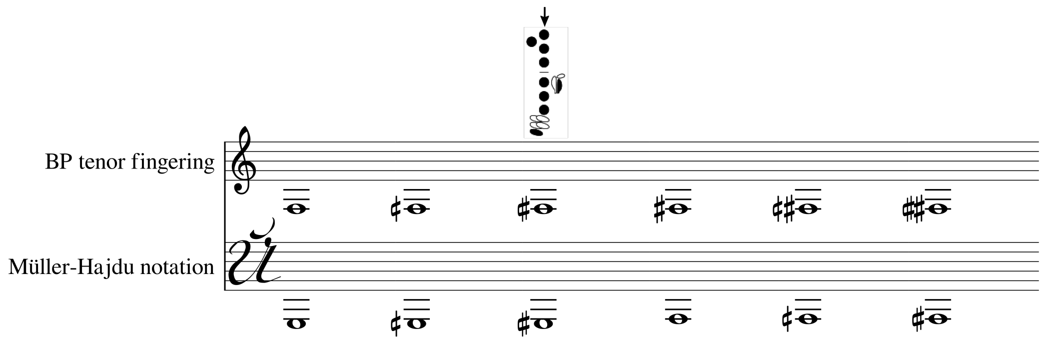
## 7.5 The BP Triple Scale on BP Tenor Clarinet

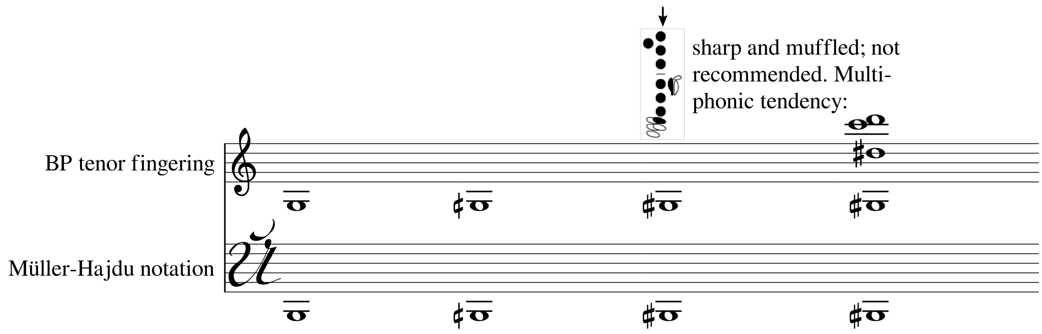
indicates a "dead" sound quality, a damped pianissimo sound containing much noise

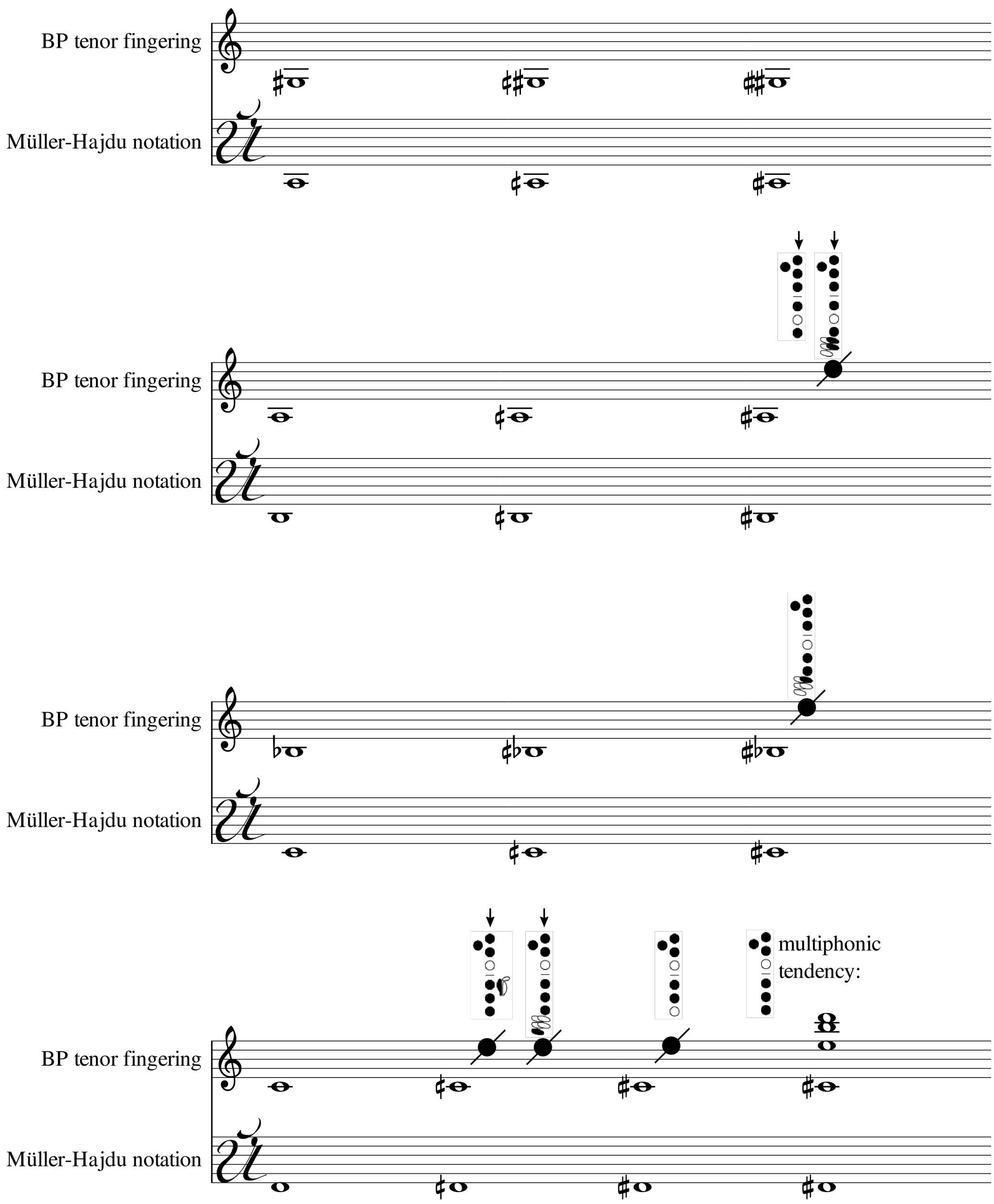
↓ sharp note, to be flattened by embouchure

↑ flat note, to be played as high as possible

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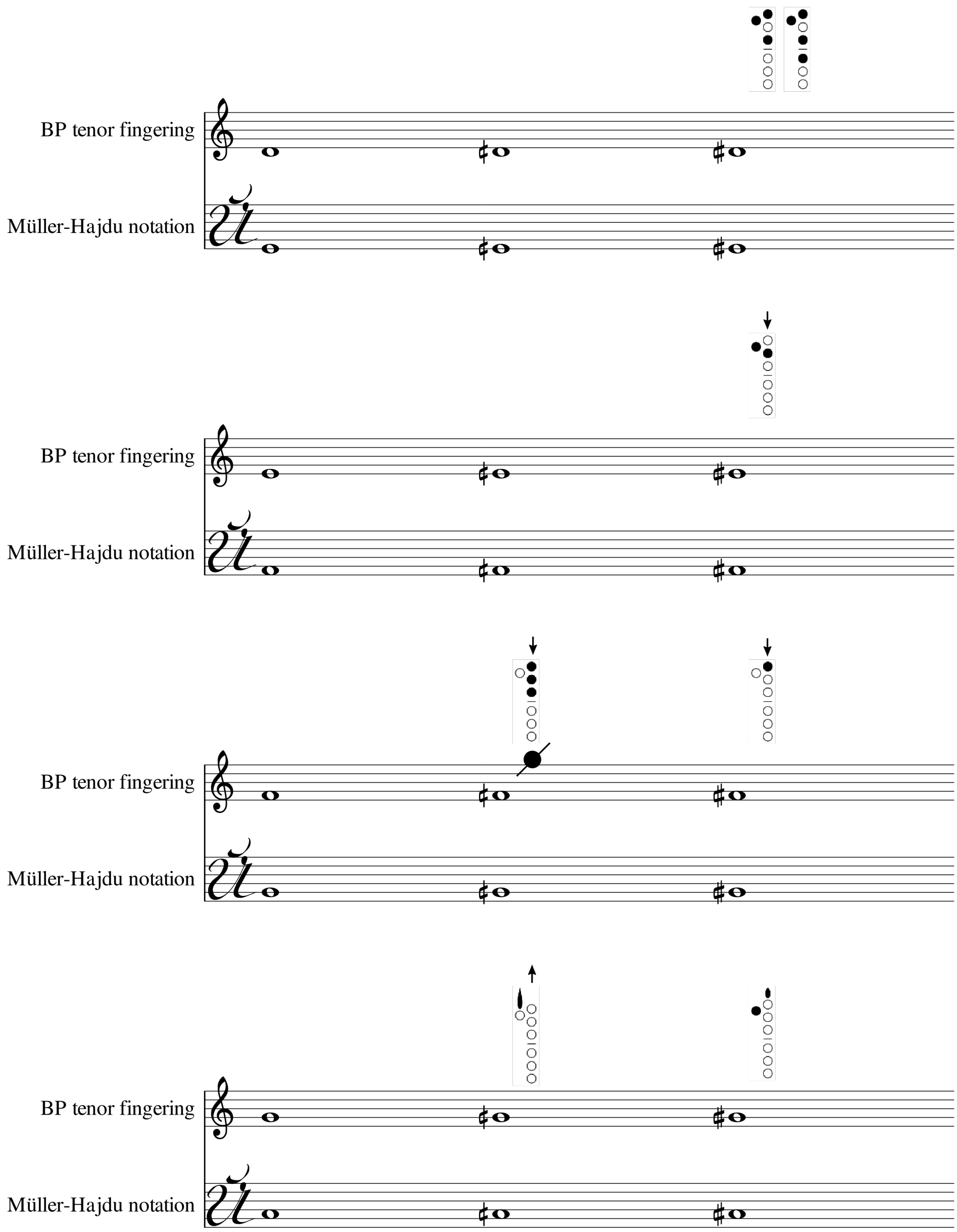
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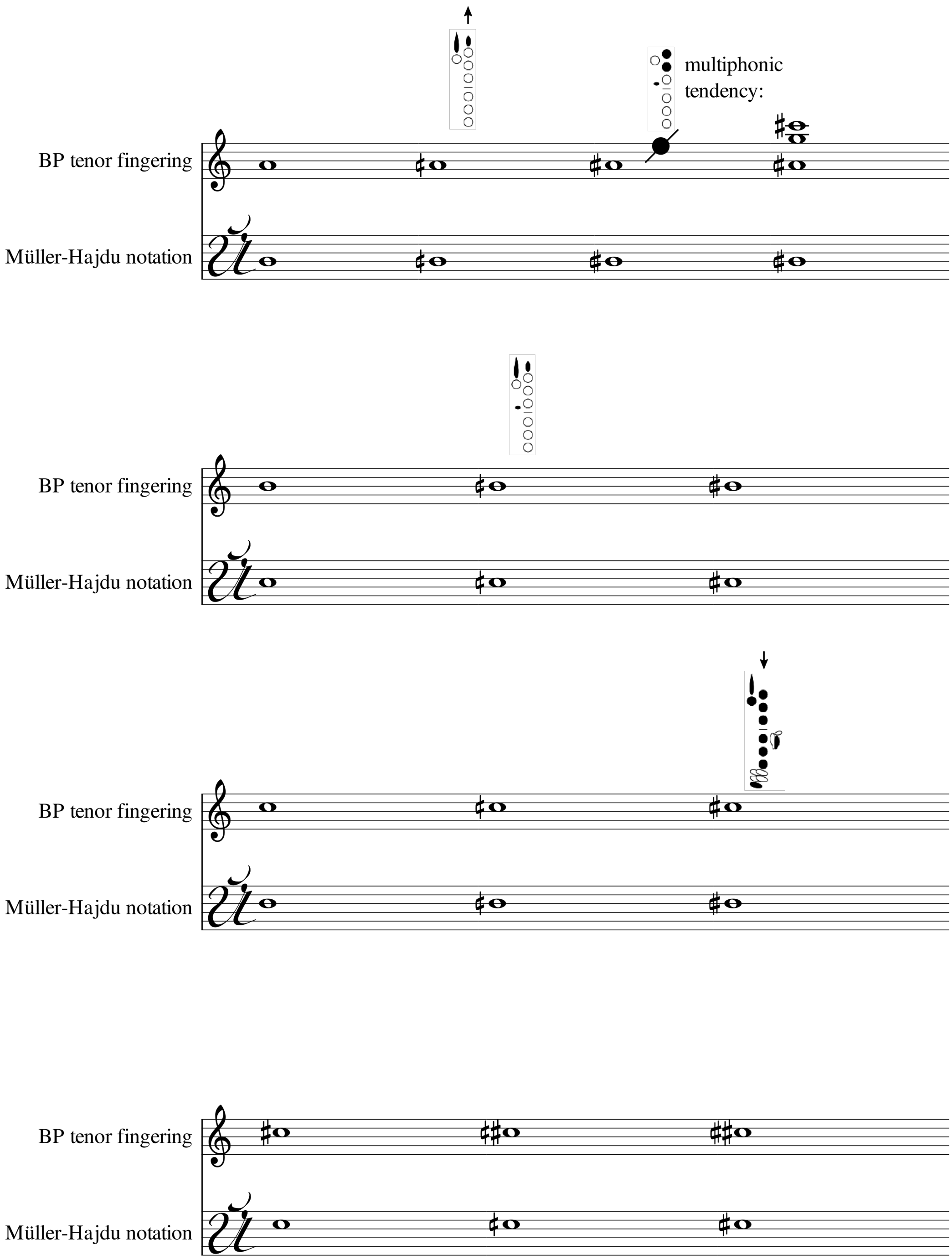
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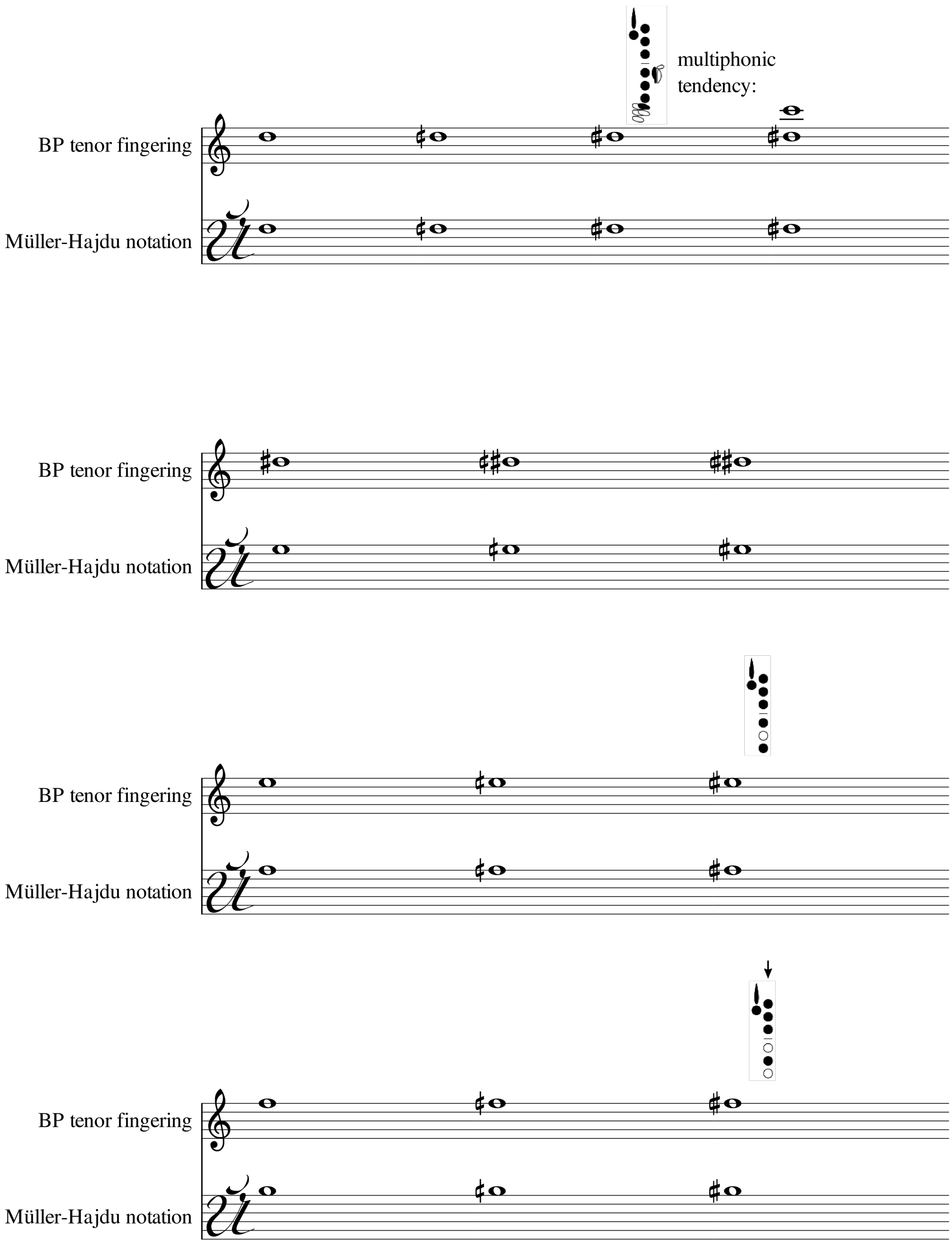
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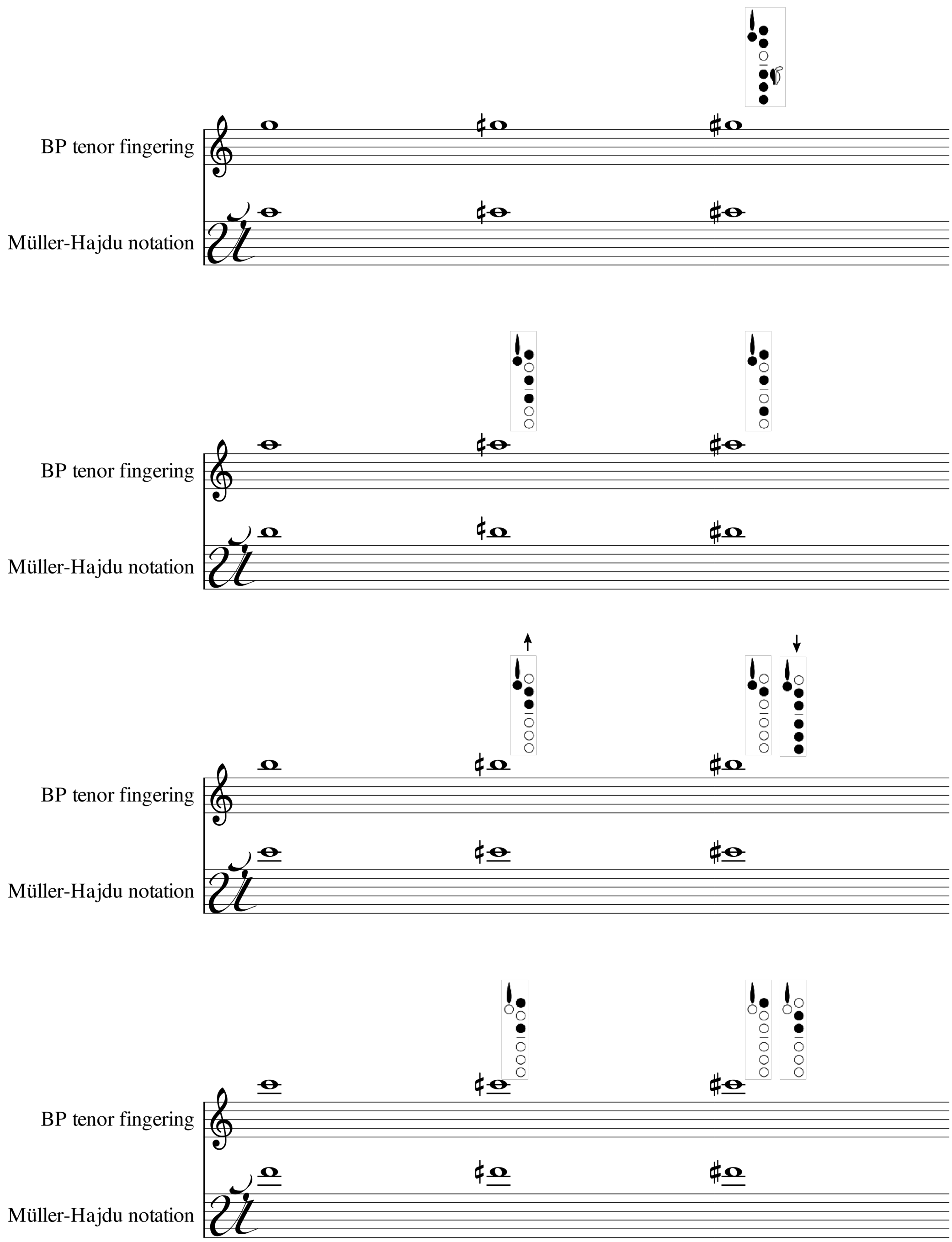
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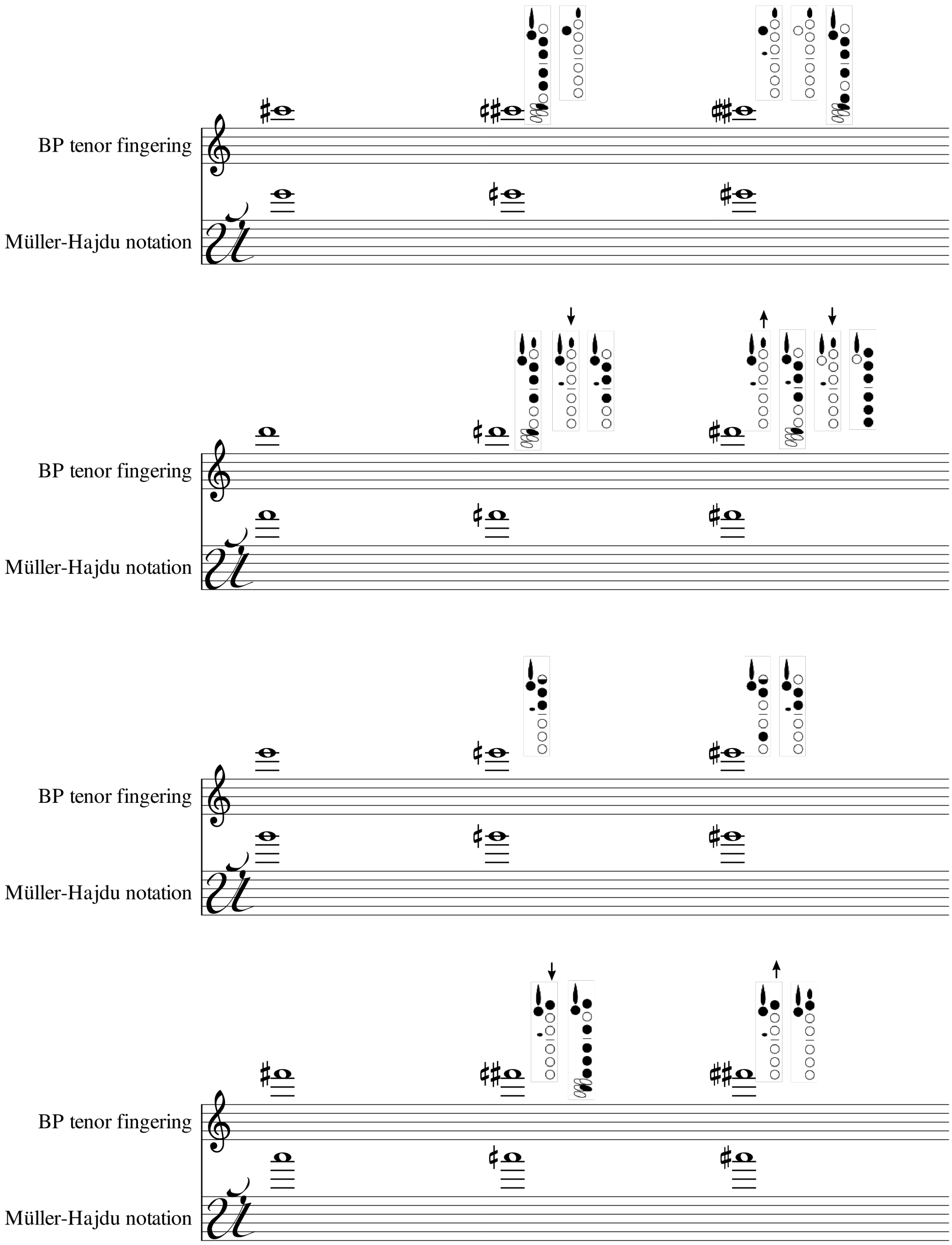
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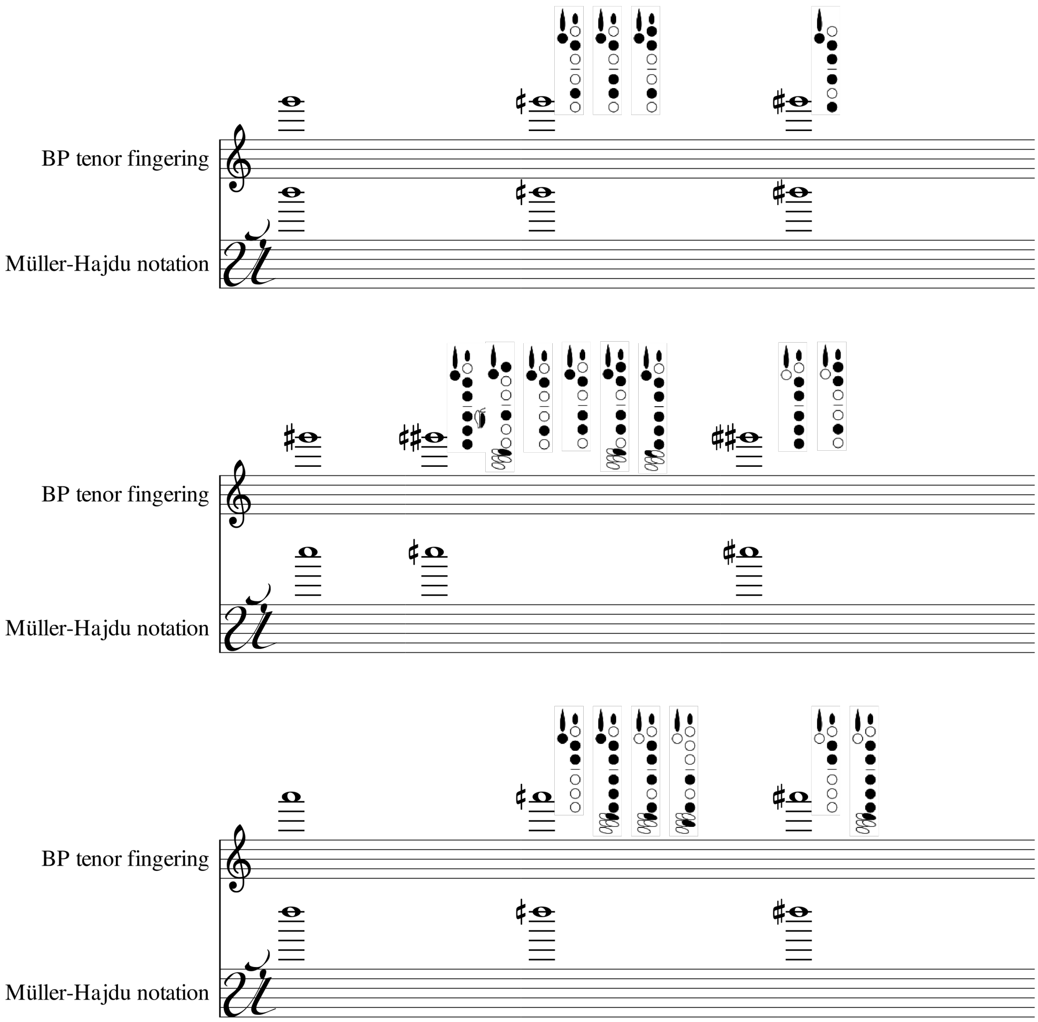


