A South African Spectral Composer, Andile Khumalo

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Declaration

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Abstract

In the 1970s and 1980s spectral music composition (spectralism) was developed by the French composers such as Gérard Grisey and Tristan Murail. The music was formulated with an understanding of acoustics and psychoacoustics. Spectral composition was born out of a tradition based on 'composing sound itself' by composers of the 20th century such as György Ligeti, Olivier Messiaen, Karlheinz Stockhausen, Giacinto Scelsi and Edgard Varése. What separated the spectral composers from their 20th century predecessors was the use of new technology, such as spectral analysis, as well as the use of the listener's perception as a compositional parameter. As a composer, my interest in spectral music composition and its relationship to South Africa encouraged an investigation into the technique and ideas of spectralism as well as the possibility of South African composers using spectral techniques. Two South African composers claiming to use spectral techniques were located: Andile Khumalo and Miles Warrington. The thesis first gives background to the nature of acoustics and psychoacoustics relevant to spectralism. Thereafter the historical trend towards spectralism is outlined. In order to understand the intricate nature of spectral composition, the background to the theories and music of two prominent French spectral composers, Gérard Grisey and Tristan Murail, is presented. Khumalo's music is then analysed, showing a strong connection to spectral technique and philosophy. Before concluding, a brief outlook on Warrington's and my own music is discussed.

Opsomming

In die sewentiger - en tagtigerjare is spektrale musiekkomposisie (spektralisme) deur Franse komponiste soos onder andere Gérard Grisey en Tristan Murail ontwikkel. Die musiek wat tot stand gekom het, is deur kennis en begrip van akoestiek en psigoakoestiek ingegee. Spektrale komposisie het voortgespruit uit die werke van 20ste-eeuse komponiste soos György Ligeti, Olivier Messiaen, Karlheinz Stockhausen, Giacinto Scelsi en Edgard Varése, werke waarin hulle die klem laat val het op 'om die klank self te komponeer'. Wat spektrale komponiste se werk egter van hulle voorgangers onderskei is die gebruik van tegnologie soos spektrale analise asook nuwe kennis aangaande die luisteraar se persepsie van klank as 'n komposisionele parameter. As komponis het my belangstelling in spektrale musiek my enersyds aangemoedig om ondersoek in te stel na die idees en tegnieke van spektrale komposisie; andersyds het hierdie genre binne die konteks van Suid-Afrika en die moontlikheid van Suid-Afrikaanse komponiste wat spektrale tegnieke in hul werk verwesentlik my geïnteresseer. Sodoende is twee SA komponiste geīdentifiseer: Andile Khumalo en Miles Warrington. Die tesis bied eerstens agtergrond tot akoestiek en psigoakoestiek in sovêr dit op sprektrale komposisie betrekking het, gevolg deur 'n historiese inleiding tot spektralisme. Om 'n beter begrip van spektrale komposisie te vorm word die teoretiese agtergrond van bogenoemde twee Franse spektrale komponiste, Grisey en Murail, uitgestip. Khumalo se musiek word dan geanaliseer om 'n sterk verband met spektrale tegniek en -filosofie vas te lê. Ten slotte word die musiek van Miles Warrington en myself oorsigtelik bespreek.

Acknowledgements

I would like to thank Professor Hans Roosenschoon for his help as supervisor and the extra hours spent talking about composition and other aspects of life as a composer. Apart from advice on my thesis, our conversations about worldly matters will remain a fond memory. I also appreciate the help from the composers Andile Khumalo and Miles Warrington for giving me access to their scores and discussing their music so freely. The Carnegie Research Commons at the Gericke Library of Stellenbosch provided a quiet working environment and team of staff that could answer any questions; the music librarians Santie de Jongh, Esmerelda Tarentaal and Sonette Fourie played an integral role in finding sources and correctly referencing them; and Barry Ross proof-read the thesis with a sharp eye, for which I am grateful. Lastly, thank you for the support from my girlfriend, Lucinda Brigitta Watts.

Preface

I first discovered the composition technique of spectralism during my BMus composition studies at Stellenbosch University. I researched the technique used by the French spectral composers Tristan Murail and Gérard Grisey, as well as their student Kaija Saariaho, by reading Kari Besharse's doctoral dissertation, *The Role of Texture in French Spectral Music* (2009). I then engaged in composing my own spectral music, *VerlorenVlei for Orchestra,* where I spectrally analysed field recordings of the wind, sea, marsh at night, pigs, cattle, and fire. In the beginning of 2015, I began communication with South African composers in order to locate any other South Africans using spectral techniques. I attended the New Music SA Indaba and the South African Society for Research in Music (SASRIM) conference (both in July 2015), in order to keep up to date with recent developments in South African music. Furthermore, I spoke to composers and musicologists about the possibility of spectral composition in South Africa.

In order to locate South African composers working with spectral techniques I communicated through e-mail with the following composers: Andile Khumalo, Cameron Harris, Chris Jeffery, Clare Loveday, Hannes Taljaard, Hendrik Hofmeyr, Jürgen Bräuninger, Martin Scherzinger, Michael Blake, Robert Fokkens, Theo Herbst, Ulrich Süsse, and Wayne Simpson. I also consulted the following musicologists: Chris van Rhyn, Hilde Roos, Stephanus Muller and William Fourie.

Of the composers, it was Jurgen Bräuninger who pointed me towards Andile Khumalo, who studied under the French spectral composer Tristan Murail. Khumalo confirmed his use of spectral techniques. Theo Herbst directed me towards a doctorate student at the University of Cape Town, Miles Warrington, who employed some spectral techniques in his doctoral portfolio. Other composers, such as Michael Blake and Hendrik Hofmeyr, said they know of no South African composers creating spectral music. In *Michael Blake 50: Personalia* (Muller, 2002:119-126), there is no mention of Blake having used any spectral techniques. In an interview with Hendrik Hofmeyr, Morné Bezuidenhout asks the composer about his musical ethos, and it is evident that no spectral techniques are present (2007:19-21).

I asked Andile Khumalo again whether he could think of any South African composers that employ spectral techniques. His response was that "not a lot of composers in South Africa understand the concepts of using and composing sound in that way which makes it difficult to find people who truly use spectralism as part of their work" (Khumalo, 2015a).

Hence I conducted interviews with two relevant South African composers, Andile Khumalo and Miles Warrington in June and July 2015, and confirmed their use of spectral techniques.

Apart from discovering two South African spectral composers, I was interested in researching spectralism further. I discovered that spectralism involves more than spectral analysis and re-orchestration, and the form is largely based on the listener's perception (psychoacoustics and higher-level auditory-cognitive processes). This motivated me to understand what the French spectral composers Gérard Grisey and Tristan Murail were writing about when they mentioned the use of the listener's perception in creating musical meaning.

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Chapter 1 - Background to Acoustics, Psychoacoustics and Spectralism

> Timbre, at first entirely ignored in composition, is eventually recognized as an autonomous phenomenon, then as a whole separate parameter; finally, it submerges, or rather encompasses the other dimensions of musical discourse (Murail, 2005a:176).

1.1 Introduction and Research Methodology

As a composer, the intention of this thesis is to enrich my knowledge on spectral composition by researching the foundation of the technique in 20th century music, as well as the techniques and philosophies formulated by two pioneering spectral composers Gérard Grisey and Tristan Murail.[1] It is possible that this thesis is the first research into spectral music composition in South Africa authored by a South African writer and featuring South African composers.[2] It was discovered that Andile Khumalo had studied with Tristan Murail and that a likelihood of his music being based on spectral techniques existed. This led the author of this thesis to the research question: What is the connection between the music of French spectral composers and the music of the South African born composer Andile Khumalo?

Khumalo studied under Tristan Murail at Columbia University where he completed a PhD in composition. His dissertation on Beat Furrer's FAMA makes use of analytical concepts central to understanding the use of the listener's perception (psychoacoustics and higher-level auditory-cognitive processes) as a compositional parameter used by spectral composers. The analytical concepts of Khumalo's dissertation could possibly give insight to the structure of his own music. Tristan Murail and Gérard Grisey, shared similarities in their theories on the use of the listener's perception as a compositional parameter. In order to ascertain whether a connection exists between Khumalo and the French spectral composers, the music and theories of Murail and Grisey are investigated. Furthermore, French spectralism arose out of the timbre-based and electronically-influenced instrumental music of the mid-20th century, such as Ligeti's atmospheric 'micropolyphonic' music. Murail and Grisey (among others) turned to the inner-details of sound

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[1] Grisey and Murail are not the only two French spectral composers and others such as Hugues Dufourt made contributions to the musical development. Furthermore, spectral movements in Romania and Germany also took place in the latter half of the 20th century.

[2] Refer to the Preface, where I give background to my search for possible South African spectral composers. I could find no publications on spectral music by a South African composer. There may, however, be unpublished research of which I am not aware.

itself by orchestrating partials discovered from spectral analysis. They furthered the ideas of the mid-20th century composers into theories regarding the perception of the listener. The use of the listener's perception as a compositional parameter is related to Gestalt psychology and psychoacoustic principles.

In Chapter 1 background to acoustics, psychoacoustics and spectral analysis will be presented to inform the reader on the listener's perception of sound and music. In Chapter 2 the foundation of the French spectral musical language in 20th century music is outlined. In Chapter 3 the theories and musical analyses of Grisey and Murail are investigated. In Chapter 4 Khumalo's *Bells Die Out* for ensemble is analysed in order to reveal possible connections to the spectral technique (and use of psychoacoustics) of Murail and Grisey. The analysis combines concepts from Khumalo's dissertation with spectral theories to discover a relationship between musical structure and the use of the listener's perception. This is derived from the analytical method of tracking changes in timbre, texture, energy and density level as proposed by Kari Besharse.

The theories pointed out in Chapter 3 were developed by two pioneers of French spectral music; other compositional approaches were introduced by younger spectral composers in the 1980s, 1990s and 2000s.[3] To close off this thesis, a brief outlook on two younger South African composers, Miles Warrington and Roché van Tiddens (the author of this thesis), is presented in Chapter 5. The outlook on the younger composers is not a critical evaluation and rather forms a brief mention of spectral analysis composition by additional South African composers.[4]

In addition, the process of research led to an enrichment of the author's (as composer) knowledge of the use of psychoacoustics as a compositional parameter, and the techniques of spectral analysis such as the transformation of spectral structures. These findings allowed the author to incorporate the ideas in the music composed for the practical component of the Master's degree in composition: the composition portfolio.

[3] An analysis of the spectral music of the later generations is not included in this thesis. The intention of the thesis is to increase knowledge of the foundations of spectral composition, by first exploring the ideas and techniques of the pioneer spectral composers. Although Khumalo is a composer from the younger generation, he was taught by the pioneer spectral composer, Tristan Murail. For this reason, there is a direct connection between the pioneers and Khumalo; hence his inclusion in this study.

[4] I recommend further investigation into the music of the two additional composers, Warrington and van Tiddens, in order to ascertain whether the use of spectral analysis in composition is connected to the French spectral technique and use of psychoacoustics.

1.2 Acoustics

Sound originates from the vibration or motion of an object changing the pressure in the atmosphere (water/air) it travels through (Moore, 1989:1). Sound can be represented by a spectrum, representing frequency and time.

Before explaining the nature of sound and the process of reception by the human ear, a few terms must be clarified. A *sinusoid* is a sine wave that has the most basic structure and is also referred to as a pure tone. The sine wave is periodic, and the number of periods per second is the frequency, measured in hertz (Hz) (Moore, 1989:1). A sine wave rotating at 440Hz is also known as the pitch A4. Therefore, *sinusoid*, *pitch* and *frequency* can be synonymous and the principle of pitch perception requires further discussion.

A complex sound wave is composed of a series of sinusoids, and can be decomposed using Fourier analysis. Jean Baptiste Joseph Fourier (1768-1830) developed a mathematical formula that decomposes any periodic waveform into a sum of a series of sinusoids (Pressnitzer & McAdams, 2000:36). Any complex waveform can be analysed as a series of sinusoids with specific frequencies, amplitudes and phases (Moore, 1989:3).

There exist periodic and continuous complex sound waves. A period is a completed cycle of a sine wave (Moore, 1989:3). The periodic complex sound wave is composed of overtones/harmonics related to the fundamental frequency and is the simplest to break apart with Fourier Analysis (ibid.). The harmonic series is calculated by multiplying the fundamental by whole number integers.

$$f(r) = f_0 \times r$$

r refers to the rank number of the harmonic series

With C1 as the fundamental at 32.70Hz, the rank numbers 1, 2, 3, 4, 5, 6, 7, 8 will give the first 7 harmonics:

32.70hz × 2 = 65.40hz (octave above rank 1)

32.70hz × 3 = 98.10hz (Perfect fifth above rank 2)

32.70hz × 4 = 130.80hz (Perfect fourth above rank 3)

etc.

Figure 1.1 - Harmonic series

Figure 1.1 displays the first 23 rank numbers above the fundamental C^1 (32.70hz) rounded off to the nearest quarter-tone.

The periodic complex wave is comprised of the fundamental and the harmonics occurring simultaneously to create a single complex wave. The overtones (harmonics) are proportional to the fundamental frequency, and therefore oscillate at a whole-number multiple within the period of the fundamental frequency, allowing the combined complex sound as a whole to be periodic. The periodic complex can be referred to as a harmonic sound that is characterized by a periodic envelope (Langner, 2005:50).

An example of a continuous complex sound is white noise, where the periodic sine wave components combine into a non-periodic structure. This creates a continuous band of frequencies with the same amplitude (Moore, 1989:5). This is on the most extreme end and between there exists non-periodic sound waves with varying amplitudes and non-proportional partials. An extension of Fourier analysis is Fourier Transform, which allows one to deconstruct a continuous non-periodic sound (Pierce, 1999:7). The non-periodic complex sound is deconstructed into sinusoids referred to as partials. Partials refers to sinusoids comprising any complex sound because any frequency component may be called a partial, whether or not it is related to the fundamental frequency (Utriainen, 2005:52). The partials of a non-periodic complex sound are not proportional to each other. This is referred to as an inharmonic sound with inharmonic partials (Anderson & Murail, 1993:322).

1.3 Pitch and Timbre Perception

Levitin describes pitch as a purely psychological construct related both to frequency and its relative position within a musical scale (2006:15). The sensation of pitch occurs in the process of hearing and is that attribute of auditory sensation that allows one to determine a musical scale (Moore, 1989:3). A musical sound that evokes the sensation of pitch is referred to as a tone as it has a proportional overtone series (ibid.).

I will briefly explain the auditory process in order to identify important aspects of pitch and timbre perception.[5] There are three parts of the auditory system, the outer, middle and inner ear. In the middle ear the basilar membrane can be found running across the length of the cochlea. Sound vibrates within the basilar membrane and it acts as a Fourier analyser by splitting complex sounds into their component frequencies (Moore, 1989:45). Different parts of the membrane are sensitive to different frequencies, and as the basilar membrane vibrates, hair cells in the organ of Corti are displaced leading to nerve fibres firing neurons to the auditory nerve (ibid.). The nerves fire at the rate of each individual frequency. The inner ear effectively turns vibrations on the basilar membrane into electrical signals that are sent to the auditory nerve where the auditory brain stem analyses the neurons (Langner, 2005:51).

A sinusoid that vibrates the basilar membrane leads to the nerve fibres firing neurons at the same rate as the sinusoid's vibration. This is referred to as 'phase locking' (Moore, 1989:45). A periodic complex tone creates the same sensation of pitch as the rate of firing of all sinusoids are proportional to the fundamental frequency occurring within the same period (Langner, 2005:50). The sensation of pitch then refers the frequency of the fundamental, while the overtones merge as a single phenomenon. A test was done where the fundamental was removed and only the overtones remained. The sound created a proportional rate of firing that merged into the sensation of pitch being the missing fundamental (Levitin, 2006:41). Therefore, the sensation of pitch in a complex tone is the fundamental frequency and the harmonically related sinusoids (proportional) reinforce the sensation of pitch as the fundamental frequency (Carterette & Kendall, 1999:763).

When short tone bursts enter the ear, there is not enough time for the frequency to complete a cycle and allow for 'phase locking' (Pierce, 1999:14). There is then no sensation of pitch. The sensation is then that of a click. In a non-periodic complex tone, there is no sensation of pitch as there is no proportional rate of firing of neurons. In the missing fundamental test, there is no difference in the sensation of pitch between the two similar periodic complex tones. What then does the listener hear? What term can we use to describe the difference in the character of these sensations? The answer is timbre.

[5] For a more extensive explanation on auditory processing, the reader is referred to Moore (1989:15-44).

When some overtones were removed out of the missing fundamental test, the sensation of pitch still occurred. Moore, however, describes the difference in sensation as a change in timbre (1989:167). Risset and Wessel describe timbre as referring to "the quality of sound" (1999:113). Unlike pitch, timbre is not a well-defined perceptual attribute of sound. Timbre distinguishes the same tone played on one instrument from another and is "a kind of tonal colour that is produced in part by overtones" (Levitin, 2006:15). The phenomenon of timbre was for so long not fully understood and only recently due to technological advances in acoustics and psychoacoustics can we understand the concept (Reigle, 2008:7). This is due to the complex phenomenon that occurs during the process of hearing and perceiving.

The word timbre is what describes the difference between two of the same pitches played one after the other, only varying in the overtone series and differing amplitudes of each overtone. The concept of pitch perception explains that when overtones are removed or the amplitude changed, the perception of pitch remains the same, and the complex wave is still perceived as a single phenomenon. It is the quality of sound (timbre) that changes.

In a periodic complex sound the amplitude structure of each sinusoid determines the overall complex wave. Varying the level of amplitude of the individual sine waves changes the shape of the combined complex wave. This representation only accounts for timbre in a single moment and the recent technological development has identified that other factors such as the attack of the tone and temporal evolution of the spectrum, which also play a role in determining timbre (Dogantan-Dack, 2008:65). Timbre can also be used to describe the perceptual difference of varying non-periodic complex sounds (no sensation of pitch) that occurs when partial content and amplitude structure is changed. These complex sounds are also perceived a single phenomenon as the nerve fibres fire at the different rates of each partial merging the details into one sound.

1.4 Gestalt Perception

We have learnt how the ear allows a single perceptual phenomenon of sound to occur. However, what follows is the cognitive process in the brain that makes sense of these proportional frequencies as they evolve in amplitude over time. Cornelia Fales, an ethnomusicologist who has done research on the history of timbre in Western and non-Western cultures, writes:

> Recall that a tone's timbre depends (in part) on the relative strength of the harmonic overtones that comprise its spectrum, and that the transformation of these overtones into the sensation of timbre is

> accomplished by means of a process called **perceptual fusion**. A crucial difference, therefore, between the parameter of timbre and the parameters of pitch and loudness is that timbre is a purely perceptual phenomenon, with no direct correspondence to the acoustic stimulus that provokes it, and no existence outside of a listener's mind. A source emits multiple frequencies from which a perceiver hears a single, timbred tone (2008:130; own emphasis).

Gestalt psychology explains that for survival we make sense of information in order to understand "what is out there" (Denham & Winkler, 2015:1). When we see an incomplete shape, we are able to complete the lines into a shape we recognize – for example, making out figures in clouds. When there is more than one sound occurring, the auditory system needs to organize these sounds in order to associate each sound with the relevant source (ibid.). This is done through the process of grouping different events into units or wholes (Snyder, 2000:31). Organization is made necessary due to limits of the human nervous system in processing information (Snyder, 2000:31). A musical Gestalt is defined as an impression of wholeness that results from the cohesion of multiple parts (Khumalo, 2014:12).

The following are Gestalt grouping principles based on Hermann von Helmholtz's (1821-1894) concept of unconscious inference, where the brain makes sense of incomplete information: grouping according to proximity, similarity, symmetry, good continuation and common fate (Shepard, 2001a:32). Figure 1.2 displays the visual representation of the Gestalt principle which also applies to the grouping of auditory information (ibid). Objects that are in close proximity, are similar to one another, and are symmetrical, are grouped together; objects that are arranged in such a way that they appear to continue from into the another are grouped due to good continuation (Shepard, 2001a:32). The above principles are used to complete otherwise incomplete information, whereas common fate is a grouping principle that groups objects that move together (2001a:33). A common onset time of different sound sources and common amplitude and frequency modulation would be grouped together due to common fate. The partials that build up a complex sound are grouped together as they are moving together from the same point in time.

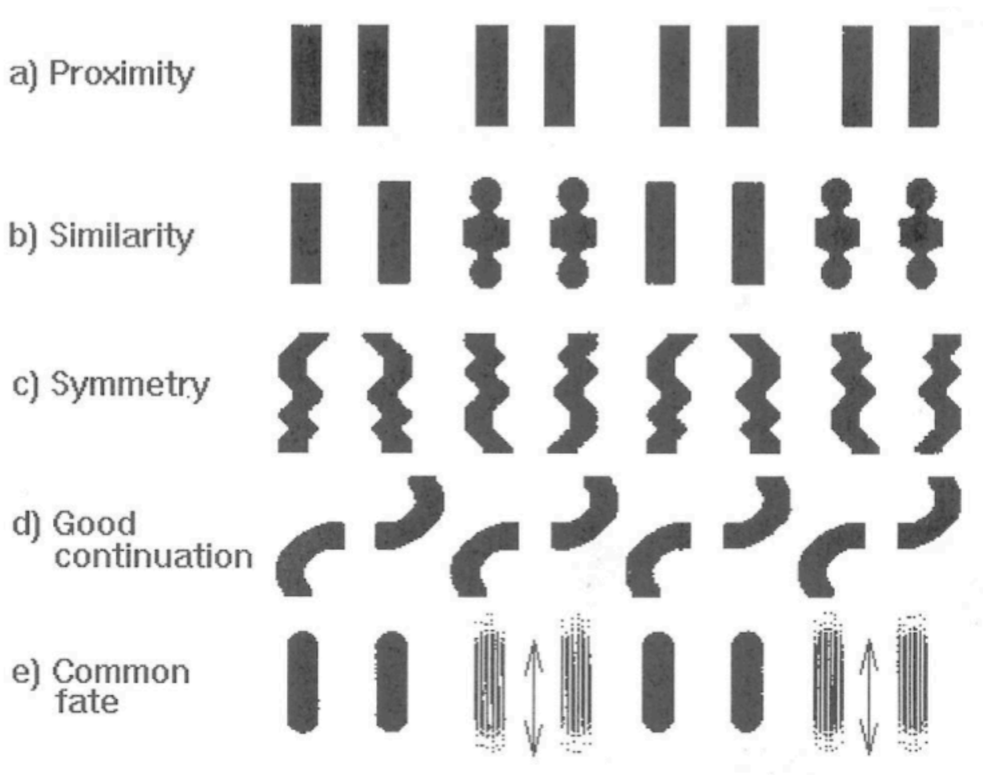

Figure 1.2 - Gestalt psychology grouping principles (Shepard, 2001a:32)

The process of organizing acoustic features into meaningful groups is known as perceptual organization, and the core observation is that larger groups are formed by smaller parts that characterize the whole (Denham & Winkler, 2015:1). The boundaries of groups are determined by changes in auditory information (Snyder, 2000:31). [6] Auditory events occurring in close proximity and of a similar nature form a continuous process and are grouped together (2000:42).

Recall that timbre is not only determined by a snapshot in time of the frequency details of a complex wave, but also by the temporal evolution of the envelope and attack transients. Common fate is the strongest Gestalt-based explanation of how timbre information is grouped, where smooth changes in partials and amplitude allow for the perception of one group and discontinuities result in the perception of new objects. The partials of periodic/non-periodic complex sounds evolve continuously as different partials change in amplitude at different moments in time. The smooth rate of change occurring in the spectral envelope, where one partial appears to be the continuation of the previous one, is an example of good continuation and the entire sound unfolds over time to be grouped as one global percept allocated to one source.

[6] This Gestalt principle is relevant to the music of Andile Khumalo and is discussed further in Chapter 4, specifically in relation to sections 4.3.2 and 4.3.4.