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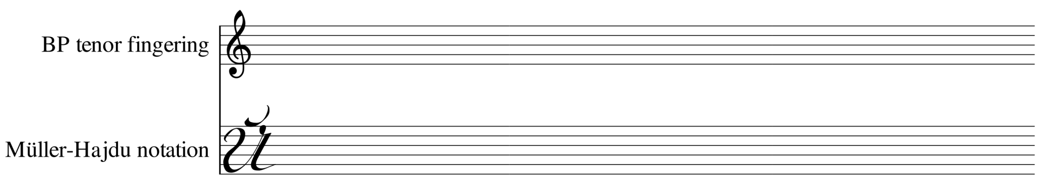

# Conclusion

This work aims to guide an approach to the Bohlen-Pierce scale in compositional and interpretational (clarinettist) terms. Details concerning the theoretical origin of the scale have deliberately been omitted, as well as considerations concerning pure, tempered and equal-tempered variants of the scale. Numerous authors from the fields of music theory or audiophysiology have already commented extensively on these topics. The scope of this work is therefore explicitly limited to aspects which are important to clarinettists in their practical work. Research of instruments has been limited to the soprano and tenor clarinet in BP; both were made in the workshop of Stephen Fox, Richmond Hill (Ontario, CA). People from a wide range of disciplines, interested in the BP scale, began to think about BP notation early