Perception occurs through processing the configuration structure of an object that is already organized; recognizing the configuration based on the structure of the object combined with the "psychophysiological structure", or in other words, a predicted structure (Reybrouck, 1997:58). In my opinion, an example of a predicted structure is found where members of different cultures are able to understand their own respective languages: an 'accent' is not perceived as such by someone with the same 'accent', because the listener is able to easily identify the speaker's words and inflections due to their own pre-conceived structure of these sound objects. In music this becomes relevant when constructing similar or different events, structures or processes.[7]

The perception of sound results in the connection of frequencies comprising a complex tone into a single phenomenon. Hasegawa writes "we are not merely passive recipients of musical sounds, but active interpreters of those sounds into logical structures" (2006:265). Regular occurring acoustic vibrations occurring more rapidly than 50msec fuse into a continuous sensation called tone (Snyder, 2000:25). A complex waveform undergoes fusion in our perception as the single events surpass this threshold of tempo and individual frequencies forming the complex wave are fused together to form a single higher-level event (Snyder, 2000:125). Timbre is therefore the result of the 'micro-rhythmic' events that are too fast for us to perceive them individually (Snyder, 2000:125). Different timbres are then grouped into larger events for us to distinguish them as patterns, streams or objects (Denham & Winkler, 2015:1).

1.5 Possibility of Hearing the Inner-Details of a Complex Sound

Cornelia Fales coined a concept of timbre perception with the term 'Perceptual Law of Seamless Reality'. Here, listeners deny the existence of an acoustic world different to the one perceived by them (2008:130). This has to do with the 'unaware' perception of timbre, where only if you try to be alert of the inner-details of a timbred tone and focus your attention on trying to hear out the parts of it, can you break away the perceptual bond of a uniform timbred tone. One cannot simultaneously hear out the individual parts of a timbred tone and experience the sensation of a uniform timbre. This is due to ambiguity in perception where the same physical stimulus can give rise to different perceptual interpretations on different occasions (Shepard, 2001b:123).[8] Refer to to Figure 1.4 (Rubin's Goblet) where one can only see a candlestick or two faces looking at each other, and it is impossible to see both in full at the same time. The ambiguity explains why it is not possible to break the bond of a unified perception of while also perceiving timbre as a whole.

[7] This will be further expanded in Chapter 3 under Gérard Grisey's theory of musical time, section 3.3.1.2 where the degree of change has an effect on the listener's perception of time.
[8] This forms the basis of Murail's theory of 'a sculptor with a block of ice' discussed in Chapter 3, section 3.3.2.2.

Shepard explains that ambiguity was used by Bach in constructing melodic patterns in different octaves, where ambiguity between the connections of the melodic line exist, makes the music fascinating to listen to (2001b:123).

Figure 1.3 - Rubin's goblet (Shepard, 2001b:123)

In the 17th century, Marin Mersenne (1588-1648) listened to the partials originating from a single string vibration and understood that the rate of vibration was related to pitch (Pierce, 1999:3). Later, Jean-Philippe Rameau (1683-1764) built his laws of acoustics by spending many years focusing attention on hearing the overtones of a sound (Fales, 2008:133). In the 19th century, Hermann von Helmholtz (1821-1894) heard out partials by listening to a vibrating string through different resonant filters (Pierce, 1999:14). Ohm's acoustical law shows that under unusual circumstances we can hear out individual overtones from a single complex tone (Moore, 1989:4).

Fales explains what is termed the 'paradox to timbre' (2002:58). Sound carries information, allowing us to identify the source of the sound as well as the environment the sound travelled through. The materials used to create the sound can be identified through the air with fluctuating pressure that enters our ear, however, spectral analysis reveals that there is a difference between the cognitively processed sound and what is displayed by analysis. Spectral analysis reveals the true physical characteristics of a sound, and not the resulting sound perceived by our minds (Fales, 2002:58). Fales writes, "the paradox emerges with the observation that while timbre is a dimension of central importance to identifying sources, it is also the dimension that is most divergent from the sound in the physical world" (2002:58). Whereas the spectrum reveals the physical nature of sound, the field of psychoacoustics refer to the term timbre to "denote perceptual mechanisms that classify sounds into families; therefore, timbre concerns the perception of sound signals" (Utriainen, 2005:66).

This is further explained by Warren (1999:20). When a sound enters the ear, there are slight changes that occur in the acoustic interpretation. The spectral components of sound are delayed and changes in intensity occur before the neural transduction occurs. Despite this spectral distortion, there are no changes in the timbre or "nature of sound" that results after neural transduction. These changes are balanced by the brain in order to make sense of the frequencies, creating a uniform timbred tone.

Timbre is one of the most sensitive categories of auditory perception and is so acute that we can immediately identify a voice over a telephone where frequencies have been filtered out (Murail, 2005a:176). The refinement, despite some inadequacy, by which our auditory system works is thus extraordinary.

1.6 Spectral Analysis

The first graphic representation of sound was made possible through Édouard-Léon Scott de Martinville's phonautograph in 1857 (Moore, 2009:92). A horn was used to focus sound waves on a small diaphragm attached to a stylus that scratched a representation of the sound waves onto a soot-stained rotating glass cylinder. De Martinville invented this technology in order to communicate with his deaf wife. The invention was taken further by Thomas Edison, who then developed it into a recording device.

More recently, the process of digital recording allows for spectral analysis to be performed easily by computer software that makes use of Fast Fourier Transform (FFT) in order to decompose an incoming sound signal into its sinusoid spectral components. The software SPEAR[9] performs FFT on a sound source and presents the user with the sinusoid components of the sound file. Other software such as AudioSculpt,[10] OpenMusic[11] and PatchWork[12] developed at IRCAM[13] offer further composition capabilities of working with harmonic spectra. Figure 1.5 displays spectral

[9] Sinusoidal Partial Editing, Analysis and Resynthesis Software developed by Michael Klingbeil. For further reading see his doctoral thesis (Klingbeil, 2009).
[10] For further reading refer to AudioSculpt (2016:1).
[11] For further reading refer to OpenMusic (2016:1).
[12] For further reading refer to *PatchWork* (PatchWork, 2016:1).
[13] Insitut de Recherche et Coordination Acoustique/Musique was founded in 1970 by Georges Pompidou, who invited Pierre Boulez to create and head the institute in acoustic research. In 1988 MaxMSP software was developed and in later years additional valuable software was developed for use by composers and electroacoustic musicians (IRCAM, 2016b:1).

analysis of a B♭ Clarinet playing E^5 processed through SPEAR.[14] The sinusoid components are graphically displayed in the three dimensions (time, frequency and amplitude) and allow the user to view the details of any global timbre. The *x*-axis indicates time, the *y*-axis frequency, and the darker/lighter shading of the sinusoids (lines) displays the amplitude level (darker for larger amplitude). The lowest sinusoid is the fundamental E^5 with the harmonics displayed above. Notice how the sinusoids are not stable and curl up and down in a continuous fashion over time. SPEAR allows one to identify the precise frequency of each sinusoid by hovering over the sinusoid with the mouse cursor. One can zoom into the details of sinusoids up to split seconds in time. Software such as AudioSculpt presents similar results and allows for additional tools such as converting the data into music notation after separating spectral areas (AudioSculpt, 2016:1).

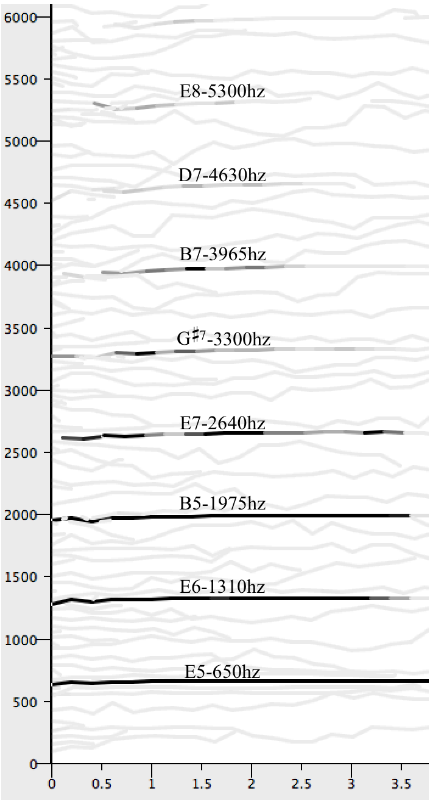

Figure 1.4 - Spectral analysis through SPEAR of the sound source, B-flat clarinet playing E5

1.7 Spectralism

Spectral composition began in France during the 1970s with the composers Gérard Grisey, Tristan Murail, Horatiu Rădulescu and Hugues Dufourt (Moscovich, 1997:21). The spectral composers furthered timbre-driven composition by 20th century composers such as György Ligeti, Olivier Messiaen and Karlheinz Stockhausen. The 20th century development in contemporary music shook

[14] The processing of the sound source through SPEAR was conducted by the author.

the basis of traditions built up by Western culture over many centuries. These composers wrote instrumental music that was influenced by electronic music. There lies a connection between the 'micropolyphonic' orchestral works by Ligeti and the orchestration of the 'micropolyphony' of partials into macro form by spectral composers. The spectral composers furthered this tradition by using technology that allows sound to be analysed and its inner structure fashioned at will (Pressnitzer & McAdams, 2000:33). The music of spectral composers was therefore electronically influenced instrumental music, with the use of technology as a tool for acoustic pitch determination.

Spectralism offered a solution to the problems of other 20th century compositional techniques such as serialism. Unlike serialism, the theory behind spectralism was close to the resulting sound. This is because the spectral composer works with sound itself, in terms of how it is constructed, to form different perceptual goals for the listener. Tristan Murail writes that spectralism is based on a continuum between parameters, and that the continuum is the space that is the same in the physical reality, but is separated by perception (1984:158). As well as the continuum between the perception of harmony and timbre, there also exists a continuum between other parameters such as frequency and rhythm (ibid.). The idea of a continuum between parameters resulting from a difference in perception stems from the ideas of Stockhausen.

The different spectral composers worked with a similar approach to constructing the inner-details of sound into musical form. Through spectral analysis they explored partial content, intensity and duration (Besharse, 2009:4). The connection between the composers is referred to by Murail as an 'attitude', and by Gérard Grisey as *écriture liminale* (Van Herck, 2008:49).[15] This connection is built on the psychoacoustic aspect of timbre perception used as a compositional parameter. The use of spectral analysis as pitch material is just an aspect that defines their music on the surface – at the heart of the technique lies a fascination for psychoacoustics and the degree of predictability and unpredictability (Anderson, 2000:8). One psychoacoustic phenomenon is what Grisey's term refers to as ambiguity when "the sounding of a chord oscillates between the perception of a chord and the perception of a timbre" (Van Herck, 2008:49).

The spectral technique involves the orchestration of partials with specific choices of instruments in order to create what is known as orchestral synthesis. Orchestral synthesis stems from the electronic technique of additive synthesis where sine waves are combined to create more complex aggregates (Lehman, 2012:1). The spectral details of a sound source provide the material for orchestration,

[15] Translated as "writing the liminal" (own translation). The Oxford English Dictionary defines 'liminal' as: "Characterized by being on a boundary or threshold, esp. by being transitional or intermediate between two states, situations, etc." (2015:1).

harmony, duration and musical form. The temporal flow of a spectrum is followed by the composer with staggered entries in orchestration (Besharse, 2009:82). The resulting sound when orchestrated is not a direct synthesis of the analysed sound, but rather forms a new sound as each instrument adds their own spectral content to the overall result. What occurs is a new global timbre as the instruments closely resemble the original spectral content of the analysed sound, and if played correctly, the aim is for fusion of voices into a single phenomenon (Besharse, 2009:84). The sound source is 'time-stretched' allowing for microscopic view on the inner details. This same structure can then be orchestrated allowing for a macro representation. Due to the sound source being represented in various dimensions in time, the perception of time in relation to the original source plays a role in forming the compositional structure. The spectral composer aims for the listener to be moved between structures that either create the perception of stasis or momentum.

Murail refers to some of the philosophies that form the attitude of spectral music:

> Spectral music is inspired or determined by the notion of the spectrum and its evolution in time. As a result, it can be understood through an aesthetics of continuity that emphasizes global structure, as well as logarithmic organization and construction of mathematical functions. All of these characteristics are fed by an awareness of the relationship between conception and perception; spectral music incorporates **psychoacoustic laws of perception** and the knowledge of sound into the compositional process and the conception of the musical piece (Murail, as quoted in Hirs, 2008:276; my emphasis).

Although there were a group of French composers working with spectral analysis, Grisey and Murail were responsible for formulating similar philosophies around the construction of spectral music with certain psychoacoustic goals for the listener. These ideas were taught to their students and a second generation of spectral composers, such as Marc-André Dalbavie, Kaija Saariaho, and Philip Hurel, arose in the 1980s and 1990s (Besharse, 2009:22). I will discuss the theories of Grisey and Murail, and present the various facets of their compositional process. The technique of spectral analysis is combined with technological tools to enable continuous progressions that form 'musical breathing'. Because the ideas of spectral composition are rooted in the 20th century, I will first give a historical overview leading up to spectralism.

Chapter 2 – A Historical Overview of Spectralism

> He who does not penetrate to the interior, to the heart of sound, even though a perfect craftsman, a great technician, will never be a true artist, a true musician. (Giacinto Scelsi, as quoted by Fineberg, 2006:129)

2.1 French Context

In the 1960s in France there was political unrest under the Gaullist Republic and the police had to repress students and workers protesting in the streets (Moscovich, 1997:21). Amongst the protesting students during this political crisis were a group of composers who would start writing spectral music. Composers such as Grisey, Murail, Hugues Dufourt, and Horatiu Rădulescu refreshed the development of contemporary music by bringing a group of instrumentalists together as the ensemble L'Itinéraire in 1973 (ibid.). The spectral composers shared a cultural movement based on sound. Dufourt's ideas of what contributed to spectral thinking were:

> The development of instrumental research, the impact of electroacoustics on musical thought, and, above all, the collapse of the social and mental barriers under which the [musical] profession was becoming ossified (Moscovich, 1997:21).

Murail stated that spectralism was a rebellion against composers who refused to take into account the perception of the listener (Besharse, 2009:19). Pasler writes that spectral music came from a cumulative development in French ideology rooted in interest in perception dating back to impressionism (2004:125). Serial music focused on discontinuous relationships as well as mathematical thinking, and spectral composers reacted against this by turning to the character and phenomenon of sound itself: its occurrence in nature as continuous and transitory, and its effect on the listener (Pasler, 2004:129). They felt that theoretical processes did not relate to musical results, and instead of turning back to tonal music, they delved into the very matter music is made of: acoustics.

Fineberg writes that spectral music was not a purely reactive movement and that predecessors had created streams of musical ideas and processes that led to spectralism (2006:123). The music of these predecessors will be placed in context below.

2.2 Natural Laws of Acoustics

According to Anderson, the origins of spectral music are too diverse to point out all precursors and influences (2000:8). Fineberg (2008:31) gives background to the term spectralism, writing that composers have been thinking about sound and its inner properties throughout history. In the 17th century, Marin Mersenne presented his acoustic research in *L'Harmonie Universelle* (1637) and investigated the relationship of the length of a string and force of vibration to the resulting frequency (Pasler, 2004:125). In the 18th century, Rameau wrote in his *Treatise on Harmony* that sound is to sound as string is to string, the faster vibrations of a string fall within the proportion of the lower (1971:5). The higher overtones fall within a proportional scope to the lower.

More recently, Arnold Schoenberg foreshadowed the idea of spectralism when in 1911 he wrote:

> The evaluation of tone colour, the second dimension of tone, is in a much less cultivated, much less organised state than is the aesthetic evaluation of [pitch]. […] Now, if it is possible to create patterns out [of] pitch, patterns we call 'melodies,' progressions, whose coherence evokes an effect analogous to thought processes, then it must be possible to make progressions out of… 'tone colour'… (1978:421).

2.3 World Music and Extended Techniques

Reigle believes that four developments influenced spectral thought: access to world music through ethnomusicological recordings; the exploration of extended instrumental techniques; advances in technology such as recording devices, sound analysis and synthesis; and understanding of psychoacoustics (2008:5).

Increased knowledge of timbre and its inner-details was predicted by one of the forefathers of the spectral movement, Giacinto Scelsi, who said that "it will be possible to perceive the complexity of harmonics before the end of the century" (Reigle, 2008:4). It is interesting that Scelsi was influenced by world music, and more specifically Rudhyar's ideas that involves the equality of tones and sound from ancient civilizations (ibid.). Rudyhar wrote a proto-spectral[16] score in 1922 consisting of fundamentals and specified changes in the strength of overtones over time (Reigle, 2008:5). He did not use technology and relied on intuition to create this music. According to Reigle this innovation has gone rather unrecognised (2008:5).

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[16] Proto-spectral music follows similar techniques, ideas, and aesthetic results as spectral music without the use of technology and perception of the listener. Jonathan Harvey uses the term in 'spectralism' (2001:12).

The Mongolian Höömi sing a fundamental pitch coloured by the changing of upper partials, which influenced composers such as Claude Debussy, Paul Hindemith, Alexander Scriabin, Edgard Varèse, André Jolivet, Giacinto Scelsi, Olivier Messiaen, Horatiu Rădulescu, Roger Vivier, and Per Nørgård (Castanet, 2000:30). The Mongolian singers explored the nature of sound in a ritual sense, and this was 'music' based on sound and the awareness of its inner-details. The sound world created by Mongolian singing is that of a constant drone with a 'melodic' line occurring above with partials. The tuning of the partials and the melodic lines affected the tonal structure of these composers, and with some of them, most boundaries of traditional music collapsed.

Karlheinz Stockhausen was influenced by aspects of non-Western music, and this is displayed in his theories. His idea that there is equality between all parameters (rhythm, melody, harmony, and timbre all being the same thing in different proportions in time) is influenced by non-Western music (Wörner, 1973:128). Stockhausen's concepts of time come from Japanese music, where they have a larger time scale than Europeans; this influenced larger durations and bigger pieces (Cott, 1974:32).

Extended instrumental techniques formed a large part of the 20th century musical palette and opened up new sound worlds by changing the notion of sound and of what music is. Musical instruments created new sound worlds never heard before. Experiments such as the Futurist's *intonarumori* explored the concept of noise, and created recognisable everyday sounds with acoustic instruments (Bayar, 2008:107). According to Edgard Varèse, the venture into new sound worlds was to combat the limited timbre, range and execution of traditional instruments (Stenzl, 2006:145).[17] The new approach to sound required new concepts of form (Besharse, 2009:8).

Krzysztof Penderecki made use of extended techniques and unusual percussion in the 1960s with pieces such as *Polymorphia*, *Strophes*, and *De Natura Sonoris 1 & 2*. This music, defined under the term 'sonorism', was influenced by the work he did in the electronic studio. In an interview Penderecki stated that he "heard the sounds of the electronic […] and it helped me to develop my music […] my pieces *Threnody*, *Polymorphia* […] were very much inspired by electronics" (Louisiana Channel, 2013). The sounds generated in the studio inspired complex sounds to be produced on instruments. For example, when string instruments are asked to play many different extended techniques, they can be viewed as different oscillators. These then combined into a mass texture, or a new synthesized timbre. The form involved moving between various vertical and horizontal densities of sound-mass textures. Penderecki's works *De Natura Sonoris 1 & 2,* explores

[17] Edgard Varèse felt that the *intonamaruri* experiments by the Italian Futurists only reproduced what is usual in everyday sounds. He dreamt of the possibilities of sonic expansion and hoped that he could reproduce these from his imagination (Varèse & Wen-Chung, 1966:11).

the inner-details of sound, with a smooth, continuous, gradual development (Schwinger, 1989:145). The complexity of the extended techniques creates sound masses that fuse into a global sound phenomenon.

2.4 Predecessors to Spectralism

The spectral composers absorbed "sound as a nucleus constructed of different parts" into their musical material and turned to factors such as the perception of sound and the psycho-physiological response to sound (Moscovich, 1997:21). The boundaries between melody, rhythm, harmony, and texture were blurred. Engaging with sound in this way can be traced back to composers such as Claude Debussy, Edgard Varèse, Giacinto Scelsi and Olivier Messiaen (ibid.). These composers, as well as Karlheinz Stockhausen, Harry Partch and Paul Hindemith, had an interest in the physical laws of sound and its place within music, as well as using timbre as the main musical parameter (Besharse, 2009:5).

Fineberg says that Scelsi, György Ligeti and Messiaen played a very direct role in influencing the music of Grisey and Murail (2008:36). Grisey and Murail both spent time with Scelsi, viewing his scores at his house in Rome (ibid.). Messiaen was a direct influence on Grisey and Murail, because he was their teacher of composition at the Paris Conservatoire (Besharse, 2009:7). The 1960 scores of Ligeti were also very familiar to the ensemble L'Itinéraire (Fineberg, 2008:36).

2.4.1 Understanding of Acoustics

The theoretical understanding of acoustic phenomena is displayed by composers who created their own systems based on the overtone series (Besharse, 2009:6). Harry Partch devised a scale of 43 notes within the octave, all derived from overtone proportions (Anderson, 2000:8). Partch also inverted his system to form the 'undertone' series, which has been used by Grisey and other spectral composers (Besharse, 2009:6). In 1972, Ligeti had an encounter with Partch which influenced his interest in microtones and just intonation (Hasegawa, 2006:271).

Wagner referred to "the sea of harmony" in his tonal language, indicating his intuition for filling up the acoustic space between each degree of the scale (Harvey, 2001:12). Wagner's orchestration often involved thinking of timbre combinations and writing chromatic chords from the 'sea of harmony'.

Frequency, time and intensity are continuous dimensions, yet traditional harmony has divided parameters as discrete dimensions (Pressnitzer & McAdams, 2000:39). For example, in measured time, rhythm functions within a linear framework, and the same is true for traditional tonality of equal temperament. Pressnitzer and McAdams write that the dissolution of equal temperament and metre in 20th century music resulted in continuous and infinite worlds which remain to be discovered and organised (2000:39).

2.4.2 Claude Debussy

Claude Debussy thought of sound as a perceived object, and used it to evoke images and feelings by mixing sounds into fields of different lengths (Moscovich, 1997:22). Debussy was one composer that extended the style of impressionism from visual art into music. The visual artists in the late 1800s began studying the relation between object and subject and the sensation that is evoked through such interaction. The colour prism and how varying wavelengths of light and colour are perceived were used to bring the viewers senses closer to perceptive nuances (Pasler, 2004:126). In 1883, Jules Laforge said that the "ear analyses harmonies like an auditory prism", and Debussy is an example of an impressionist bringing the same attitude towards sound. More recently, Debussy began composing sound to create sensations of 'colour' as sensory effects on the ear (Pasler, 2004:127).

Debussy focused on specific timbres through solo instruments and smaller ensembles, instead of blending homogenous backgrounds. He also wrote ninth and extended chords not for functional purposes, but rather to allow for multiple resonances to vibrate. The attention to overtones was further emphasized by the use of gongs and complex timbres to bring the listener closer to perceptive nuances of sound (Pasler, 2004:127). In *Sirènes* from the orchestral work, *Nocturnes,* Debussy writes quick rhythmic patterns in order to form a rhythmic density colouring a broader phenomenon (Pasler, 2004:129). Pasler writes that Grisey's music moves between various sensations of the same sound object, and is influenced by Debussy (2004:130-133).

2.4.3 Edgard Varèse

Edgard Varèse imagined music based on the interaction of timbres and textures with a scientific perspective on sound:

> The movement of sound-masses, of shifting planes…which take the place of counterpoint…the role of colour or timbre would be completely changed from being incidental, anecdotal, sensual or

> picturesque; it would become an agent of delineation, like the different colours on a map separating different areas, and an integral part of form (Varèse & Wen-Chung, 1966:12).

Varèse constructed music based on timbre and wanted to free sound from the restraints of traditional ideas. He believed music was "organized sound" and saw timbre as the acoustic phenomenon that can be organized in the place of "theme and motif" (Kropfinger, 2006:157). The "movement of sound masses and shifting planes" took the place of melody, as melodic thinking became vertical and not horizontal (Bernard, 2006:151). Varèse saw rhythm not as a succession of beats but rather an element of stability that generates form (Bernard, 2006:151). It is the interplay between related or unrelated sonic events that creates a feeling of motion or stasis forming the flow of music.[18]

Musical form was seen as resulting from a process analogous to crystallization, where the inner structure of an atom is what determines the extension into the whole crystal (Varèse & Wen-Chung, 1966:16). Varèse's music presents the idea as an internal structure expanded into shapes of varying size and flowing in varying directions at varying speeds forming varying perceptions. He spoke of sound being projected into space as rays of light, and saw this process of projection as flowing through different geometrical planes separated by speed and angle (Kropfinger, 2006:159).

In *Intégrales* (1925) for wind and percussion, Varèse constructs sound masses separated by timbre and 'gestural elements'. In bar 43 of the 2nd movement, the horn, trombone and double bass are separated from the clarinet, oboe and bassoon; as well as from the trumpet (Strawn, 1978:145). These masses are then projected on varying planes. The 'elements' are varying musical gestures such as *appoggiatura*, *glissandi* or *prolongation* that form distinct masses (Strawn, 1978:153). His 'ionisation' technique was based on projecting different zones of sound into an acoustic space (Moscovich, 1997:22). His piece for 13 percussionists, *Ionisation* (1931), allows the different elements within the overall sound to transform and evolve as they move around the acoustic space. Factors such as intensity and density were considered as he constructed elements to 'ionise' one another into sound masses. Varèse made use of Hermann von Helmholtz's theories in understanding the nature of sound (Besharse, 2009:9).

2.4.4 Giacinto Scelsi

Giacinto Scelsi "considered sound as an entity we have to explore and compose with, to feel its pulse at every instance" (Moscovich, 1997:22). He composed pieces that utilized slow growth and

[18] This idea is further expanded in Chapter 3 under section 3.3.1.

development, with a constant flow and evolution of sound masses. He was aware of the inner details of sound and spoke of "smooth or rough particles" (Moscovich, 1997:22). Scelsi's aim was to "de-compose the sound into its spectrum, and not to compose sounds with one another" (Murail, 2005a:173). He thought further than just a single pitch, and approached each element separately before combining them to create different intensities of global phenomena (Elezovic, 2008:3). Scelsi felt that each sound had a living energy and was influenced by Rudhyar's idea that each sound is a solar system with orbiting planets (ibid.).

Scelsi presented a feeling of oriental imagination through mysticism and imagery (Murail, 2005a:176). Salvador Dali's film *Visions de Haute Mongolie* plays with imagination versus physical reality, and this same idea is displayed in Scelsi's thinking. Scelsi explores the physical phenomenon of sound by drawing on the imagination of the listener with shapes and colours of Asia (Murail, 2005a:177).[19] Some of Scelsi's music, such as *Okanagon*, displays a ritualistic sense that seems to beat with the "heartbeat of the earth" as the double bass, tam-tam and harp played from behind a curtain allow the 'heartbeats of sound' to colour the imagination (Murail, 2005a:179).

Scelsi's *Quattro Pezzi per Orchestra* (1959) comprises four pieces based on a single pitch, and is an adventure into sound and its perception (Murail, 2005a:175). Here, Scelsi works with the 'depth of sound' by writing microtone inflections. These inflections create beats and allow the listener to move between varying degrees in strength of vibrations (2005a:178). By isolating himself to only a single pitch, Scelsi explores micro aspects of combining sounds such as attack, types of sustain, spectral modifications, *vibrato*, *glissandi*, and *tremolos* (2005a:176). These form the 'planets of the solar system' or a global sound moving timelessly in space with 'inner-orbiting overtones'.

Scelsi created the ambiguity of 'stasis in motion', which is an aspect of time perception the spectral composers make use of (Murail, 2005a:178). All micro durations merge into the global continuity of sound. When rhythmic variations come into play, the music always returns to a static moment - into the global continuum that is a sustained, isolated moment in time (2005a:179). Scelsi's music involved static sound masses that slowly change. He created the term 'smooth time' which describes the way in which timbres and textures evolve in a continuous way, rather than in cells, or juxtaposed blocks (Besharse, 2009:12). This influenced the spectral composers to embrace the

[19] This aspect of imagination was explored further by spectral composers through the use of perception. The spectral composers present a timbre that could oscillate between a chord and a timbre creating new imagined worlds of sound. Murail was also influenced by Dali's art by oscillating between the imaginary 'micro-worlds' of sound and the real macro phenomenon.

aesthetic principle of slowly evolving growth (2009:10). Scelsi's idea to penetrate the interior of sound had an impact on spectral composers (Fineberg, 2006:129).

2.4.5 Olivier Messiaen

According to Fineberg, Olivier Messiaen "was the composer who assisted most directly in the birth of spectral music" (2006:124). He found inspiration in nature and timelessness and therefore his music was said to colour time (Griffiths, 1985:196).[20] His influences, from Debussy and Stravinsky, are outweighed by the impact of plainsong, birds, Hindu rhythms, and exoticism (1985:17).

Messiaen was interested in complementary colours[21] and their analogous double found in the natural resonance of sound (Messiaen, 1994:61). He also assigned different colours to his modes of limited transposition, and said that changing the order of a vertical structure changes the colour (1994:48). He writes: "When I hear music, I see complexes of colour corresponding to complexes of sound" (1994:61).

Messiaen was not only a composer but also an ornithologist who was familiar with many aspects of birdlife. He was fascinated by the different timbres birds produce (Messiaen, 1994:94). He recorded an abundance of different bird calls and spent hours notating them. He then brought this natural phenomenon into his music, along with the landscape birds resided in–or, as he referred to it, "the perfumes and colours of the countryside" (ibid.). In his music he accompanied the bird calls with the atmosphere of a mountain stream (Healey, 2013:122).[22]. This was not a traditional accompaniment, but rather a 'lens' through which the birdsong made it into his music. He claimed that birdsong is too fast for instrumentalists to reproduce, and some intervals are too small for equal temperament; by maintaining the same proportions, he transposed the durations and intervals to 'human size' (Messiaen, 1994:95). Messiaen then claims the main challenge was reproducing the timbre of each bird, and said that in order to achieve a translation of timbre, harmonic combinations are necessary: "When I reproduce birdsong, every note is provided by a chord, not a classified chord, but a complex of sounds which is designed to give the note its timbre" (ibid.).

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[20] "Time is coloured, in that colouring lies the music's claim to be operating in a time where time is still, the frozen present of the time when the music was composed" (Griffiths, 1985:196).

[21] Messiaen said that a complementary colour is created when you stare at red next to white: the complementary colour of red starts to appear in a blurry form, which is green. He said that the same happens with sound when you strike a low C on the piano with the sustain pedal open, the sympathetic vibration of overtones is analogous to complementary colours (Messiaen, 1994:61).

[22] Messiaen recreated the sounds of water such as water droplets, foaming waterfalls, and the low bass rumbling by orchestrating these sounds imaginatively (Messiaen, 1994:10).

The second bar in Figure 2.1 is an attempt to render a shrill timbre with major sevenths and ninths (Griffiths, 1985:171). Amongst Messiaen's diverse harmonic language is the 'resonance chord', a chord built up from the natural overtones (Moscovich, 1997:22).

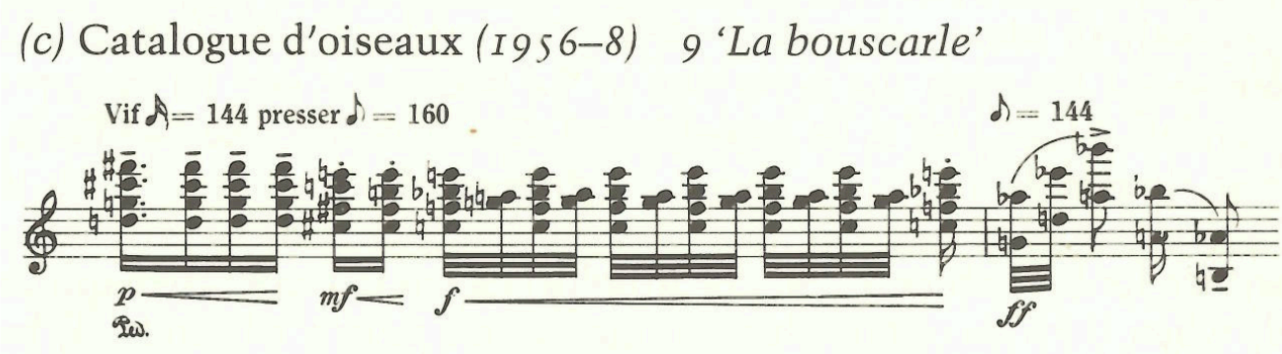

Figure 2.1 - An example of Messiaen's interpretation of birdsong (Griffiths, 1985:171)

Messiaen was asked about the precision with which he includes bird calls in his music, and whether this makes him a man of science or art. His response was that while he does present the exactness of bird calls, he also employs an instrumental technique of manipulating the material in the same manner as *musique concrète,* reaching the abstract form of sound (Messiaen, 1994:95).

Messiaen was interested in linking musical ideas to natural phenomena (Besharse, 2009:7). He was also particularly intrigued by percussion instruments, such as gongs, and complex timbres. Besharse writes that the interest in non-harmonic metallic timbres is a trend that continued through to the spectral movement (ibid.). The way in which Messiaen interpreted natural sounds by transposing material into different time dimensions with varying colouration, and the use of many different sources of sonic inspiration such as bird-calls, Höömi singing, bell sounds, and *gagaku* influenced the spectral composers (Fineberg, 2006:125).

2.4.6 György Ligeti

The most concrete starting point in discovering the source of spectral music according to Fineberg is Ligeti's earlier music, such as *Atmosphères* (1961) or *Lontano* (1967) (both for large symphony orchestra), where the micro-canons are used to generate dense rich textures and the music is made purely out of timbre (2008:37). Ligeti's music allowed spectral composers to visualize music that worked and sounded differently (Fineberg, 2006:125). Murail states that electronics allowed for sounds of infinite duration, and that the true revolution of the 20th century is when composers started thinking in terms of masses where sound could be stretched out into macro perspectives (2005c:123). Murail writes that the "fluctuation between abstract concept and aural perception that permits access into the depth of sounds, that allows us truly to sculpt sonic material, rather than piling up bricks or layers" (ibid.).[23]

Ligeti's 'micropolyphonic' orchestral works such as *Apparitions* (1959), *Lontano* and *Atmosphères* were influenced by three tape pieces he composed in the studio in the late 1950s. For these electronic pieces, he layered sounds together to form large scale textures and global colours (Fineberg, 2006:126). Ligeti says the micro-canons in *Lontano* form "an extensively branching and yet strictly refined polyphony which, however, veers suddenly into something else… A kind of complex of tone colour, movement, changing harmonic planes" (1983:95).[24] The harmonic planes fuse together to form a global timbre constructed of different 'micropolyphonic' parts.

Figure 2.2 displays the beginning of *Lontano*, opening with a flute in the low register at a very soft dynamic producing a prominent fundamental tone. One by one, non-periodic entries occur as the rest of the flutes, clarinets and bassoons begin playing at a soft dynamic, blurring each entry. The clarinets at this dynamic also produce a prominent fundamental and softer overtone structure. The bassoon is muffled with a cloth in the bell, allowing the harmonics in that range also to be muted (Bauer, 2001:54). What results is a timbral fusion into a global phenomenon as the micro-canon evolves.

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[23] 'Bricks and layers' refers to composing with harmony and melody. In opposition, Murail refers to a sculptor working with material as he gradually reveals different aspects from a global approach (2005c:123).

[24] Ligeti also said that the interval and pitch structure flowed through a "constantly changing pattern of colour like a moiré fabric" (1983:56).

Figure 2.2 - Bars 1 to 4 of *Lontano* (Bauer, 2001:40)

The non-periodic entrances and pure tone structure in question was inspired by Ligeti's work in the electronic studio. Ligeti said of 'micropolyphony':

> It's often an artificial timbre created by the great density of successions and by the blurring of this succession. This combination produces a new timbre that didn't exist with separate instruments; it comes from my experience in the electronic music studio, although I don't employ any electronic sounds. I use very few special instrumental effects… the totality, the combination, the manner of combining the instrumental voices gives new timbres. (Bauer, 2001:55)

In addition to Scelsi's influence of slow evolving growth, Ligeti's atmospheric music also added to the idea of slow evolution of sound. Grisey was influenced by the way Ligeti's textures gradually developed over time (Besharse, 2009:12). Ligeti's music inspired Grisey to stretch out the 'fabric' of sound in order to bring out its inner details (2009:13).[25] The way in which Ligeti worked out micropolyphonic motives adding to a mass texture influenced the idea of zooming into a sound and bringing the micro details to the foreground. The continuous evolution of sound became an important characteristic for spectral composers who felt that contrasts such as high/low, loud/soft, fast/slow should be smoothed over with a gradual transition (ibid.).

Fineberg points out that the 'post-electronic' thread runs through spectral music, from its beginnings with Stockhausen, Penderecki, and Ligeti (2008:37). Instrumental music that attempts to synthesize the diverse possibilities of electronic music is central to spectral music (2006:127).

2.4.7 Stockhausen

Stockhausen's theory, presented in his article *...how time passes...*, attempts to create a "new morphology of musical time" (1959:11). Stockhausen describes how duration and pitch amount to the same phenomenon as different percepts in time. By speeding up a stream of impulses so that the duration between each impulse disappears, a constant stream of pitch can be experienced (1959:10). He was criticized by the physicist, John Backus, for his incorrect use of terms such as phase, impulse and quantum (Koenigsberg, 1991b:1). Despite some technical inadequacies, Stockhausen's ideas opened up the micro-structure of sound as he began to think of the "smallest atoms of the acoustical phenomena" (Koenigsberg, 1991a:1). The theory draws on the harmonic series and hypothesizes that the tone colour is the result of 'time structure', and that the opportunity to intervene compositionally amongst these complex structures is the case of that time's electronic music (Stockhausen, 1959:19). Stockhausen's interest in the boundary between pitch and rhythm and between successive events and a continuous texture formed the notion of a 'continuum between percepts'.

Technological development lead Karlheinz Stockhausen to work with the character of sound. In 1953 he wrote:

> We reduced everything to the element, which is the basis for the variety of sound; the pure sound wave, electrically producible, called 'sine wave'. Every existing sound is a mixture of [sine] waves - we call it a spectrum. The numbers, intervals and dynamics of such sine waves make up the

[25] The inner-details of sound discovered through spectral analysis display a 'micropolyphony' of partial content.

> characteristics of every spectrum. They determine the timbre. For the first time the possibility was given to compose timbres in the real sense of the word, that means to compose them out of elements, thus applying the universal structural principle of a piece of music to the sound proportions as well. (Ungeheuer, 1994:26)

Stockhausen went on to synthesize sounds with sine waves, and the first experiments in *Studie I* (1953) were unsuccessful as they resulted in the sounding of a chord (Ungeheuer, 1994:26). Stockhausen in *Studie II* (1954) only made use of five partials, blurring the contours of the individual sine waves with reverberation. This allowed them to move at different dynamic levels, and formed the overall sound into a single conceptual phenomenon (ibid.).

The notion of the continuum was explored in *Gesang der Junglinge* (1955-1956) where Stockhausen attempted to create a continuity of transition between timbres by using the four different elements of impulse, the human voice, sine waves, and noise (Ungeheuer, 1994:26). The means to achieve a continuous approach was discovered by Meyer-Eppler with his sound experiments. He presented transitions from the different elements, such as tone to noise and timbre to impulse. An example of one experiment is a repetitive melody that slowly turns into a rhythmical noise with the slowing down of the tape (Ungeheuer, 1994:28).

The idea behind *Gesang* was to fuse spectral aspects of the human voice with electronically generated sounds (Smalley, 2000:1). The continuum between periodic structures, such as vowels, or sinusoid tones, and non-periodic structures such as consonants or white noise, was explored by filling the gap. Stockhausen combined aspects of the recorded voice with synthesized sounds by understanding the sound structure of the voice, and how to similarly synthesize it by electronic means. For example, he filtered white noise, so as to achieve a similar structure to the consonant 's' (Smalley, 2000:1). He then explored the continuum between noise structures and vowel/sinusoid structures.

Stockhausen was interested in periodicity, and said that "there is a fundamental periodicity of the whole cosmos when it expands and contracts, it *breathes...* This is the fundamental of the universe, and all other things are partials of this fundamental… there is always periodicity" (Cott, 1974:27). He also said that aperiodicity is the result of intricate layers of periodicity which is true for sound that can be decomposed into a series of sine waves (periodic waves).

Fineberg writes that Stockhausen was a powerful model to Grisey, who knew Stockhausen's work quite well (2008:36). Grisey went to Germany to work with an acoustician and spent time with Stockhausen in the 1970s prior to writing his first spectral pieces. These influences are displayed in *Les Espaces Acoustique* (1974-1985) (a two-hour long cycle for orchestra) where the work is big and continuous: a very Stockhausen-like gesture (ibid.). Stockhausen said that in *Kontakte* (1958-1960) he presents a sound for a long duration in order to create the perception of a 'time freeze' that would allow the listener to follow the inner-details of the sound; he refers to this as a microscopic analysis of sound (Cott, 1974:31).

2.5 Technology

Studio techniques allow for sound to be manipulated in many ways: fade-in, cross fade, sudden cut, ring-modulation, and synthesis, amongst others, are all techniques available in electronic composition (Fineberg, 2006:126). These techniques provided valuable sound models for spectral composers (2006:154). Furthermore, technology has advanced towards computerized sound analysis, allowing composers to spectrally analyse, modify and recreate new sounds providing control over timbre. New musical architectures could be designed with the tools of timbre creation and extraction (Moscovich, 1997:22).

Pressnitzer and McAdams write that the spectral composers posed a solution to the problem of structure by delving into the inner structure of the sounds themselves (2009:34). The way in which they brought the spectrum to musical life is based on aesthetic influences by their precursors. The eradication of a tonal system led to "a realm of sound in which the musical material appears for the first time as a malleable continuum of every known and unknown, conceivable and possible sound" (Wörner, 1973:124). Fineberg states that despite clear connections with precursors, one cannot dismiss the originality of the spectral composers due to their markedly different approach (2008:37).

Chapter 3 – Spectral composers

The music and theories of the two prominent spectral composers, Gérard Grisey and Tristan Murail, will now be presented in order to uncover the technique and 'attitude' of spectral composition.

> I like to imagine myself as a sculptor in front of a block of stone that hides a form; a spectrum might, in this way, contain forms of various dimensions that one may extract under certain conditions – with certain tools: active filtering, selection of tempered pitches, spectral regions, formants, spectral exploration, etc. (Murail, 2005b:154).

3.1 Background to Gérard Grisey

In 1972 Gérard Grisey won the *Prix de Rome* and took up residency at the Villa Médicis in Rome where he developed his first spectral pieces (Féron, 2011:348).[26] Olivier Messiaen influenced the way in which Grisey anticipated the listener's perception of musical time through his composition process; Messiaen also provided an example of how to appropriate sound material derived from nature into a compositional structure (ibid.). During the 1970s, Stockhausen had a profound influence on Grisey in working on the perception of sound as varying proportions in time. He played a leading role in pointing Grisey towards the inner-details of sound itself. In 1972, Grisey heard Stockhausen's *Stimmung* (1968), which features overtones in a structural way. This lead Grisey to turn his attention to giving all sound phenomena purpose in his compositions by focusing an entire piece on the proportions of a spectrum (Féron, 2011:349). Grisey's piece *Dérives* (1974) for two orchestral groups and those that followed were constructed in order to give the listener direction and meaning based on structural aspects determined by the spectrum. Grisey used sound as a processing object 'breathing in air of time' (Grisey, 1987:269).[27] How sound 'breathes' is a perceptual aspect that determines overall form. Grisey worked strictly with mathematical calculations in order to determine these structural aspects.

Grisey began composing *Dérives* in 1973 for an orchestra of 50 performers and an amplified ensemble of 13 musicians. In 1974, *Périodes* for ensemble was written for a performance by the ensemble L'Itinéraire, interrupting the composer's work on *Dérives* (Féron, 2011:349). Represented by these pieces and found in his work from here on is the spectrum, used to determine

[26] Féron is a relevant source on the music of Gérard Grisey as he has written a number of articles on Grisey while consulting other sources. He has worked with the sketches of Grisey and presents well informed knowledge of Grisey's compositions.
[27] For further explanation of this analogy I present Grisey's theory on the perception of 'musical time' below under section 3.3.1.

overall/macro and sectional/microscopic structure. Grisey liked the 'truth of nature' and made use of music's ability to alter our perception of this truth (Castanet, 2000:33).

Between 1974-1985 Grisey put together the cycle *Les Espaces Acoustique:*

- *Périodes II* – (1974) for ensemble
- *Partiels III* – (1975) for 18 musicians
- *Prologue I* – (1976) for viola and electronics
- *Modulations IV* (1976-77) for orchestra
- *Transitoires V* – (1980) for large orchestra
- *Epilogue VI* – (1985) for four solo horns and large orchestra

3.2 Background to Tristan Murail

Tristan Murail studied composition with Olivier Messiaen at the Paris Conservatoire, graduating in 1971. He was then awarded the *Prix de Rome* (Smith & Murail, 2000:11). Murail founded the ensemble L'Itinéraire together with Grisey, and through their music formed a connection with what is known today as spectralism. Murail's composition *Memoire-Érosion* (1976) for horn and nine instruments represents a direct influence from working in the electronic studio, by creating an instrumental replication of the studio technique, 'reinjection loop' (Anderson & Murail, 1993:321). The piece moves from periodicity and harmonicity to aperiodicity and inharmonicity through the gradual process of distortion because the 'reinjection loop' results in a sound that is continuously worn down (eroded) and transformed by new frequencies emerging from electronic interferences (Murail, 2005c:125). The French horn acts as the 'input sound' and the strings the 'resulting sound' after "reinjection that gradually distorts" (ibid.). The gradual shift involves moving from a predictable loop towards lack of order and inharmonicity, where rhythmic structures become ever more complex; this is likened to wind erosion of rock faces over time, revealing shapes - this is, indeed, the structural inspiration for the piece (ibid.).

3.3 The Composer's Theories

3.3.1 Grisey's Theory of Musical Time

In *Tempus ex Machina: A composer's reflection on musical time*, Grisey explains his understanding of the difference between 'chronometric' real time and perceived 'musical time', as used in his spectral works (1987:239). 'Chronometric time' refers to real time measured in seconds, and 'musical time' refers to the listener's perception of time during the musical experience. The latter is explained through the analogy of a skeleton, flesh and skin, where each category accounts for different perceptual structures of time ranging from the quantitative towards the qualitative.[28] This theory accounts for the use of psychoacoustics as a compositional parameter by spectral composers.

3.3.1.1 Skeleton of Time

3.3.1.1.1 Periodicity/'Fuzzy-Periodicity'

The skeleton of time accounts for the quantitative aspect of the perception of musical time and focuses on the immediate perception of time as the present. Grisey writes that previous measurements used by composers to organize durations,[29] such as Bartók's golden section, Stockhausen's Fibonacci sequence and Messiaen's prime numbers "confused the map with the lie of the land" (1987:240). He writes these calculations were not perceptible as such and substitutes a system of complexities in their place. He calls this the 'Table of Continuum', which structures the perceptive distance of durations from predictable to non-predictable and harmonic[30] to inharmonic (Grisey, 1987:244). Harmonic and predictable are here analogous. On the one hand, the perfectly predictable is represented by a periodic structure, while on the other, the unpredictable is represented by discontinuity. Movement between the two ends creates dynamism that occurs as the result of a dynamic continuous process with motion.

A duration that repeats periodically creates an expectation from the listener, resulting in predictability: "a perfectly regular recurrent pattern… in time is periodic and a recurrent pattern… that has small variations in period is quasi periodic" (Chowning, 2001:263). Refer to Figure 3.1, which displays how events occur evenly in time. Absolute periodicity can tire the listener as the sensation becomes saturated (Grisey, 1987:245). Harmonic consonance is also seen as periodic as it allows for the listener to predict the sound as an expected phenomenon.[31] This overlaps into the flesh of time, and is explained below. Music cannot go without periodicity as it forms a reference

[28] Grisey's theory on time suggests a connection to Stockhausen's *...how time passes...* through the emancipation of parameters. For example, he proposes there exists a relationship between harmonicity/inharmonicity and predictable/unpredictable durations. Theories by other composers and musicologists propose similar and contrasting ideas such as those by Stravinsky and Zuckerkandl.

[29] Duration is used to refer to not only rhythm, but also to length of climax of a dynamic curve, length of similar timbre, and lengths of sound sequences (Grisey, 1987:244).

[30] Here harmonic can be related to time (duration) in a similar fashion as proposed by Stockhausen's *…how time passes…*, as explained in Chapter 2.

[31] All the frequency components of a harmonic sound are periodic and in proportion, and therefore 'predictable', as explained in Chapter 1 section 1.2.

point that allows for the possibility of hesitation and suspension of time (1987:247). Periodicity through repetition found in African music results in a hypnotic, transcendental state, and is due to the saturation of memory (explained further under the skin of time). Grisey makes use of what he calls 'fuzzy periodicity', which is a slight imperfect fluctuation around a constant period (1987:245). This relates to our organic nature, such as breathing in and out, or our heartbeat, which does not have precisely repeated durations.[32] Grisey mentions that this is also found in *gagaku* music (1987:248).[33] Chowning writes that quasi-periodic waves are typical of nature and that only computers can produce perfectly periodic waves; sound produced in nature will always have variations in amplitude, pressure, and frequency (2001:263).