on. Some of these suggestions are discussed and their advantages and disadvantages weighed up. Finally, the author makes her own proposal on BP notation, to which Georg Hajdu has also made important contributions. In practical work with musicians of different instrument families and styles as well as in cooperation with composers, the notation proposed here (Müller-Hajdu notation) has received positive feedback from the persons involved and has proved to be practicable without exception. Müller-Hajdu notation has already been used in a number of compositions. This has made compositional work and ensemble rehearsals much easier. Furthermore, compositions from the early days of the BP soprano clarinet are presented, some of which have been transcribed into Müller-Hajdu notation or other notations (e.g. eighth-tone notation) which can be helpful for the analysis in terms of better legibility. However, contemporary instrument-specific playing techniques have been rarely used in BP clarinet compositions to date, suggesting that in the early years of the BP clarinet its expressive possibilities could not yet be fully exploited. For this reason, the presentation of the current BP clarinet repertoire - composed between 2008 and 2018 - is followed by in-depth research, particularly into multiphonics on the BP soprano and BP tenor clarinets, and playing in the altissimo register. On the basis of practice-based research methods, the sonorous possibilities of the instruments are explored thoroughly. Outcomes apply to the BP clarinet models developed by Stephen Fox. A different instrument design would therefore give different results in multiphonic playing, or require different fingerings for playing in the highest registers. The proposed fingerings may serve the clarinettist more as a general guide than as a binding fingering