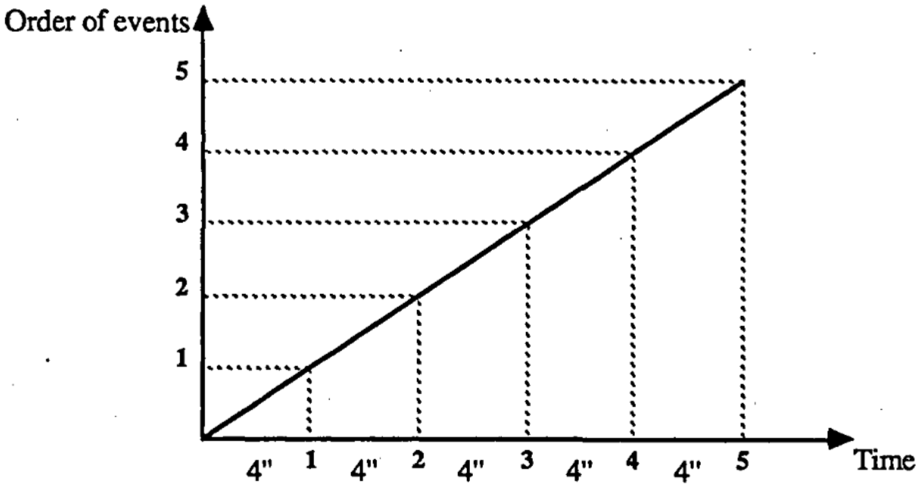


Figure 3.1 - Periodic events (Grisey, 1987:248)

3.3.1.1.2 Continuous Dynamism

Dynamism is the result of a continuous transition from periodicity to either an acceleration or a deceleration, and is explained as having a dynamic effect on the listener's senses. The listener is no longer predicting the next event (static) and is now in a dynamic state (motion). The dynamic effect alters the listener's perception of time by either a smaller or larger factor by way of a logarithmic equation (Grisey, 1987:248).[34] (Refer to Figure 3.2, a graph that resembles the continuous increase.) In the case of acceleration, the listener is propelled forward towards a new expectation and becomes focused on the immediate present/near future with little focus on the memory of the immediate past; alternatively, deceleration has the effect of a stronger memory of the immediate past as durations

[32] Stockhausen said that 'God breathes' all the time, naturally and quasi-periodically, each year the snow does not fall at precisely the same time (Cott, 1974:27).
[33] Recall that Messiaen held an admiration for *gagaku* music of the Japanese people.
[34] See Grisey (1987:248) where the equation $s = k\log E$ solves for sensation as a result of a constant factor multiplied by the log of excitation. The equation proves that an increase of excitation (acceleration) or a decrease (deceleration) forms a logarithmic curve.

are slowed down, however, biological/chronometric time continues to move forward, placing the listener in suspense (1987:249). Maximal acceleration/deceleration will result in a confused listener who is either trapped in the immediate present, or in a moment of suspense (ibid.). According to Grisey, empirical research shows that the listener prefers a longer acceleration followed by a shorter deceleration rather than the opposite. This is because the 'void of expectation' of suspense created by deceleration cannot be tolerated for too long (1987:252). The progression allows the listener to not be neutral or static as with periodicity, but rather to be charged with direction and momentum. These are ways of increasing or decreasing tension. With continuous dynamism there is still a sense of predictability as the exponential increase/decrease maintains a sense of expectation.

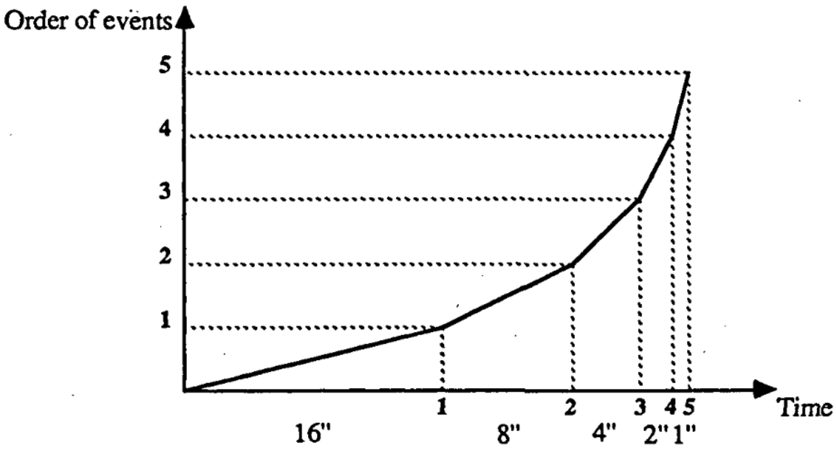


Figure 3.2 - A continuous progression through acceleration of events in time (Grisey, 1987:248)

A continuous transition from harmonicity to inharmonicity can resemble the logarithmic (continuous) transition, and also creates forward momentum.[35] The sinusoid components of a timbre can be changed from a periodic complexity to a non-periodic complexity through an exponential process. Recall that the non-periodic complex wave comprises of an inharmonic spectrum without a fundamental frequency. Therefore, inharmonic partials can exponentially increase over a harmonic sound creating a forward motion as the harmonic background is no longer perceived as harmonic/periodic/static.

3.3.1.1.3 Dynamism through Elision

Dynamism can also occur in a discontinuous fashion where the discontinuity is perceived as a continuous motion due to the Gestalt theory of grouping (Grisey, 1987:253). The continuity occurs through elision, where gaps are barely noticed due the smooth transition between the different

[35] This overlaps with the flesh of time.

groups. Figure 3.3 displays a graph where the gaps result in three different groups, A, B and C. This occurs under the pre-requisite that there is enough similarity between the groups and that the gap is not too large. The changes are smooth enough in order for a vector charged with magnitude and direction to be perceived (Grisey, 1987:253). The orientation of the vector would not be known if the change is irregular; if the change is too sudden then the focus falls on the surprise of the moment and the forward charge is lost. This form of deviation from periodicity/harmonicity is relevant to Grisey's music, where he filters out spectra and where complex timbres such as gongs are used (ibid.).[36]

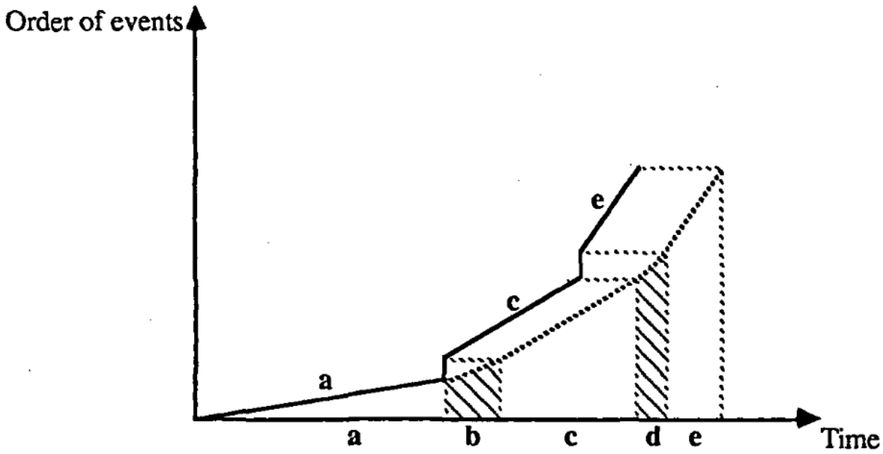


Figure 3.3 - Acceleration by elision (Grisey, 1987:252)

As dynamism increases, predictability decreases: what is gained in dynamism is lost with predictability (1987:253).

On the end of complete unpredictability is absolute discontinuity where durations are compared to white noise (Grisey, 1987:256). Here, the attention of the listener can only be held for a limited amount of time as there is no dynamism. A constant seamless duration without temporal division also results in unpredictability as the length of the duration is not known due to there being no previous reference point. In order to create a perceptible message, the structure of durations must take into account these borders of the skeleton of time (ibid.).

To conclude, periodicity/predictability creates the foundation for stasis and connects to real 'chronometric' time; dynamism occurs via deviations from periodicity in order to deviate from real time towards a new perception held within 'musical time'. It is within 'musical time' that the

[36] This idea overlaps with the flesh of time.

perception of time changes from stasis to motion or vice versa. Grisey makes use of 'fuzzy-periodicity' in order to immediately form a perception of 'musical time'.

3.3.1.2 The Flesh of Time

The flesh of time accounts for sound as a living organism, breathing life and quality into the skeleton of time (Grisey, 1987:256). The flesh of time provides a qualitative understanding of 'musical time' as timbre inhabits the skeleton, causing further changes to occur in perception. This accounts for a larger area of time around the present. The flesh of time features the 'phenomenological and psychological organization' of sound (psychoacoustics of timbre; 1987:257). The same skeleton (temporal organization) can be filled by different timbre combinations and will result in a completely different perception of time.

In the flesh of time, predictability is referred to as pre-audibility and accounts for expectation of the same quality of sound. For example, if the same timbre is repeated, the listener has a pre-auditory expectation of what is to occur. However, if the occurring sounds differ vastly, the listener has no pre-auditory expectation of the following sound. The level of pre-audibility determines the density of time perception (Grisey, 1987:259). Pre-audible sounds allow the density of time to increase as they are recognizable and fill the listener's memory. A strong sense of memory and expectation creates an expanded perception of time, because events seem to move slower than 'chronometric' time (ibid.).[37] Grisey explains the opposite occurrence by referring to air pockets in time. Here, a stream of predictable auditory events that is suddenly changed with an unpredictable jolt causes the listener to be shocked into the present; loss of memory occurs as focus shifts from an expanded perception to the immediate present: a pocket of time is surpassed (1987:257). With no sense of pre-audibility, the density of time decreases as new events continue to jolt the listener into the present with no sense of past or future events. The lens of time contracts.

A continuously sustained sound causes no quantitative predictability of its end. However, it does create a strong sense of pre-audibility because one is immersed in the sonic material. In this case, the expansion of the lens of the density of time allows the listener to zoom into the microscopic character of sound. This presents the perfect scenario for orchestral synthesis[38] where all voices do not start at the same time; the barely recognizable changes in the temporal envelope keep a coherent

[37] This brings to mind an analogy of heat that allows for the density of molecules in air to expand. Heat is a stream of concentrated energy that flows continuously. A static sound resulting in pre-audibility can be viewed as the same structure that repeats itself continuously. With more heat, the molecules in air expand within the space they inhabit. This is likened to pre-audibility where the time span under which the sound unfolds appears to expand.

[38] Orchestral synthesis is explained in section 3.4.3.

flow and the density of time is increased (Grisey, 1987:259). The microscopic details of sound are presented in macro form and the perceptual result is expansion. For this to occur, a longer temporal value of the sound is required in order for the auditory acuity to strengthen (ibid.). The microphonic aspects are made more visible through magnification and the deeper the listener goes, the less aware they become of global changes. Grisey says he works with 'the lens of time' as a structural determinant that is, he works with both duration and sound variation in order to achieve various effects on the perception of time as it relates to the quality of sound (1987:268).

Grisey writes that sound is alive: it has a birth, life, decay and death; it is mobile and fluctuating as a continual transform of energy; it does not operate in a linear manner and is transitory (1987:268). This makes sound very powerful in altering the listener's perception of musical time as the variations of the energy transformation are so diverse.

Grisey says that sound as an object and sound as a process are analogous to one another. The process allows the listener to identify the object, and the object directs the process to be perceived as movement (1987:269). Time is the air that the object and process 'breathes'. The process allows the listener to become aware of the inner-dynamism of the object as it changes and transforms allowing slight differences to become visible (Grisey, 1987:269). The object allows one to identify the Gestalt of the process because the inner-parts of the sound are objects that can be perceived in groups. Different sound objects/processes have different effects on the perception of time. This is related to their degree of change, and the saliency thereof. For example, clear attack of a sound allows one to identify the beginning of the sound, whereas sustained entrances are not easily identified for their beginning and therefore create a blurred memory of the immediate past (Snyder, 2000:163).

3.3.1.3 The Skin of Time

The skin of time is that area where the listener's organic time meets 'musical time'. It is within this area that the composer notices more than he acts (Grisey, 1987:272). Psychological and cultural factors determine this area of perception, leaving the composer little control. In order to account for the listener's perception of time, Grisey comments on the process of memory: the immediate present is lead by the 'constant of time', and memory allows for the width of the perceived present to extend towards including the immediate past. Timbres sorted according to their degree of change can lead the listener through different focal points of these areas in memory: the repetition of events allows the memory of immediate past to be the object of focus together with the present 'constant of time'; violent sudden changes with a strong degree of salience allow for the focus to lie on the present of this moment which is sustained through to long term memory (1987:273).

Snyder (2000:5) writes that events that have a striking effect are transferred from the short term memory window of 3 to 5 seconds into long term memory. The structure of auditory processes is organized by events from echoic memory flowing into short- and long-term memory (2000:3). Echoic memory represents intake of the present as time passes; within this area, events with simultaneous features occurring chronologically are bound together as single, coherent auditory events (ibid.). This information is stored in short-term memory, and, where a change with a large degree of salience occurs, it is transferred to long-term memory (Snyder, 2000:4). Therefore, change has an effect on the immediate present allowing for information to be stored in memory. With the continuous repetition of events in minimalist music, there is no degree of change; Grisey writes:

> …the memory slips. It has nothing to latch on to – hence the effect of intense fascination or hypnosis – and all that emerges is a hazy memory of the contours of sound's evolution. Time past is no longer measurable: I would call this process psychotropic, or better still chronotropic.
> (1987:273).

3.3.2 Murail's 'Attitude'

Murail writes that the use of spectral analysis as the basis for composition is not the sole source of spectralism, and rather refers to five principles that build up the 'spectral attitude':

- thinking in terms of continuous rather than discrete categories, and the smooth connection between parameters;
- a global approach, rather than a sequential or 'cellular' one;
- organizational processes of a logarithmic or exponential, rather than a linear, type;
- construction with a functional, not combinatorial, method; and
- keeping in mind the relationship between concept and perception (2005c:152).

Murail writes that younger composers have absorbed these principles and have arrived at new and differing results (2005c:152).

3.3.2.1 Continuity

Equal temperament and proportional rhythmic values are examples of discrete categories. However, when frequency is used to measure pitch, a continuous world is opened. Instead of measuring time in discrete durations, it is considered in its continuity as seconds (Murail, 2005c:154). A spectrum forms the 'nexus' that roots the continuous transitions: it determines melody, harmony, rhythm and timbre, and it is the relationship between these phenomena that is important (2005c:153). By focusing on the relationships between these elements, an ambiguity between the perception of the parameters can be fostered (harmony perceived as timbre). According to Murail, natural sounds are interesting because they are transitory and do not remain static or evolve in a discrete fashion. A harmonic spectrum is enriched through the process of evolution and the different strengthening of partials over time, and the change of harmonic density and frequency changes contribute to the interesting evolution of sound (1984:143).

3.3.2.2 Global Approach

Working with graphic methods allows for the composer to map texture from a global perspective. While the micro details of the composition are determined by transitions of spectrums, the treatment of time that serves dynamism or stasis is planned from a global approach. Murail works with proportions between the duration of larger sections, episodes and processes, and a change in an individual duration has an effect on the global form (2005c:154).

The global structure is related to the minute detail found within, because the minute is based on microscopic detail of a sound source. Therefore, by varying the magnifying strength of a spectrum, different proportions of the same spectral source can create global connections.

The spectrum is 'a block of ice' that is waiting to be carved by a sculptor; there are forms that can be extracted, filtered, distorted and enhanced by the sculptor (Murail, 2005c:154). By changing the inner-details of a spectrum, the same sound object is perceived differently, as if the 'block of ice' is carved into the 'same sculpture' that is viewed from different angles.[39] The global approach means that different aspects of a composition can be approached with the same technique, and the inner-details of a spectrum, as it unfolds over time, can determine the macro form. This can also be applied to textural densities, registers and different types of musical sound (ibid.). The global approach is necessary for working with complex sounds (gongs or cymbals) because these sounds

[39] Explained in Chapter 1, section 1.5.

cannot be broken into discrete parameters and need to be placed within a continuum from a global perspective (2005c:155).

3.3.2.3 Logarithmic Over Linear; Functional Over Combinatorial; Relation Between Concept and Perception

Logarithmic calculations are one method of organizing duration and harmonic spectra continuously over time. Linear calculations do not take into account the continuum of frequencies or that of musical time. Acceleration/deceleration and 'fuzzy periodicity'[40] requires the deviation from linear grids, and this is required to create different percepts of musical time for the listener. Acceleration is used to create the perceived zoom-out effect so that a large phrase is seen as a single impulse; deceleration creates the zoom-in effect where the details of sound are enlarged as time is slowed (Anderson & Murail, 1993:322).

Murail made use of mathematical functions to determine spectra as well as to distort and calculate smooth transitions between different spectra. The use of functions creates interesting spectral phenomenon where the complexity of sound can be re-mastered. Combinatorial methods refer to building harmony and duration by combinations of simple structures.

The difference between the periodic/harmonic and aperiodic/inharmonic sections of spectral music requires that intermediate processes are charged with attraction and dynamism (Murail, 2005c:157). This is the 'vectorization' of music where processes have a direction charged with magnitude that is felt by the listener (ibid.).

3.4 Composing the Spectrum

3.4.1 The Spectrum as Structural Determinant

3.4.1.1 Grisey - *Dérives* (1973/74) for two orchestral groups

Grisey's *Dérives* (1973/74) for two orchestral groups resembles a boat steering off and on its path; the furthest distance from the path is represented by silence and the axis guiding the path is represented by a main harmonic spectrum (1974:129). The axis is used as a pitch beacon to fuse together transitions between the small ensemble's sequences and those of the large orchestra. The path is illuminated by recognizable, 'fuzzy periodic' material (ibid.). The analogy of steering off the

[40] The term is coined by Grisey and is referred to above under section 3.3.1.1.

path is achieved as the two different orchestral groups move away from predictability/harmonicity/pre-audibility towards unpredictability/inharmonicity in order to work with the density of time.

Grisey exercises a smooth transition between these structures and creates differing timbre and textural backgrounds. According to Féron, the spectrum forms the axis that stabilizes musical revolution, while Grisey works with degrees of change (2011:351). The main spectrum represents an axis guiding the path because it is the pure harmonic material with ‘fuzzy periodic’ durations in order to create the ‘point of zero development’ (ibid.). Development is achieved by means of altering the perception of time and harmonicity by moving away from this stable percept.

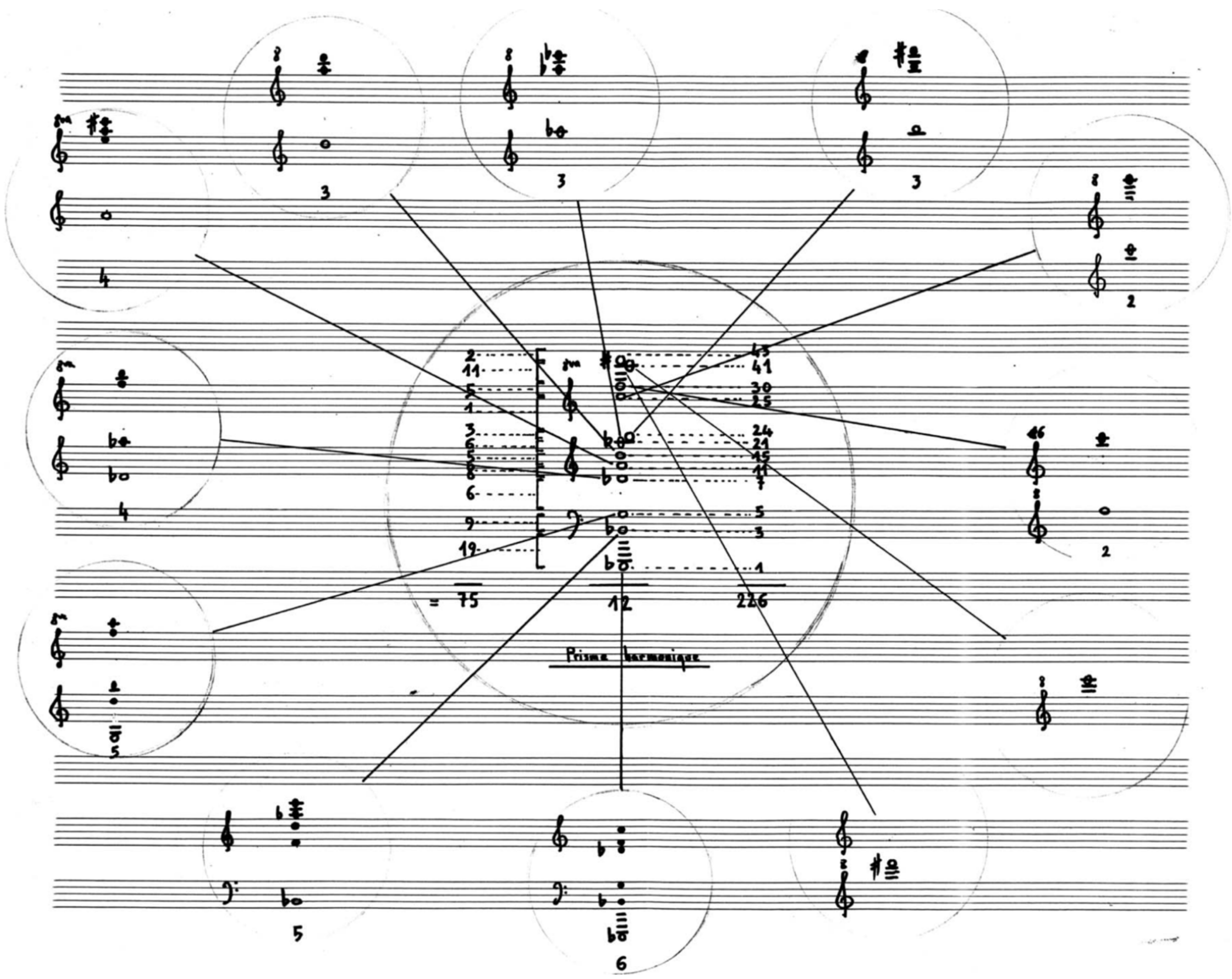


Figure 3.4 - Grisey’s main harmonic spectrum (axis) with the extraction of secondary spectrums (Féron, 2011:350)

Dérives represents Grisey’s first piece where the main spectrum acts as the structural determinant of the entire piece. The spectral writing is within equal temperament, as with Messiaen’s resonance chord writing (Féron, 2011:352). Figure 3.4 displays the main harmonic spectrum (axis) in the centre (2011:350). On the right of the pitches appear the harmonic rank numbers 1 – 43; the majority of harmonics are odd-numbered (2011:352). On the left of the pitches the intervals between the members of the spectrum are calculated, where the number 1 represents the distance of a semitone. Grisey then extracted certain pitches by drawing a line to a new circle and forming a new fundamental with overtones. These are referred to as the secondary or complementary spectrums (Féron, 2011:352).[41] Apart from this sketch, Grisey also constructed an inharmonic spectrum which includes inharmonic partials that are not present in the main spectrum and bear no fundamental.

Grisey then related the structure of the main spectrum to the duration of sections throughout the piece. Each section of *Dérives* is related to an interval written on the left of the main harmonic spectrum. The work is made up of sixteen parts, with the large orchestra and small ensemble playing 8 sequences each. Grisey chose eight intervals from those written next to the axis: 1, 2, 3, 5, 8, 9, 11, and 19, and in this chronological order, multiplied each by 11" for the small ensemble and 17" for the large orchestra. This determined the length of each sequence (Féron, 2011:353). In each section the sequence from orchestra to ensemble overlap in an unnoticeable way because Grisey connects pitch material by using the main harmonic spectrum (ibid.).

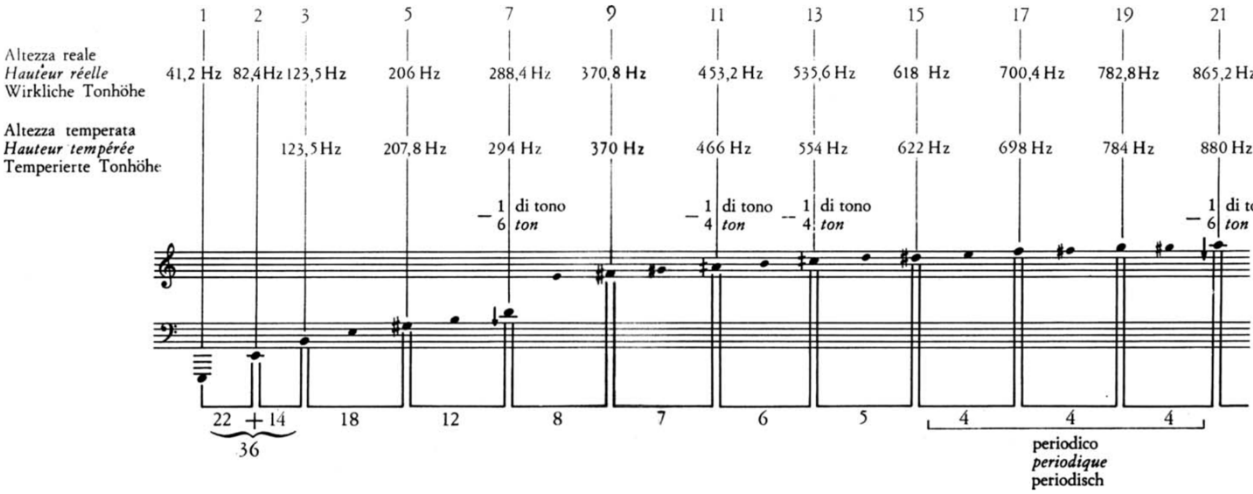
In the programme notes, it is written that each section is meant to represent as many deviations from the main harmonic spectrum as possible (Féron, 2011:353). These deviations are formed not only by harmonicity to inharmonicity, but durational aspects are represented by the temporal outline constructed on graph paper.[42] The map indicates duration, intensity, pitch and density. These aspects were considered before writing a single note and the outline indicates the transitory aspect of moving away from the main harmonic spectrum.

3.4.1.2 *Périodes* (1974) for flute, clarinet, trombone, violin, viola, cello and double bass

Périodes is the first piece composed for the two-hour cycle, *Les Espaces Acoustique*. Grisey makes use of 'fuzzy periodicity' by relating periodic events to that of a human's natural rhythms, such as the heartbeat and breathing (1987:245). For the first time, Grisey makes use of microtones to accurately represent the natural acoustics and does not approximate to equal temperament. As with *Dérives*, he constructs a main harmonic spectrum out of 11 odd-numbered harmonics and lets the intervals determine the length of sections. This occurs now with further refinement as he includes

[41] Influenced by Messiaen's idea of complementary colours, mentioned in Chapter 2, section 2.4.5.
[42] Another example of Grisey's use of graph paper is discussed under section 3.4.1.2.

logarithmic calculations of microtonal intervals (Féron, 2011:358). Figure 3.5 displays the harmonic spectrum used in *Périodes* where he once again favours odd numbered harmonics and calculates the intervals.



<u>Figure 3.5 - The harmonic spectrum from *Périodes* (Féron, 2011:357)</u>

Grisey writes the sections of the piece are formed to represent breathing:[43] inhalation, exhalation and repose, where the resting phase is characterized by the harmonic spectrum/periodicity, inhalation moving towards tension and inharmonicity, and exhalation moving back towards repose (Féron, 2011:358). The global form is then that of 'fuzzy-periodicity', as the sections are not entirely even while they reoccur in a periodic fashion.

Refer to Figure 3.6, where Grisey used graph paper to plan out 'musical breathing' as different sections in terms of texture, range and density (Féron, 2011:359). The fermatas represent repose sections, the upward arrows indicate inhalation, and the downward arrows indicate exhalation. The piece begins and ends with repose and the timing of each section is determined by calculations from intervals of the harmonic spectrum (2011:358). He maps a general idea of pitch and different texture types, with the *y*-axis representing frequency and the *x*-axis time. Grisey draws in pitches as straight lines, dots or squiggly lines, indicating the difference between sustained and 'micropolyphonic', sparse and dense, respectively.

Grisey focuses on the degree of change between sound events and forms a continuous transition between harmonic pillars. At each of these points a different character of sound is featured by varying the spectral foundation (Féron, 2011:363).

[43] The concept of 'musical breathing' is important to spectral composers, and is discussed further under section 3.5.

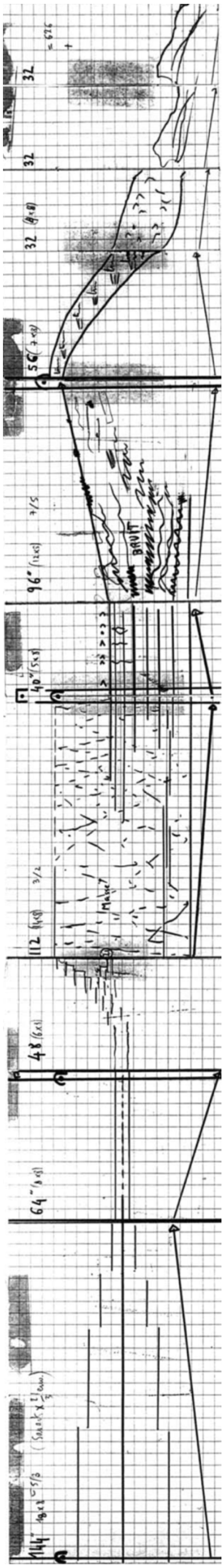


Figure 3.6 - A temporal map as a sketch for Grisey's *Périodes* (Féron, 2011:360)

3.4.1.3 *Partiels* (1975) for 18 musicians

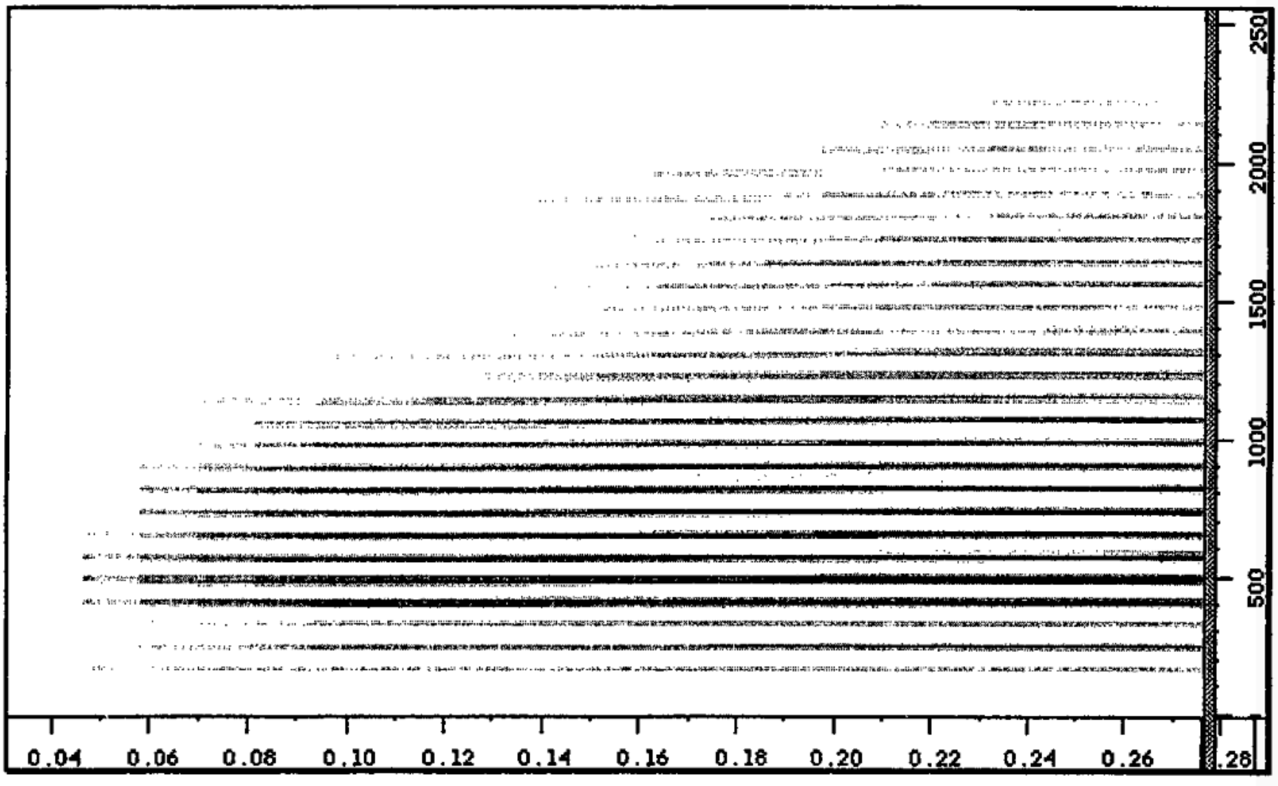


Figure 3.7 - Spectral analysis of the trombone playing low E2 (Fineberg, 2000:116)

Partiels is written for 18 musicians and displays the influence of electronic studio techniques through the use of orchestral synthesis and ring modulation (Arrel, 2008:218). The harmonic spectrum is taken from a trombone playing low E^2 (2008:221). The remarkable technological abilities used today were not available to Grisey in the 1970s, and he had access to a sonogram machine that he used to analyse the attack and sustain of E^2 of a trombone (Besharse, 2009:81). Figure 3.7 shows a graphic representation made with more recent technology to illustrate these findings (Fineberg, 2000:116). In *Partiels,* Grisey focuses on the perceptual difference between successive events and once again forms sections based on inhalation, exhalation and repose, similar to *Périodes* (Arrel, 2008:219). The piece begins with harmonicity/periodicity and ends with the noise of paper crumpling, wind instruments being dismantled and dialogue between players (Chen, 2010:18). The musical journey shifts through eight different processes, and is each charged with their own direction and meaning. Once again Grisey used a textural map to plot the layout of the piece and the range moves from low to high and vice versa as the sections progress.

3.4.2 The Spectrum as a 'Block of Ice'

Instead of structuring his music according to calculations derived from the spectrum, Murail rather works from the global approach where the spectrum is viewed as a 'block of ice' that can be carved into different forms. The aim is for continuity to be created between these forms. This involves changing the perception of the same object (block of ice) through continuous alterations to the inner-details of the spectral content. Murail makes use of electronic techniques in order to generate artificial spectra. He also makes use of spectral analysis in order to discover spectral content of various sound sources.

3.4.2.1 Murail – *Gondwana* (1980) for large orchestra

Murail employs the technique of frequency modulation (FM) to artificially generate the harmonic spectra of a bell and other instrumental timbres. FM is used to calculate frequency aggregates for orchestral synthesis whereby each frequency is played by an instrument, so as to acoustically synthesize a new global timbre (Murail, 2005c:130). FM is a technique developed by John Chowning and is based on an algorithm that generates the partials and their relevant amplitudes through the algebraic equation (Moscovich, 1997:23):

$$\text{Partials} = \text{Carrier} \pm [\text{Modulant} \times \text{Index}]$$

The carrier *(c)* and modulant *(m)* are two different frequencies and the index *(i)* is an integer. The greater the complexity of the ratio between the two frequencies, *c* and *m,* the more inharmonic the resulting partials will be (Anderson & Murail, 1993:323). If *c* and *m* are related by a whole number, the resulting spectrum will be harmonic. The product of the modulant and the index is added to and subtracted from the carrier *i* number of times (Murail, 2005c:130). The first chord of *Gondwana* was calculated with *c* as 392hz ($G^{\sharp 4}$) and *m* as 207.65hz (G^3) and *i* as 9 (Moscovich, 1997:23):

Additionals:

$$H1= 392 + (207.65\times1)=599,65hz$$

$$H2=392 + (207.65\times2)=807.30hz$$

(up to ×9)

Differentials:

H1=392 – (207.65×1)= 84.35hz

H2=392 – (207.65×2)=23.30hz

(up to ×9)

Figure 3.8 - The opening chord from *Gondwana* calculated with FM representing a bell's spectrum (Moscovich, 1997:23)

Figure 3.8 displays the results. The ratio between G^3 and $G\sharp^4$ is complex and therefore the resulting spectrum has the inharmonic structure that closely resembles the vertical structure of a bell's spectrum (Anderson & Murail, 1993:323).

3.4.2.2 *Désintégrations* (1982/83) for 17 instruments and tape

Murail worked at IRCAM from 1980 onwards and had access to a variety of spectral analyses of instruments such as the piano, clarinet, flute and trombone (Hirs, 2008:278). Together with programmers, he helped develop the software OpenMusic, used to calculate harmonic spectra and proportions between different spectra to form intermediate spectra, playback sounds, and transform spectral analysis and artificially generated spectra into music notation (Moscovich, 1997:23). Static sound analysis was available to composers in the 1970s where information on sound was taken as snapshots of time windows; dynamic sound analysis came about from the late 1980s when the spectrum could be modelled over time more accurately (Fineberg, 2009:101).[44] Murail made use of dynamic sound analysis in his later pieces such as *Les Esprit des Dunes* (1994) for 11 instruments and electronics.

[44] In the 1970s and 1980s scientists and computer technicians were working with Fourier analysis, and their method was not easily accessible to composers. However, David Wessel created a number of static Fourier analyses of the different instruments that were used for Murail's *Désintégrations* (Smith & Murail, 2000:12).

Désintégrations makes use of spectral analyses of the above-mentioned instruments to serve as spectral models for artificially distorted spectrums (Hirs, 2008:278).[45] The spectral analyses of instruments serve as pitch models and the process of composition is based on structuring these models in time (Anderson & Murail, 1993:323). There are eleven sections each characterized by varied spectrum-treatment of a different analysed instrument. In each moment there is a varied process of harmonic/rhythmic ordering to inharmonic/rhythmic disordering, and this is said to create movement between shade and light (Murail, 2004:6). Murail makes use of progressive distortion and additive synthesis as notable compositional techniques and 'sculpts' the spectrums in the following ways:

- fractioning: one region only of the spectrum is used;
- filterings: certain component elements are exaggerated or toned down [formants];
- spectral exploration: movement within a sound. The component elements are heard one after the other, the [inner-details of] timbre becoming melody;
- creation of inharmonic spectra. Those that are linear are made by adding or subtracting frequencies [frequency modulation], while the "non-linear" are made by twisting a spectrum [distortion].

3.4.2.3 *Les Esprit des Dunes* (1994) for 11 instruments and electronics

This piece expresses Murail's continued fascination with the desert after his piece for orchestra *Sables* (1975), which used slow moving sound masses in order for individual notes to have "no more importance than individual grains of sand" (Anderson, 1994:1). In *Les Esprit des Dunes* Murail evokes the psychological aspects of the desert by connecting to the timbre of Mongolian overtone singing and the Tibetan horn. The piece is dedicated to both Giacinto Scelsi and Salvador Dali, who both engaged with the exoticism of the desert (Anderson, 1994:1). The Gobi say that when the grains of sand rub against each other in the wind, the desert sings; Murail recreates this atmosphere with melodic development based on spectral analysis of various different musical aspects of the Mongolian desert. Furthermore, Murail connects the perceived ambiguity between the imaginary 'micro-worlds' of each 'grain of sound' with the sonic reality of the sweeping wind.

Murail had access to dynamic sound analyses of Mongolian overtone singing, Tibetan horn playing, and Tibetan monks' psalmody. These sound samples served as important acoustic models that

[45] The piano's harmonic series does not follow the pure harmonic series and presents a case of natural distortion that can be used as a model to generate artificial distortion. This is explained further below under section 3.5.3.

allowed for the perceptive connection between the real and imaginary (Hirs, 2008:282). The dynamic analysis allowed for partial tracking, so that details of the polyphony of partials could be used for melodic writing by extracting different melodic shapes ('Gestalts') (ibid.).

Murail made use of three acoustic models for varying compositional uses. The first of melodic extraction is explained in the current section. The second and third are explained under section 3.4.3 and 3.5 respectively.

The acoustic model of Mongolian overtone singing was used to extract melodic material through partial tracking. Figure 3.9 displays the dynamic spectral analysis processed through AudioSculpt where different melodic patterns were highlighted and linked by neighbouring relations (Hirs, 2008:286). On the *y*-axis the partials are numbered 5-10 and the patterns 6-5-6, 7-8-7 and 9-10-9 were linked by their neighbouring relations. These are the partials with the largest amplitude, represented by darker lines. Murail revised this data with the software PatchWork and changed the amplitude structure in order to create new timbres that serve as a continual transition (ibid.).

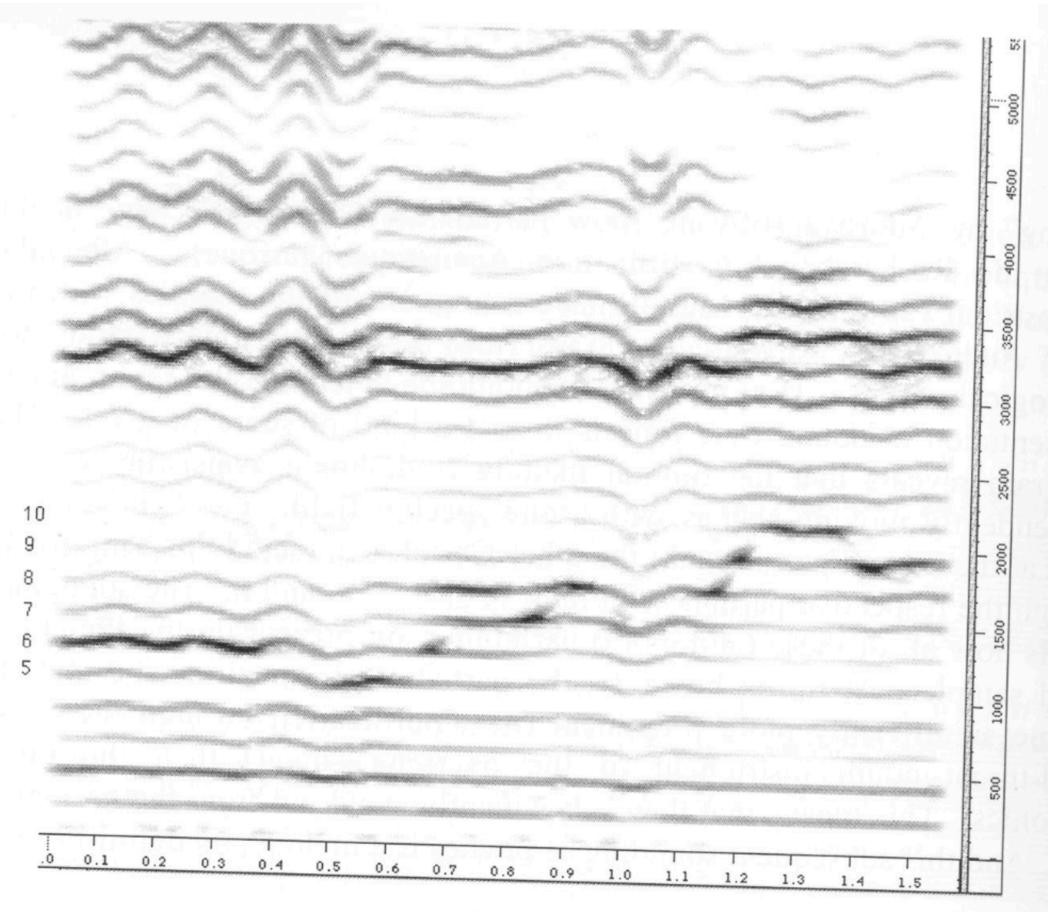


Figure 3.9 - Partial tracking of Mongolian overtone singing; partials 5 to 10 are numbered on the left (Hirs, 2008:286)

3.4.2.4 *Le Partage des Eaux* (1995) for large orchestra

Murail says that *Le Portage des Eaux* was his first study into highly complex sounds made available due to advances in technology (1995:1). In this piece for large orchestra with four-fold woodwind and six horns, Murail makes use of analysed sounds of the sea such as waves breaking, stones hitting the shore, and waves gurgling the sand (Hirs, 2008:292). The piece works with time, memory and reminiscence, and the sound analyses of crashing waves inspired the piece's shapes and sounds (Murail, 1995:1).

PatchWork software was used to transcribe the data into music notation, and Murail closely follows the relative dynamics of each frequency component in orchestration (Hirs, 2008:294). Murail employs the vocoder: a device that "inflicts the spectral content of one sound onto the envelope of another; the resulting sound possesses the harmony of the first and the movement of the other" (Hirs, 2008:295). Late in the piece the envelope of the crashing wave is kept while a different harmony is imposed, calling for different orchestration of this spectral representation. Take note that there are no electronics in this piece, therefore electronic manipulation of the vocoder occurs during the sound analysis process. This data is then orchestrated and shaped into the composition that is performed.

3.4.3 Orchestral Synthesis

The most notable technique of spectral composers is orchestral synthesis, whereby spectral data is orchestrated in order to create a new global timbre (Besharse, 2009:80). Each instrument adds their own spectral content to the global timbre and thus the orchestration is not an exact recreation of the original sound source, but rather results in a new timbre. An important factor in orchestral synthesis is following the envelope of the spectral source (Fineberg, 2009:90).[46] Spectral composers employ this technique to create the ambiguity of perception between timbre and harmony.

3.4.3.1 Grisey – *Partiels*

In the opening section of *Partiels,* displayed in Figure 3.10, Grisey makes use of orchestral synthesis and alternates between two perceptual structures (Grisey, 1976:1). The first is a 'fuzzy-

[46] The spectral envelope accounts for the attack, sustain, and decay portions of a sound source. The different partials vary at different rates in frequency and amplitude throughout the envelope. This usually occurs in a complex fashion and the failure to mimic this flux due to complexity is why some electronically synthesized sounds appear as artificial (Fineberg, 2009:90). For this reason, orchestral synthesis requires careful orchestration of dynamics and playing techniques.

periodic' repetition of double basses playing low E^2 (sounding E^1) as they are asked to repeat with slight variations, while the trombones sustain the fundamental presenting the source of spectral inspiration in real time (recall that Grisey had access to the sound source of a trombone playing E2). What follows is a slow, static chord of the orchestrated partials, crafted with similar dynamics to the spectral envelope in order to create the percept of a fused timbre. The different onset times and dynamic inflections of the trombone's spectrum are orchestrated (Fineberg, 2000:116). The orchestration of the trombone's spectrum is 'filtered' because only the 1^{st}, 2^{nd}, 3^{rd}, 5^{th} and 11^{th} partials are orchestrated (Arrel, 2008:221). The structure of the sustained texture resembles that of a pyramid, the lower partials held longer and the higher partials entering with staggered entries (Besharse, 2009:82). Arrel writes that Grisey was sensitive to the attack transient of a trombone's spectrum: the double bass playing *sul ponticello* in the opening is to bring out the noise structure of the trombone's attack transient (2008:221).

Figure 3.10 - The opening of *Partiels* (Grisey, 1976:1)

The sustained chord increases the density of time and the lens of time expands over the spectral components of the previously heard timbre (trombone). There is a sense of 'pre-audibility' and a long enough temporal duration to allow for the density of time to increase. The listener is then transported into the 'micro-details' of sound: a "macroscopic journey into the microscopic interior" (Arrel, 2008:221). This is referred to as *temp dilaté* because the duration of the original sound is stretched (Chen, 2010:29). There is contrast between the opening clear attacks and the subsequent sustained entrances; the latter creates no clear perception of the onset. However, the multiple parts form a cohesive group perceived as one global timbre.[47] The opening attacks allow for the listener to form clear groups of the initial notes, whereas the partials of the following sustained chord are

[47] Recall the Gestalt grouping principle *common fate* from section 1.4 - the difference between a sound with a clear attack and blurred entries is also mentioned by Grisey, and is discussed in section 3.3.2.2.

grouped to flow in a coherent manner with slight and unnoticeable changes that form a seamless percept. The latter forms one large perceived group as a sound-mass texture, where a number of sustained voices fuse together to form a globally perceived sound (Besharse, 2009:85).