chart, since finger positions in the high register are known to vary from player to player to no small degree. The practicability of the fingering combinations also plays an important role, so that research into the higher registers on the soprano and tenor clarinets in BP can by no means be regarded complete. The same can be said for the multiphonics. It is generally known that clarinet fingerings for multiphonics cannot be generalised easily, even on B♭ clarinets that are largely standardised in terms of keywork, and that different sounds for the same fingerings can result from different clarinet models. This thesis also discusses the division of the BP scale into third tones, which leads to 39 steps in the tritave (39div3), the so-called BP triple scale. To the author's knowledge, the BP triple scale is so far a theoretical construct that has not been applied in practice as of yet. Evidence of compositions in BP triple could not be found. In order to create the conditions for an investigation of the melodic and harmonic content of this scale, suggestions are made in the corresponding chapter. Not all pitches of the BP triple scale can be produced on soprano and tenor clarinets in BP, and some tones differ so much in tone colour and quality that their use lies more in the area of sound objects and colour fingerings.

Through theoretical and practical considerations, the potential of the BP clarinet for contemporary music is being explored and the foundation laid for an expressive, sonically flexible BP clarinet repertoire that combines the peculiarities of the sound material with the specific possibilities of the clarinet.

Having played BP clarinets for 10 years, I dare say that the BP system does not have the same musical potential as the traditional octave-based twelve-tone system. This may be due to the