3.4.3.2 Murail - *Gondwana*

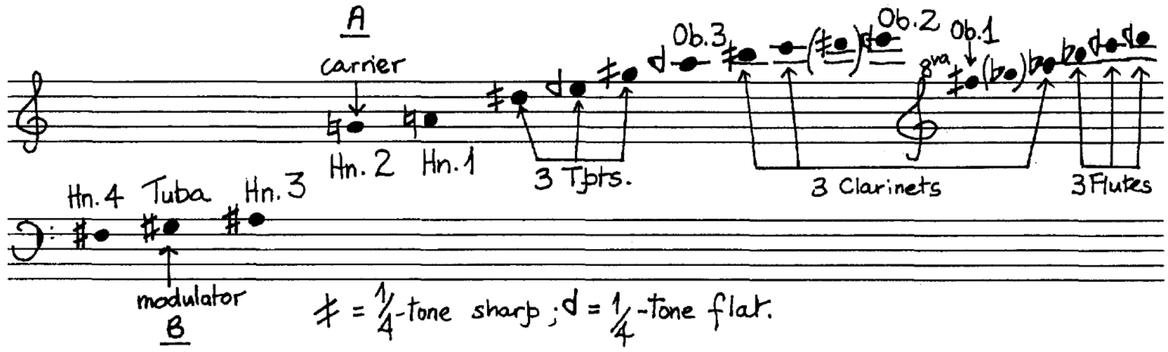


Figure 3.11 - The orchestration of the opening chord from *Gondwana* (1980) (Anderson & Murail, 1993:323)

In *Gondwana,* Figure 3.11 shows Murail's orchestration of the frequency content generated through FM. The modulant is played by the tuba because it has the largest spectral mass. The high frequencies are placed in an imbalanced fashion, with the clarinets playing above the oboes in a very resonant register while oboes 1 and 3 are in a weaker register (Moscovich, 1997:23). This orchestration is chosen in order to bring out the larger amplitude of the relevant frequencies, to create a similar bell-like timbre. To bring out the attack portion of a 'bell-like' timbre, Murail makes use of the piano, vibraphone, two crotales, and two tubular bells (Rose, 1996:32). Murail then begins a process of continuous evolution by constructing 11 chords to form a progression from the 'bell' timbre towards a 'brass' timbre (Fineberg, 2000:128). The 2^{nd}, 4^{th}, 5^{th} and 8^{th} transitory chords are constructed with the same process of frequency modulation. However, each time the relationship between *m* and *c* is made more harmonic. The remaining 3^{rd}, 6^{th}, 9^{th}, 10^{th} and 11^{th} chords are the result of the combination of more than one of the calculated chords (Moscovich, 1997:23). Murail makes use of five different carriers (G^4, A^4, B^4, D^5, and $F^{\sharp 4}$) while the modulant remains as $G^{\sharp 3}$ (Fineberg, 2000:128).

In summary, Murail orchestrates the dynamic envelope of a bell with the use of FM to construct spectral chords. He then creates a continuous transition towards a different global timbre through different spectral structures by altering the FM calculations.

3.4.3.3 *Désintégrations*

In *Désintégrations*, Murail creates 'auditory fusion' between the part for tape and the instrumental synthesis. The tape plays back a recorded synthesizer that played frequencies discovered from spectral analysis of a sound source, and this is combined with the orchestral synthesis of the same partials (Hirs, 2008:278). The purpose of the tape is not to resynthesize the analysed instruments, but rather to aid the construction of new timbres and harmony with additive synthesis by following temporal, frequency and amplitude information accurately (Murail, 2004:6).

In the opening of *Désintégrations*, Murail extracts certain frequency regions of an analysed piano sound in order to create a 'bell' timbre (Murail, 2004:6). This is characterized by progressive chords that reoccur in 'fuzzy-periodicity'; they have a hard attack and a lengthened sustain where inner motion occurs that resembles the temporal flow of the piano's spectrum. The representation results in orchestral synthesis of a new timbre. Refer to Figure 3.12 for an example of the score where the shape of each chord oscillates between the perception of a global timbre and harmony (2004:10). The progression occurs as different spectral regions are highlighted and densities and durations vary. The notation for the tape found on the top line displays the partials that are played, as well as a graphic symbol in a triangular form used to shape filtering in the indicated direction. Note how the different instrumental voices have different vibrato, dynamic and offset markings representing the temporal flow and relative amplitudes of a spectrally analysed sound source.

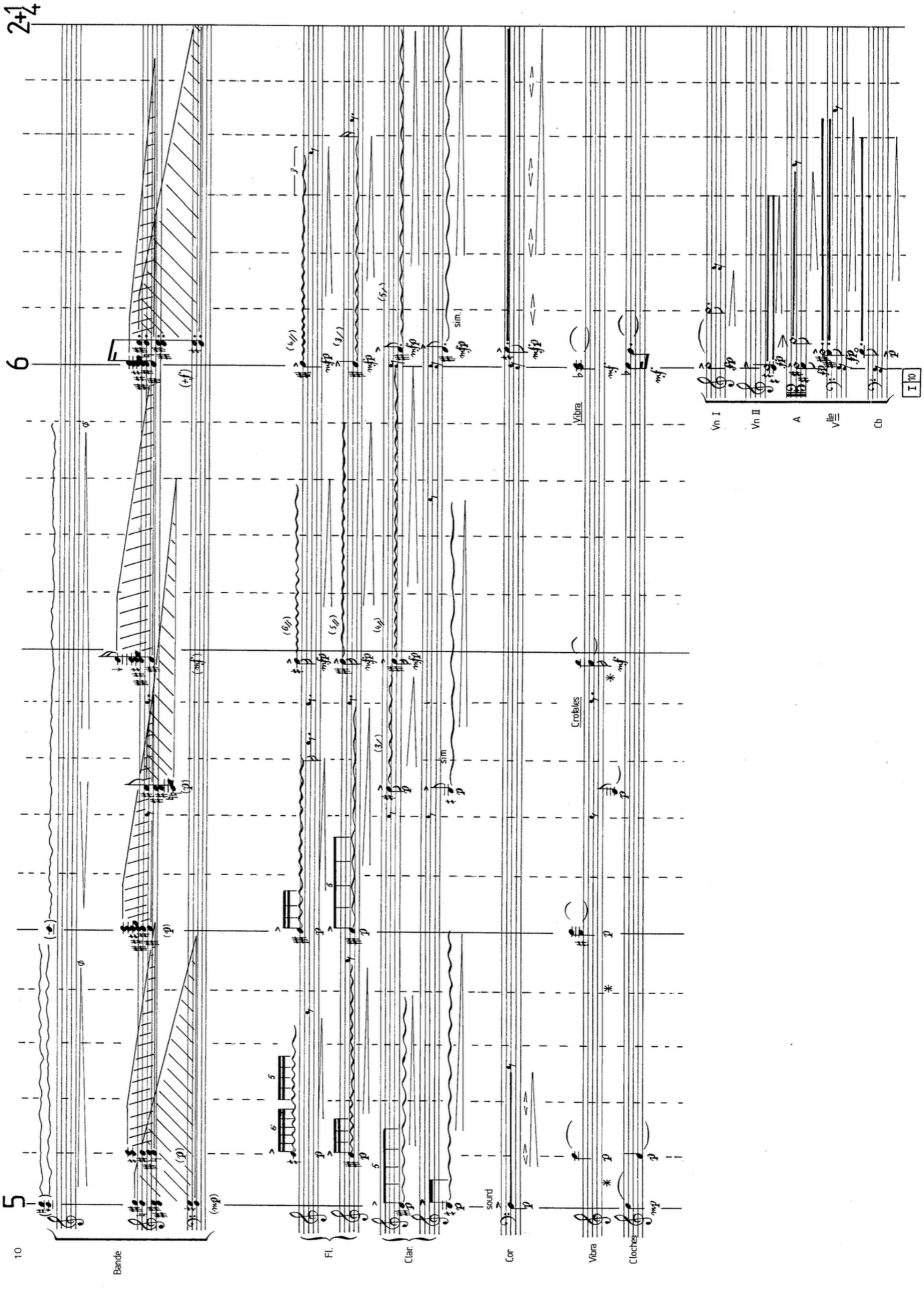


Figure 3.12 - The second page of the score to *Désintégrations* characterized by slow evolving changes in the periodic chords (Murail, 2004:10)

3.4.3.4 *Les Esprit des Dunes*

In *Les Esprit des Dunes* Murail performed spectral analysis on the Tibetan monks' psalmody with AudioSculpt, and translated the data into music notation with OpenMusic as displayed by Figure 3.13 (Hirs, 2008:289). The partials were used as models for electronic and orchestral synthesis (ibid.). The spectral data created a re-synthesis model for 40 sine wave oscillators in MaxMSP.[48] The data was further used to filter sounds of white noise created by recording polystyrene and maracas. These sounds were processed through 40 band-pass filter banks which were modelled on the spectral data of the monks' psalmody, creating cross-synthesis between noise elements and the spectrum of an analysed sound (Hirs, 2008:292). The filters focused on the corresponding frequencies and their amplitudes over time, creating a connection between the white noise elements and the sound of Tibetan monks.

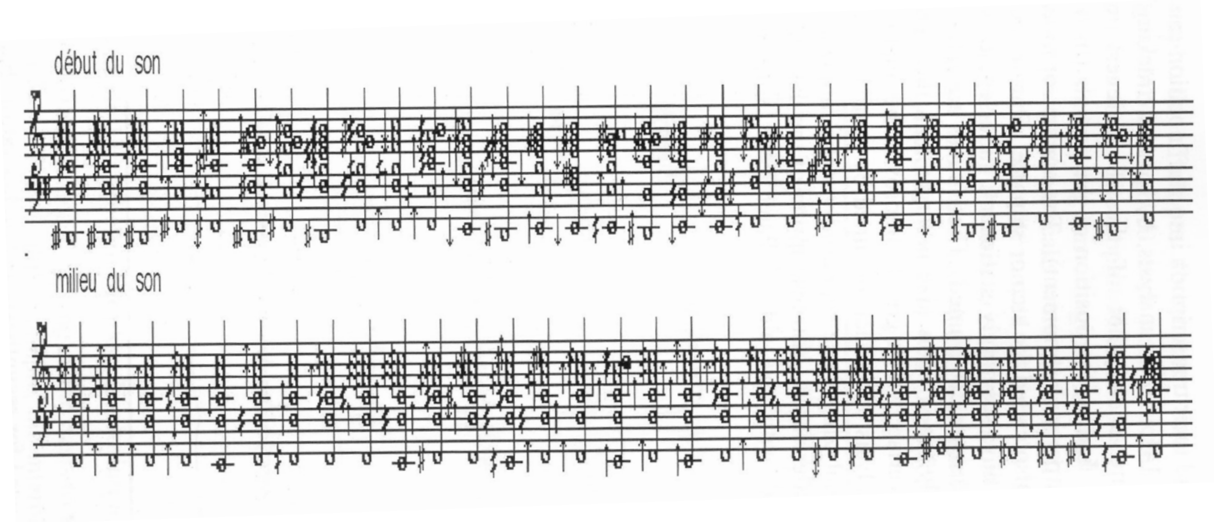


Figure 3.13 - Chords extracted from spectral analysis of the Tibetan monks' psalmody (Hirs, 2008:290)

Les Esprit des Dunes is an example of the use of more recent technology (in the time of the 1990s) to combine orchestral synthesis with electronic synthesis techniques.

3.4.4 Acoustic 'a priori'

Ledoux writes in a footnote that humans have 'a priori' knowledge of the acoustic reality because of the theory of Gestalt perception of sound (Ledoux, 2000:52). The spectral composers in some cases present the acoustic reality and thereafter create a macroscopic journey into the interior of sound by orchestrating the inner-details of the sound (Arrel, 2008:221). There then exists a connection

[48] As mentioned in footnote 12, MaxMSP software was developed at IRCAM. For further reading refer to *Cycling 74: About Max* (Cycling 74, 2016:1).

between the real sound source and the orchestral synthesis occurring thereafter. The orchestral synthesis forms the acoustic 'a priori' as it is a theoretically based on the original sound source due to spectral findings.

In *Désintégrations* Murail connects acoustic 'a priori' through the process of gradual distortion: the listener is presented with the original sound that is then magnified and altered through distortion while the magnification constantly remains related to the prior (Ledoux, 2000:52).[49] In the opening section the material is modelled on the spectrum of a piano. Murail presents the original sound of the piano in order for the listener to connect the original sound with the macroscopic representation of the material. Furthermore, the macro-material undergoes distortion/filtering to create ever-evolving macro-representations. A two-fold relationship exists as a connection between the original sound source and the macro-representations, and a relationship between the various distorted macro-representations themselves.[50]

3.4.5 Texture and Embellishments

Besharse refers to the sound-mass and 'micropolyphony' as 'additive textures' arising out of the music of the 20th century (2009:54). The two texture types feature in spectral compositions as the result of orchestral synthesis. Sound-mass texture is the result of the orchestration of sustained partials (Besharse, 2009:89). 'Micropolyphonic' textures are the result of orchestrating more complex partials (2009:102). Layered textures are the combination of sound-mass and 'micropolyphonic' textures at various levels of foreground prominence.

In *Désintégrations*, Murail presents an example of a layered texture as displayed by Figure 3.14 (Besharse, 2009:114). The strings and flute perform *ad lib* repetitions of rhythmic cells that create a 'micropolyphonic' texture, dense with attacks, while the sound-mass texture produced by the brass sneaks in from a soft dynamic. The density of instrumental voices creates timbral fusion and a global sound is perceived (2009:114).

[49] Murail's use of distortion is explained below under section 3.5.
[50] This is similar to the opening of Grisey's *Partiels* where the trombone is heard before zooming into the micro details of its sound. The initial sound connects with the successive spectral representation in magnified form (as an acoustic 'a priori').

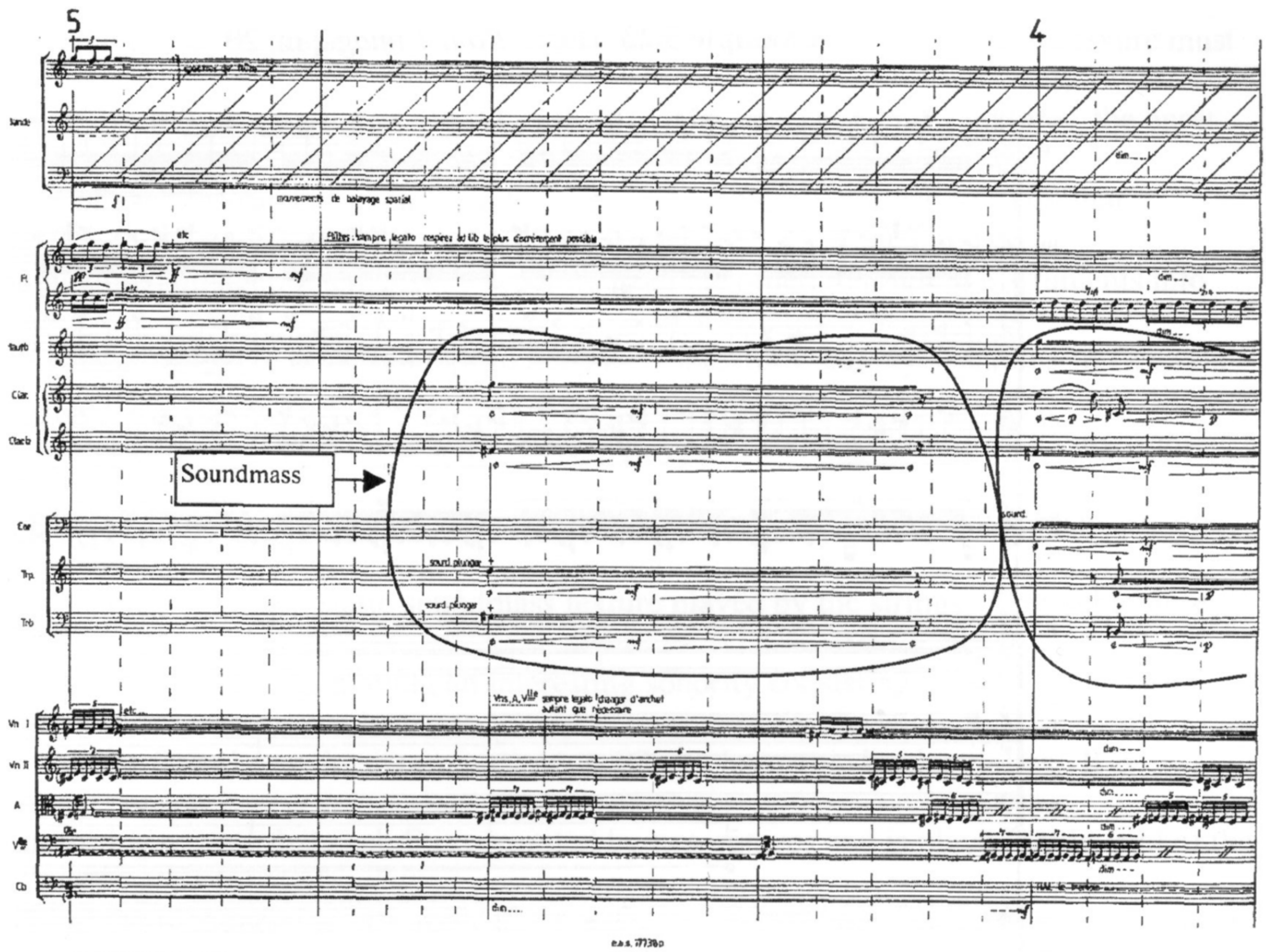


Figure 3.14 - An example of a layered texture from *Désintégrations* where a sound-mass texture is layered with the 'micropolyphonic' texture created by the strings and flutes (Besharse, 2009:115)

Murail goes further to embellish the sound-mass textures with melodic, rhythmic and gestural fragments (Besharse, 2009:97). Figure 3.15 displays these different embellishments, and Besharse writes that these are used to "activate or disturb the surface of the texture". In the case of *Désintégrations*, the start of a sound-mass texture is accented with a hard attack to give the static sound a clear beginning (ibid.). The embellishments are therefore used to enhance the effect of a cohesive group and in other cases, to break them apart.

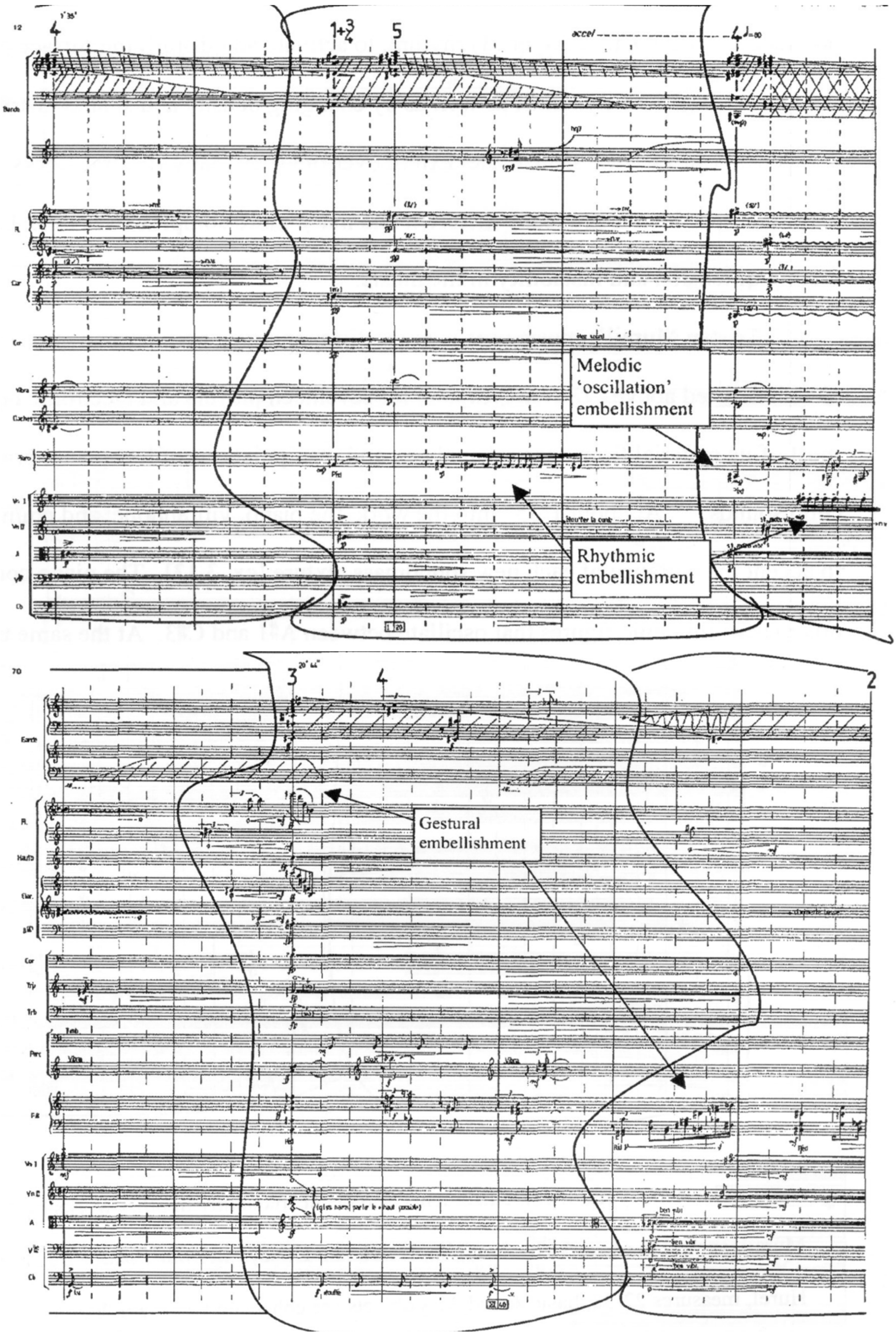


Figure 3.15 - Embellishment of a sound-mass texture in *Désintégrations* (Besharse 2009:98-99)

3.5 Musical Breathing

Kaija Saariaho, a second-generation spectral composer taught by Murail and Grisey, mentions that her first piece after learning about technology, acoustics and psychoacoustics at IRCAM, *Lichtbogen* (1986) for large ensemble and electronics, was 'breathing' music (Service, 2011:11). The main feature of spectral music is that of 'breathing', in accordance with the principles on the perception of time discussed above. As mentioned before, 'Musical breathing' is at the heart of the 'attitude' of spectral music. Murail and Grisey employ various techniques to evolve harmonicity/inharmonicity and rhythm in order to allow for the perception of 'musical breathing'.

3.5.1 Grisey – *Périodes*

The idea of breathing relates to different densities of time; Grisey zooms into sound by expanding the density of time through inhalation sections and moving back to a suspended time in exhalation sections (Féron, 2011:362). This is achieved through harmonicity/inharmonicity, predictability/unpredictability, and pre-audibility, as mentioned above in Grisey's reflection on musical time. One feature pointed out by Féron is that sound is used to exert a force of either attraction or repulsion of its direction and the listener is drawn towards expectation or loss of expectation (2011:363). These forces are rhythmically characterized by pulsating 'fuzzy periodicity' or static durations.

The fourth inhalation section of *Périodes* features a series of trills moving lower in range and moving away from the main harmonic spectrum towards inharmonicity (Féron, 2011:364). Grisey constructs three chords acting as pillars between which the progression moves. These are called A, B and C, as shown by Figure 3.16 (2011:366).

A - the main harmonic spectrum

B - the complementary spectrum

C - the anti-spectrum dense with inharmonic partials

Grisey constructed chords between these pillars by gradually adding notes derived from the next pillar and reducing notes from the previous pillar to form a continuous transition (Féron, 2011:365).

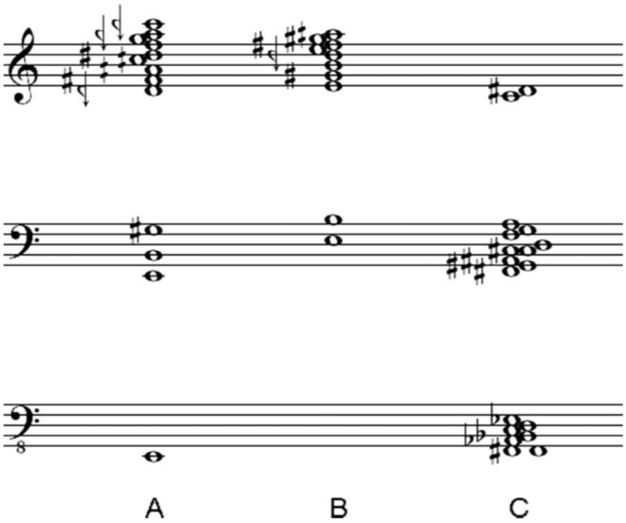


Figure 3.16 - The harmonic aggregates A, B and C differing in density in *Périodes* (Féron, 2011:366)

Grisey constructed a map on graph paper for individual sections with precise calculations for the separate musical parameters. The fourth inhalation is an example of the transitory process as displayed by the map on graph paper in Figure 3.17 (Féron, 2011:367).

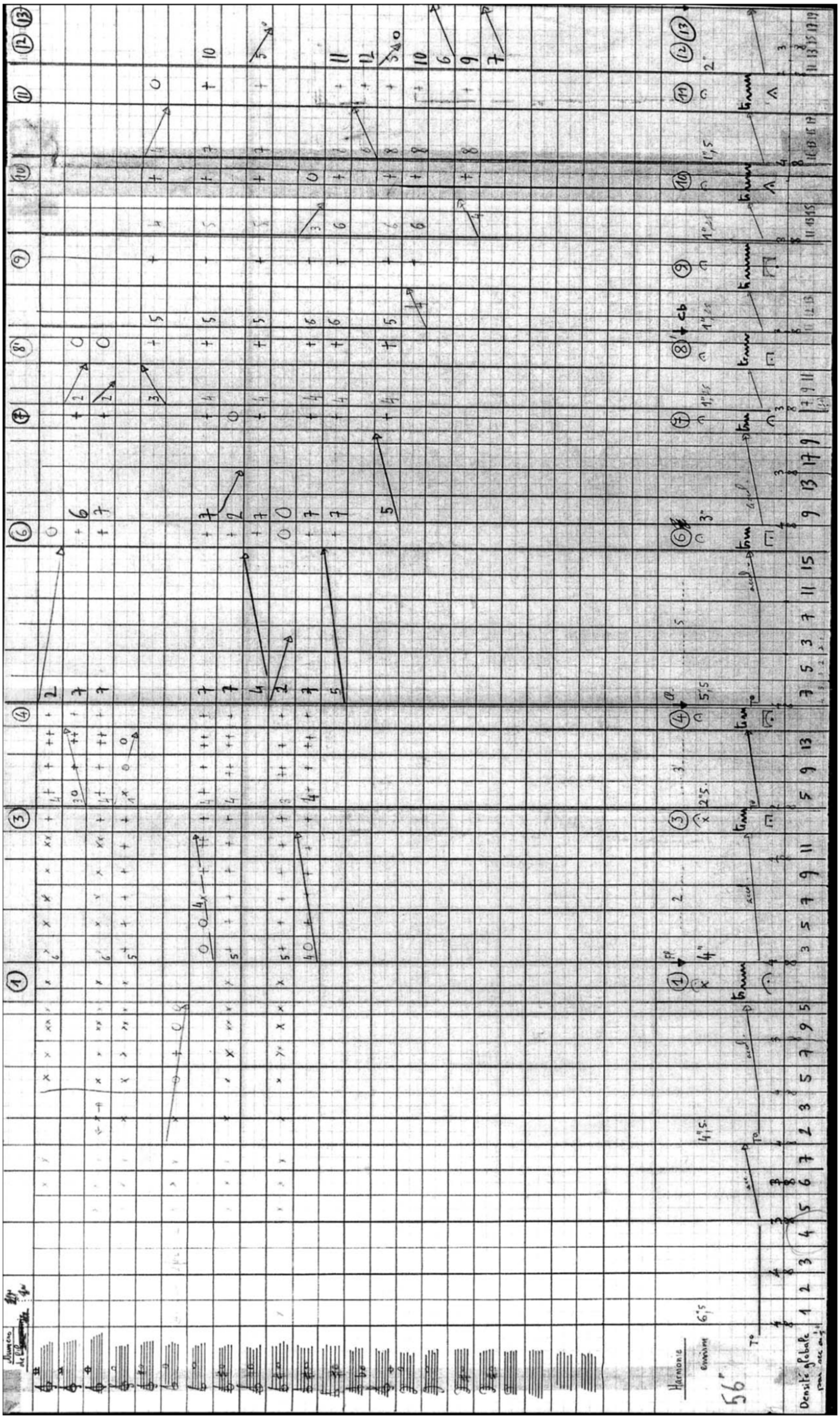


Figure 3.17 - Musical map for the fourth inhalation section of *Périodes* (Féron, 2011:367)

The *y*-axis displays several aspects, one being the pitches from the harmonic spectrum. On the *x*-axis, the timing of sections is indicated in seconds (the large 56” is for the entire duration) as well as the density of musical material per second (Féron, 2011:368). Along the *x*-axis are upward diagonal arrows indicating acceleration followed by a fermata in each case. Each grid measures the space of one second, and the density per second refers to how many different attacks will occur in the space of a second. The greater number of attacks, the greater the rhythmic complexity of that second. In most cases density per second increases with acceleration. The accelerated events occur in ‘fuzzy periodicity’; for example, the third acceleration is 4” followed by 2.5”, 5.5”, and 3”, forming a pattern of long/short.

This section displays Grisey’s treatment of duration and harmonicity/inharmonicity. He takes control over the musical output by carefully mapping each feature of sonic development and its relationship in time. There is intent to give each moment direction and validity in the perception of the listener.

3.5.2 *Partiels*

The inhalation section consists of 11 repeats of the repeated double bass rhythm and the proceeding *temps dilate*. More instruments are added on more partials in the ‘magnified sequences’, and in doing so, different formants are strengthened (Arrel, 2008:221). The periodicity of the double bass pulse moves towards more aperiodic pulses displayed in Figure 3.18; inharmonic partials gradually feature by transposing intervals of the upper reaches of the spectrum downwards (2008:223). The rhythmic progression combined with the harmonic structure becoming increasingly inharmonic directs the listener with dynamism towards forward momentum (Chen, 2010:29).

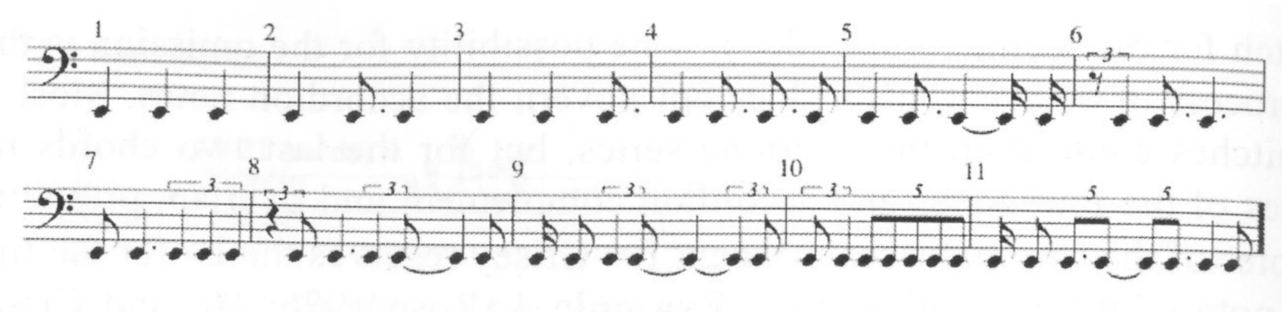


Figure 3.18 - The pulsations of the double basses forming a continuous rhythmic progression towards aperiodic repetitions (Arrel, 2008:224)

At the point of arrival of inharmonicity, Grisey brings the attack transient of a trombone's spectrum to the macro by extending the temporal structure through orchestration: over-bowing, wind growls and bass muting bring these noise features of the attack transient to macro time and also create a new timbre background for the listener (Arrel, 2008:223).[51] The texture becomes dense with rhythmic activity and the 'macro-phonic' perception of time comes into view for the listener.

In the exhalation section the return back to the main harmonic spectrum from inharmonicity occurs with the use of ring modulation (Arrel, 2008:224). Two generative frequencies result in the sum and difference frequency (Grisey only makes use of the difference; Chen, 2010:24). Grisey firstly uses two bass notes, 58.22Hz and 55.00Hz, as the generative frequencies resulting in 3.22Hz as the difference frequency (Arrel, 2008:224). This is below the human threshold of human hearing, and Grisey solves this with a rhythmic pulsation of the tam-tam. Figure 3.19 displays how the generative frequencies form an ascending spiral (the first three difference tones are in the percussion stave).

[51] The attack transient is the miniscule portion at the start of an instrumental sound's envelope (such as the scratch of a violin bow) which usually consists of a noise-like structure (Fineberg, 2009:90). According to Fineberg, the attack transient is important for the listener to identify the sound. If it were taken away, the resulting timbre would be perceived entirely differently.

Figure 3.19 - Ring modulation used to generate the ascent back to harmonicity in *Partiels* (Arrel, 2008:224).

At the end of this continuous procedure, the resulting difference tone (F^2 slightly flat) is within approximately three quarter-tones of the fundamental of the main harmonic spectrum E^2 (Arrel, 2008:224). This represents the continuous progression towards a point of arrival. The end of the exhalation section results in the second repose section displayed by Figure 3.20 and characterized by 'fuzzy-periodic' repetitions and orchestral synthesis of the E^2 harmonic spectrum. The sound-mass texture represents repose and stasis allowing for the density of time to increase (Besharse, 2009:102).

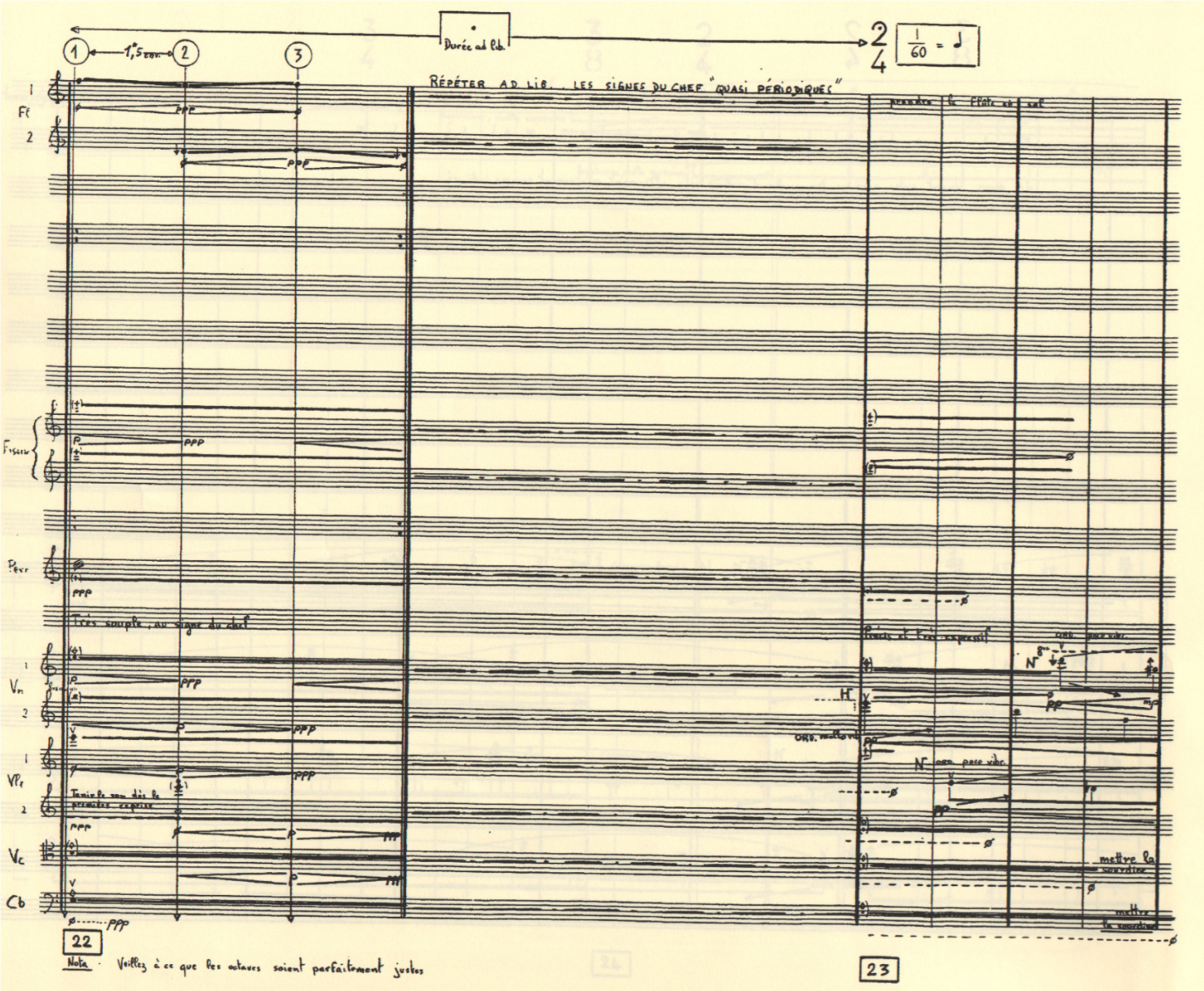


Figure 3.20 - The second repose section of *Partiels* characterized by the orchestral synthesis of the harmonic spectrum and 'quasi-periodic' repetitions (Grisey, 1976:25)

3.5.3 Murail – *Désintégrations*

Murail forms 'musical breathing' by gradually moving from harmonicity to inharmonicity. In *Désintégrations*, Murail makes use of the natural distortion of the overtone series of the piano's timbre as a model for distortion. In this piece and others, he constructs separate levels of distortion in order to create a continuous transition between different levels of harmonicity/inharmonicity.

The harmonic series is calculated as:

$$f(r) = f_0 \times r$$

The harmonic series can be distorted by changing the rank number by a distortion coefficient *d*:

$$f(r) = f_0 \times r^d$$

If *d*=1 then there will be no deviation from the harmonic series; if 0<*d*<1 then the intervals of the harmonic series will contract; and if *d*>1 then they will expand (Hirs, 2008:278). In *Désintégrations*, Murail made use of the analysed harmonic series of a piano playing low C^2 that presented a naturally expanded harmonic distortion. This was used as a model to calculate a distorted series. The theoretical harmonic series (above) and the distorted series (below) is displayed by Figure 3.21. Figure 3.22 displays a graphic example of the continuous transition.

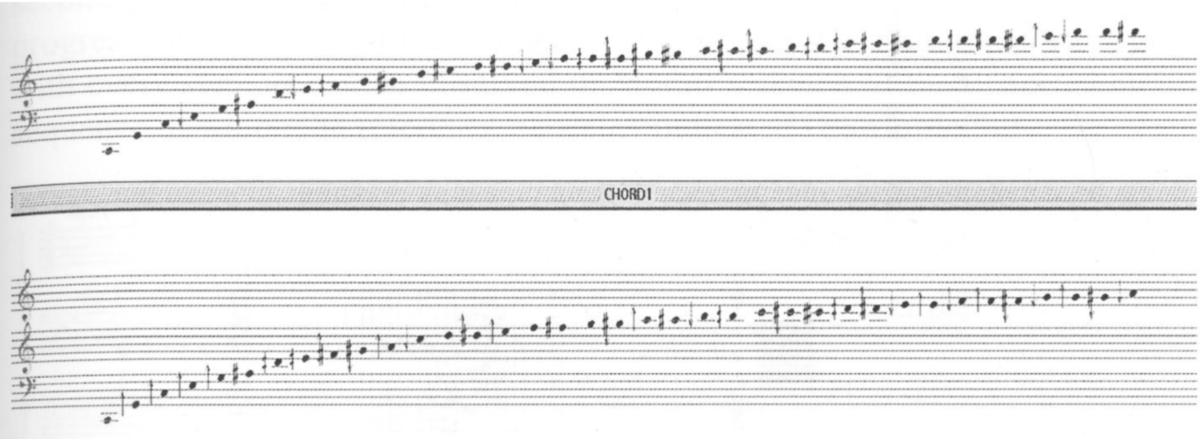


Figure 3.21 - The distorted (expanded) harmonic series based on the spectrum of a piano (below) against the theoretical harmonic series (above) (Hirs, 2008:279)

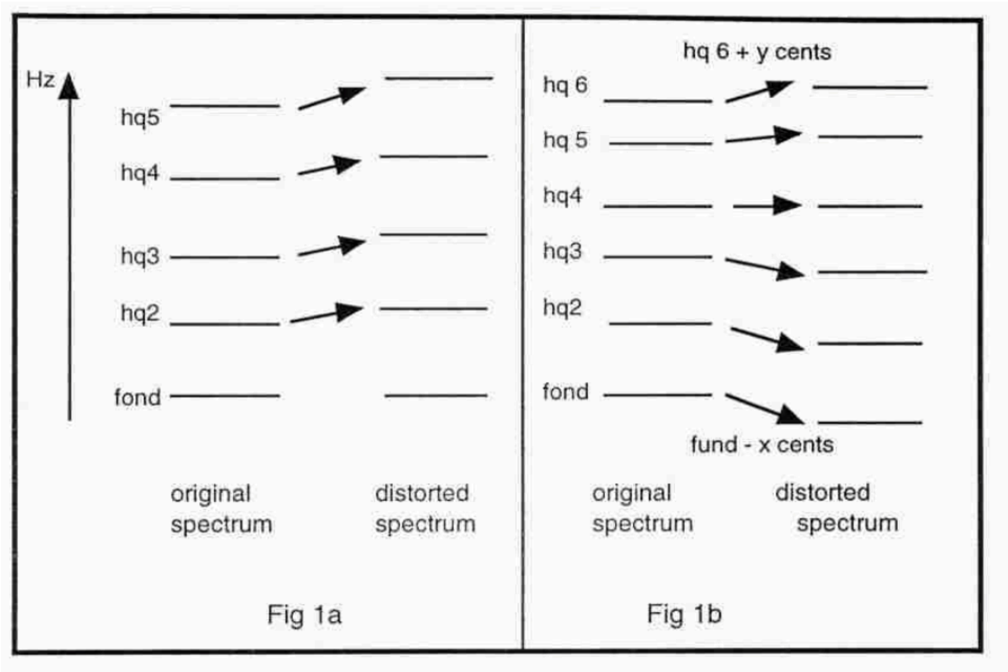


Figure 3.22 - An example of continuous transformation through the distortion of a spectrum (Ledoux, 2000:53)

The difference between the harmonic series and the natural distortion of the piano was calculated with an OpenMusic patch framework and the deviation amount calculated in midi cents; the patch framework allowed Murail to design a strategy to create a smooth transition between the distorted spectrum and the natural harmonic series (Hirs, 2008:279).[52] An example of the progressive distortion calculation is displayed by Figure 3.23, where seven steps of distortion result in partials ranked 3 and 21 ascending gradually (2008:281).

Figure 3.23 - The harmonic ranks 21 (above) and 3 (below) are distorted to create a continuous progression (Hirs, 2008:281)

[52] OpenMusic works with patches that define a specific function or class. Separate patches connect to each other to form an order for functions to have an effect on classes. The patches are programmed with the Lisp programming language (OpenMusic, 2016:1). In this example, Murail used the various frequencies of the spectral source in order to calculate the level of deviation from the overtones with a patch. Further patches (functions) were then connected in order to convert the frequency content into midi cents rounded off to the nearest quarter-tone.

3.5.4 *Les Esprit des Dunes*

The sound source of the Tibetan horn served as a model for spectral distortion as the partials are contracted with shrunken octaves between partials 1 and 2, and 3 and 4 (Fineberg, 2000:122). The coefficient d=1.03 was used to correct the distortion for continuous transition (Hirs, 2008:284). The Tibetan horn also has a gradual attack envelope and the fundamental frequency changes dramatically in this time (ibid.). The temporal evolution of the horn, displayed by Figure 3.24, is orchestrated in different forms by adding varying amounts of artificial distortion (Fineberg, 2000:122). MaxMSP was used to resynthesize aspects of the horn's spectrum by way of the sine wave oscillator bank (Hirs, 2008:284). Murail said that MaxMSP allowed for synthesis to behave in a similar chaotic nature as the live acoustic sounds. After dynamic sound analysis it became apparent that attack transients create a complex temporal evolution that can be described as chaotic. The acoustic models kept the chaotic behaviour so that MaxMSP could be used for electronic synthesis (Smith & Murail, 2000:15).

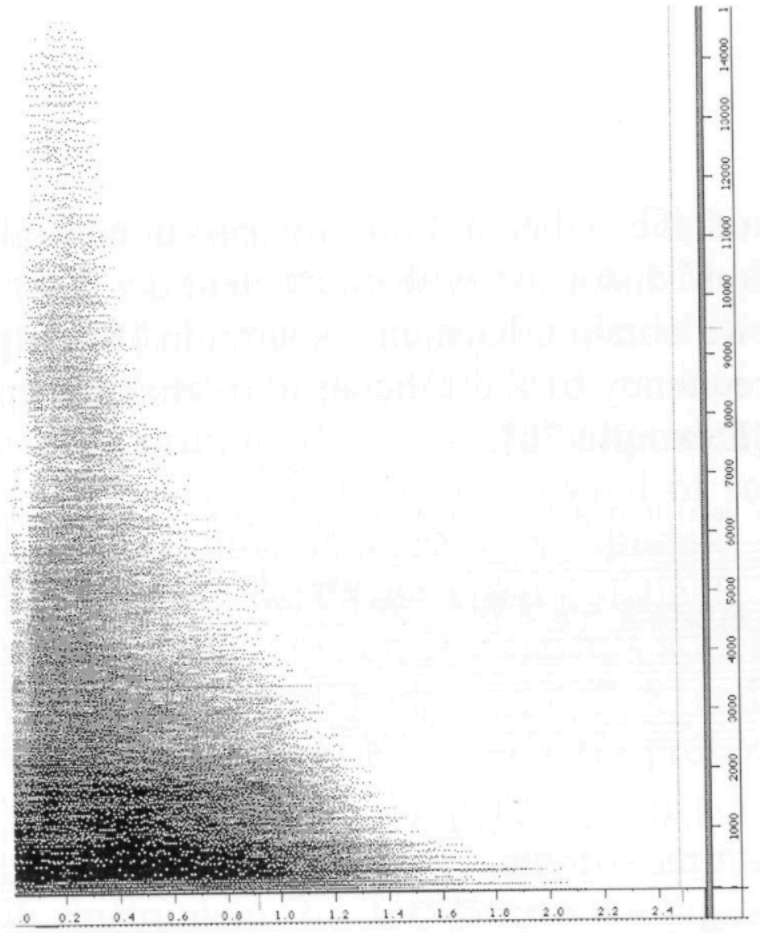


Figure 3.24 - Spectral analysis of the Tibetan Horn (Hirs, 2008:283)

In the opening of *Les Esprit des Dunes*, Murail gradually shifts the level of distortion as displayed by Figure 3.25. A larger percentage of distortion results in expansion, while a smaller percentage results in contraction. The partials are orchestrated as inner-moving rapid lines that create rhythmic density as displayed by Figure 3.26 (Fineberg, 2000:124). This method involves embellishing the true temporal flow of an analysed source, and results in a layered texture between the true sustained partials and the embellished 'micropolyphonic' rhythmic activity.