fact that the BP scale is, ironically, poor in dissonances and instead contains predominantly consonant intervals; the dissonant intervals, on the other hand, e.g. the BP eighth, are so dissonant that their use in harmonic context is virtually impossible. In addition, due to the large step size, even small intervals can be perceived as jumps rather than steps. Consequently, there is only one step size in the BP system that is heard as step-by-step progression, the simple BP tone step. In the twelve-tone system, on the other hand, two step sizes are distinguished, half-tone and whole-tone. If classical music of the Western world would have been in the BP system rather than the traditional 12-tone system, I doubt that Beethoven (and others) could have attained an equivalent level of sophistication in his symphonies as we know them today. Nevertheless, BP music can serve as a welcome change on the musical menu and enrich contemporary music with its high harmonic content. Its strange, unfamiliar harmonies, which sound as if they come from another star, can satisfy a need for new musical stimuli in the most interesting way. Thus BP music and the BP clarinet deserve a place in contemporary concert life.

Two currently existing instruments of the BP clarinet family could not be considered in detail in this thesis, the BP contra clarinet, completed in 2018, and the high clarinet in BP, which Fox named Epsilon clarinet on the basis of the tranSpectra notation system. Only a short time after the unveiling of the BP contra clarinet, the instrument already sparked the interest of several composers who welcome a deep-sounding harmony clarinet, and new repertoire is currently in preparation. Thus, more subjects wait for attention by BP researchers.

Lübeck, September 2019

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