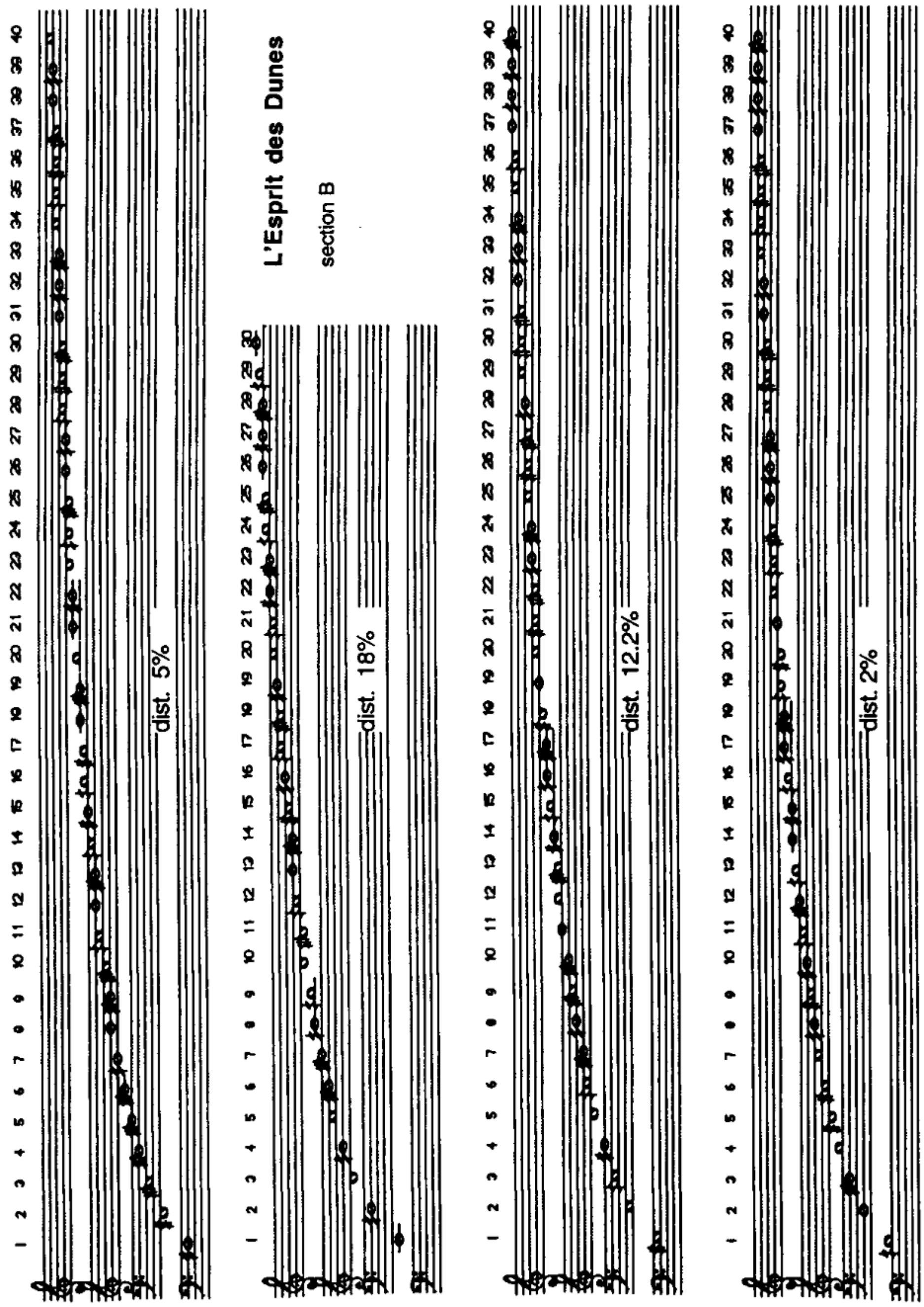


Figure 3.25 - changes in the level of distortion in *Les Esprit des Dunes* (Fineberg, 2000:123)

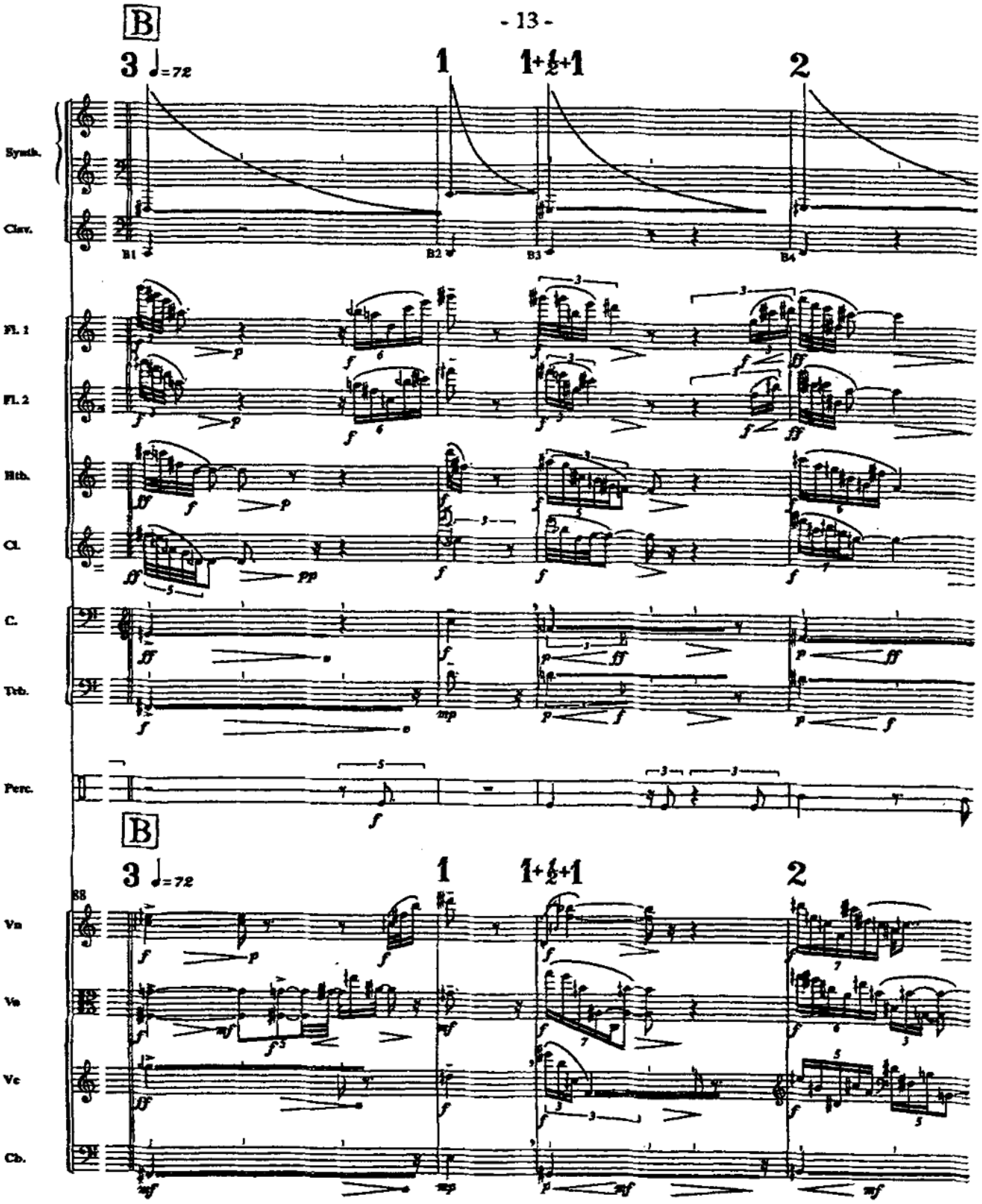


Figure 3.26 - Orchestration of the changing distortion of *Les Esprit des Dunes* (Fineberg, 2000:124)

Chapter 4 - Andile Khumalo - *Bells Die Out* (2013)

> …the composer does not work with twelve notes, *x* rhythmic figures, *x* dynamic markings, all infinitely permeable – he works with sound and time. (Murail, 1983:168)

4.1 Biography and Background to Compositions

(Refer to **Appendix A** for the interviews conducted with Andile Khumalo.)

In 1998 Andile Khumalo (b. 1978) began his composition studies in Durban at the University of Natal (now known as University of KwaZulu Natal), under composer Jürgen Bräuninger (Khumalo, 2016a:11). During these years he became interested in composing 12-tone music (Van Rhyn, 2013:171). After completing a degree in composition in 2001, he started an exchange programme at the Musikhochschule Stuttgart, Germany, and studied under Marco Stroppa,[53] a composer and specialist in music technology (Wits University, 2016:1). In 2003, he began a Masters in music composition at the same institution, and completed it in 2007.

Khumalo was introduced to spectral ideas by Marco Stroppa and learnt spectral analysis with the software OpenMusic and AudioSculpt (Khumalo, 2016a:13). The most important principle that Stroppa taught Khumalo, however, was working with sound space as a resource for composition where sound is perceived differently when heard from different angles or filters, as a result of the partial content changing the perception (2016a:12). Khumalo's first piece with spectral principles,

[53]The ideas of Marco Stroppa presented in his music in the decade leading up to 1983 had some connections to the spectral movement (Tiffon & Sprenger-Ohana, 2011:377). Tiffon and Sprenger-Ohana write that there was "an underlying trend of spectral thought" in Stroppa's mind while composing his work *Traiettoria* for piano and synthetic sounds between 1982 and 1985 (2011:377). Stroppa started working at IRCAM in 1983 and heard of the spectral movement for the first time at a concert of Grisey's *Solo pour deux* for amplified clarinet and trombone (2011:380). The common links to spectralism include Stroppa's connection to the ideas of Olivier Messiaen, scientific knowledge of sound and synthesis, focusing on the microstructure of sound and the influence of Varèse in composing sound itself. Stroppa learnt from Messiaen to compose chords oscillating between the perception of harmony and timbre through the 'resonance chord' (2011:378). *Traiettoria* was composed based on the tradition of composing sound itself that was advocated by Varèse. Stroppa worked with electronics to produce sound synthesis, therefore acoustic instruments were not the tools used to achieve his goals. He did not perform orchestral synthesis, but rather used electronics to add synthesized sounds to the resonances of instruments (2011:380). His works, therefore, fall under the ambit of electroacoustic music. Stroppa studied at CSC Padua, and learnt about the relationship of partials to the fundamental and how this effects the degree of harmonicity/inharmonicity of a timbre. Stroppa displayed particular interest in 'timbral space' (2011:390). During the 1980s Stroppa worked at IRCAM together with Roger Reynolds, Barry Anderson, Jean-Baptiste Barrière, Jonathan Harvey and John Chowning, and developed the notion of 'auditory fusion' whereby a chord, or multiple sonic events, are fused into global phenomena due to Gestalt perception. The most important influence of Stroppa for Khumalo was not the use of spectral analysis, but the use of perception of sound and space.

Iso(r) (2004/2005) for flute, cello and piano, works with directing the resonances of the piano towards the cello and piano in different angles (2016a:13).

During the performance of *Brüc(h)ke* (2005) for flute, clarinet, cello and piano, in Berlin, audience member Fabien Lévy, after hearing the piece, invited Khumalo to complete a doctorate in composition at Columbia University (2016a:11). Khumalo accepted the invitation and applied to work as an academic fellow at Columbia University and completed a doctorate in composition under Tristan Murail, Fabien Lévy, and George Lewis (Wits University, 2016:1). Apart from the above-mentioned composers, Khumalo also received training from the composers Fred Lerdahl, Georg Frederich Haas, Salvatore Sciarrino, and Stefano Gervasoni (Wits University, 2016:1).

Khumalo started focusing on spectralism under the guidance of Murail and learnt to transform the perception of sound groups based on a spectrum. Khumalo also studied with the prominent spectral composer Lévy, who studied under Grisey at the Conservatoire de Paris (IRCAM, 2016a:1). Lerdahl, an expert on auditory cognition and perception, was important in Khumalo's doctoral defence at Columbia University. Lerdahl reinforced the idea of Gestalt psychology and how the perception of sound changes through multiple hearing. Haas, a prominent spectral composer, was also important in Khumalo's doctoral defence, as he was in Austria at the time Beat Furrer's FAMA was performed (Khumalo, 2016a:12).

The three works that comprise Khumalo's doctoral portfolio received international performances: *Cry Out* (2009) for viola, oboe, marimba and piano was performed at the Takefu Music Festival in Japan; *Shades of Words* (2011) for narrator and seven musicians was performed by Rachel Calloway and the Talea Ensemble in New York City; and *Bells Die Out* (2013) for large ensemble was performed at the DiMenna Center, New York, by the Wet Ink Ensemble.

Despite Khumalo's international acclaim as composer there is, however, no existing discourse on his music (Van Rhyn, 2013:172). Khumalo is briefly mentioned in Colette Sipho Mabingani's dissertation *Madiba 46664* (2014). Mabingani writes about the expressive dimension in Khumalo's piece, *Shades of Words*, as working with the idea of space "to convey the idea of the physical and economic separation of both apartheid South Africa and contemporary South Africa" (2014:14). He writes that Khumalo projects the same musical object in different variations of shape and musical context, and that rhythmic ideas are varied and move between foreground and background by growing continuously more prominent in the foreground or disappearing into the background as almost inaudible.

Chris van Rhyn presents a short analysis of Khumalo's early piece, *Ekuboleni kunempilo (2001) for mezzo-soprano, flute and viola*, in his dissertation, *Towards a Mapping of the Marginal: Reading of Art Songs by Nigerian, Ghanaian, Egyptian and South African Composers* (2013). Khumalo employs 12-tone writing in the above-mentioned piece during his early academic years in Durban (Van Rhyn, 2013:174). Van Rhyn writes that repetition of sections does not occur and material is constantly varied though 'improvisations' (2013:175).

4.2 Method of Analysis

4.2.1 Primary Framework

Besharse writes that spectral music

> offers many challenges for people who wish to understand its deeper structures. Complex manipulations of spectral data are difficult to discover unless the composer writes or speaks about their processes for a particular piece. Even if an analyst can obtain this data, it describes technical details that will remain obscured from the listener. Instead, the listener will likely track the unfolding music in terms of changes in **timbre, texture, density and energy level** (2009:133; my emphasis).

The purpose of the analysis is to bring to surface aspects of Khumalo's work *Bells Die Out* (2013) for large ensemble that connect to the principles of spectralism. According to Besharse's description above, the analysis on Khumalo's music requires a method that will track the changes in timbre, texture and density level. Besharse's proposed method is noteworthy as it suggests that musical structure affects the perception of musical time. The technique of changing musical time is related to the music of Grisey and Murail. In addition, McAdams, Depalle and Clarke propose a method of analysis that requires the analysis of the acoustic property of sound and how this is perceptually organized (2004:157). This is applied by creating a sonogram of the recording of *Bells Die Out* in order to give a visual representation of the piece. The visual representation assists the track in changes of the above mentioned parameters. Moreover, composition principles related to spectralism are pointed out in Khumalo's doctoral dissertation. It is speculated that these principles will support the connection to spectralism and will therefore be used to analyse Khumalo's work. The significance of the concepts from Khumalo's dissertation is demonstrated by the analytical application on *Bells Die Out*: the concepts establish a connection between the structural aspects of *Bells Die Out* and Murail and Grisey's theories on time.[54]

The two different spectral texture types pointed out by Besharse contribute to momentum and stasis forming directionality (2009:55-69). The author of this thesis refers to Besharse's description of 'micropolyphonic' texture as energetic texture, and sound-mass texture as sustained texture. Energetic textures result in a sense of momentum while sustained textures result in a sense of stasis. When the two texture types are layered, there is a magnetic pull from the type that is most prominent in the foreground. These forces determine the form of the piece when the listener is drawn in the direction of stasis or momentum. (Directionality is also achieved through increasing/decreasing harmonic complexity.) The method of analysis of *Bells Die Out* is thus based on the combination of the concepts from Khumalo's dissertation with the texture types pointed out by Besharse, in order to discover directionality in structure as used by Murail and Grisey (addressed in Chapter 3). Furthermore, the use of spectral analysis and orchestral synthesis (discussed in Chapter 3) is also applied to *Bells Die Out* and the significance thereof to the overall structure is highlighted.

4.2.2 Background to Principles presented in Khumalo's Dissertation

Khumalo's doctoral dissertation focuses on *FAMA* (2005) for orchestra and sound theatre composed by the Austrian composer, Beat Furrer. Khumalo analysed and discussed the compositional techniques used in *FAMA* including 'Gestalts', musical moments, block form, trigger, loop and filtering (2014:10).

Khumalo defines a 'Gestalt' as the impression of wholeness from the cohesion of multiple parts and 'musical moments' as sections set off from one another due to discontinuity of texture, timbre or durational characteristics (2014:12). Musical moments[55] can be understood as larger Gestalts that are perceived as a unified group due to continuity of musical attributes and at times, the coherence of multiple parts.

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[54] The concepts derived from Khumalo's dissertation are chosen instead of other analytical methods such as 'structural' or 'Schenkerian' because of their significance in pointing out structural aspects related to spectralism. The fact that Khumalo's dissertation was written under supervision of spectral composers supports the current author's use of Khumalo's terms to analyse his music.

[55] The term musical moment could be understood in alternative ways and argued that a different term such as 'section' or 'phrase' would work better. However, the author of the thesis remains true to the terms used by Khumalo because of the relationship to the listener's perception.

Khumalo refers to a musical moment in *FAMA* where sustained voices form a cluster. Through just intonation, the instruments blend together to create the illusion of a uniform timbre, an example of orchestral synthesis (2014:15). He defines a musical moment lasting two bars due to a continuity of texture (Khumalo, 2014:15). 'Gestalts' typically last one bar and are characterised by explosive energy. Gestalts can therefore be identified as smaller gestures and musical moments as sections with connected material where length is determined by the amount of continuity.

'Block form' is where different textural sections are separated by juxtaposition against one another. Blocks are essentially larger musical moments and where juxtaposed blocks differ in material, energy is created that drives the music forward (Khumalo, 2014:18). According to Grisey's theory of time, this is due to the non-expectancy of change, contracting the lens of time, and creating forward motion. Similarity between different blocks is created by keeping some characteristics the same while changing others (e.g. timbre, texture). This creates continuous development.

'Triggers' are used to start something new. A Gestalt, such as a fast descending glissandi performed by a group of instruments, creates a salient energetic characteristic appearing in the foreground for the listener, and triggering attention towards the proceeding musical moment (Khumalo, 2014:21).

'Looping' occurs through the repetition of Gestalts/musical moments. The repetition is never exact, and in Furrer's music at least 20% is new material (timbre, harmonicity, rhythmic treatment etc.), whilst 80% is maintained (Khumalo, 2014:23). This creates continuous development from one type towards the other (energy to stasis or inharmonicity to harmonicity).

'Filtering' is referred to as the changing of musical layers or instrumental voices of a musical moment (Khumalo, 2014:21). Instruments, and musical layers such as a sustained line or an energetic line, can be added or reduced. Addition and reduction can occur in a continuous fashion, creating development from one musical moment towards the next (ibid.). The orchestration of textures determines how many partials are present, once instruments are reduced and voices taken away, fewer partials are present. This is relevant for the precision of crafting a global timbre through orchestral synthesis.

Khumalo uses AudioSculpt, OpenMusic and SPEAR to perform spectral analysis of instruments in order to perform orchestral synthesis (Khumalo, 2016a:13). He uses the spectrum to map sound, and says that what is important about spectralism is the idea of working with sound (2015:1). He uses spectral analysis to allow for 'acoustic a priori' or foreshadows in his music. Khumalo's ideas involve working with a sense of directionality that is based on Grisey's theory on musical time. The analysis aims to connect the techniques pointed out by Khumalo in his work, *Bells Die Out*, composed during his time at Columbia University, with the theories on spectral composition presented in Chapter 3.

4.2.3 Structure of Analysis

The following principles are outlined in the analysis of *Bells Die Out*:

- musical moments joined by texture and timbre, as well as embellishments;
- gestalts as triggers;
- block form;
- continuous progression through looping, filtering and harmony;
- orchestral synthesis and the ambiguity of perception
- directionality – Momentum and Stasis.

In order to discover whether there is a connection between *Bells Die Out* and spectralism, the above-mentioned points will be used to track changes in timbre, texture, density and energy level. Each of these principles are discussed in turn, while referring to different sections throughout the piece. The first four principles need to be discussed first, so as to present the various factors that contribute towards directionality. How these principles work together to form musical breathing is discussed under section 4.3.7. The piece is therefore, not discussed as it unfolds in time, but rather in the order of the principles outlined. The discussion on each point results in the overlapping of different principles. The reader should bear in mind that each point should be read before understanding how directionality/musical breathing is formed. While the first four points are concepts derived from Khumalo's dissertation, the last two points are based on the theories uncovered in Chapter 3 and relate to Besharse's method of tracking changes in above mentioned parameters.

4.3 *Bells Die Out (2013) for ensemble*

4.3.1 Structure

The reader is referred to Appendix B (score for *Bells Die Out*). The piece is scored for flute, oboe, clarinet, horn, trumpet, trombone, percussion, piano, two violins, viola, cello and contrabass, with one player per part (Khumalo, 2013a:1). A recording of *Bells Die Out* is attached as Appendix F. The durations of the recording are referred to throughout the analysis.

Form is governed by the directionality of musical breathing: repose, inhalation, and exhalation. There are two large sections of inhalation, exhalation and repose. Each section can be divided into the smaller musical moments, 'Gestalts', and block forms, as presented by Table 4.1 and 4.2 below. The detailed demarcated sections in Table 4.2 are presented similarly in Appendix C[56] and Appendix D.[57] (An explanation for the construction of the appendices is found in each respective appendix).

Section 1:

- Sub-section a (b. 1-25) (repose)
- Sub-section b (b.25-89) (inhalation)
- Sub-Section c (b.90-124) (exhalation-repose)

Section 2:

- Sub-section d (b.125-144) (repose)
- Sub-section e (b.145 - 178) (inhalation)
- Sub-section f (b.179-234) (exhalation-repose)

Table 4.1 The demarcated sections of *Bells Die Out*

[56] The orchestration map presents a calculated average of the density of each instrument for the specified range of bars. For example, if an instrument plays for 80% of the range of bars, this will result in high density. This gives an idea of how much each instrument is used throughout the piece.
[57] Refer to the colour-coded key given in the beginning of Appendix D.

Section 1 - Sub-section a (b. 1-25) (repose)

- b.1 – 'Bow' Gestalt trigger
- b.2-6 – Musical Moment
- b.7-9 – Musical Moment
- b.10a – 'Bow' Gestalt trigger
- b.10b-14 – Musical Moment
- b.15-17 – Musical Moment
- b.18-19 – Musical Moment
- b. 20-25 – Musical Moment

Section 1 – Sub-section b (b.25-89) (inhalation)

- b.26-36 – Block
- b.37-40 – Musical Moment
- b. 41-42 – Musical Moment
- b. 43-44 – Musical Moment
- b.45-53 – Block
- b.54-56 – 'Bow' Gestalt trigger
- b.57-63 – Block
- b.64-68 – Block
- b.69-74 – Block
- b.75-79 – Block
- b.80-85 – Block
- b.86-89 – Block

Section 1 - Sub-Section c (b.90-124) (exhalation-repose)

- b.90-93 – Musical Moment
- b.94 – Musical Moment
- b.95 – Musical Moment
- b.96 – Musical Moment
- b.97-99 – Block
- b.100-102 – Musical Moment
- b.103 – Musical Moment
- b.104-107 – Block
- b.109-112 – Block
- b.113-117 – Block
- b.118-124 – Block

Section 2 - Sub-section d (b.125-144) (repose)

- b.125-128 – Musical Moment
- b.129-132 – Block
- b.133-140 – Block
- b.141-144 – Block

Section 2 - Sub-section e (b.145 - 178) (inhalation)

- b.145-153 – Block
- b.154-157 – Block
- b.158-162 – Block
- b.163-167 – Block
- b.168 - Block
- b.169-174 – Block
- b.175-178 – Block

Section 2 - Sub-section f (b.179-234) (exhalation-repose)

- b.179-181 – Block
- b.182-184 – Block
- b.185-189 – Block
- b.190-194 – Block
- b.195-197 – Block
- b.198 – 'Bow' Gestalt trigger
- b.199-202 – Block
- b.203-204 – Block
- b.205-207 – Block
- b.208-210 – Musical Moment
- b.211-212 – Musical Moment
- b.213-217 – Musical Moment
- b.218-231 – Block
- b.232-234 – Musical Moment

Table 4.2 – The detailed demarcated sections for *Bells Die Out*

4.3.2 Musical Moments Joined by Texture and Timbre; and Embellishments

As with a Gestalt, a musical moment is the impression of wholeness from the cohesion of multiple parts. Recall from Chapter 1 the Gestalt grouping principle of 'good continuation', which explains that a group is perceived from multiple parts that appear as if they are the continuation of one another. A musical moment describes a small period of time of between 3" to 5" where the music is formed by similar timbre, texture and energy level. Similar moments appearing one after the other are developed continuously by altering some aspects (timbre, harmony, texture) and keeping others the same. Different musical moments are separated by discontinuity of timbre, texture, energy level, or silence. Musical moments are also bound by similar embellishments or orchestral synthesis.

4.3.2.1 Texture and Timbre

4.3.2.1.1 Small Musical Moments

From bars 2 to 6, [1"-9"], a moment is formed that returns in variations throughout the opening section and once in the second half of the piece. The tremolo sustain of the viola is coupled with repetitive pizzicato attacks in random octaves. The string timbre and this type of sustained texture join these four bars together as a moment. Bars 8 to 10 [13"-19"], 10 to 14 [21"-31"], 15 to 17 [34"-39"], and 20 to 25 [42"-52"] are variations of the original moment characterized by the same timbre and texture. At bars 125 to 128 [4'07"-4'14"], the moment returns with same texture and timbre selections with the addition of a sustained chord in the woodwinds and horn. The sustained tremolo is changed to an oscillation between the interval of a major second, where the tremolo only falls on the lower note.

4.3.2.1.2 Medium Musical Moments

From bars 47 to 53 [1'38"-1'53"], a moment is formed through coherence of texture and timbre with moderate energy level from the continuous tremolo in the strings and random short bursts from the strings (pizzicato), marimba and piano. The energetic texture is layered with sustained multiphonics in the winds. The moment returns again at bars 57 to 63 [1'58"-2'11"], now richer in energy level due by a greater density of attacks from the piano, strings (pizzicato) and marimba. The energetic texture is first layered against a chord in the woodwinds, and then a sustained multiphonic from the oboe.

Large musical moments are used to create block form and are explained below under section 4.3.4.

4.3.2.2 Embellishments

4.3.2.2.1 Melodic Embellishment

The musical moment from bars 128 to 130 [4'14"-4'20"] is embellished by a short melodic fragment. The melodic material is split between the instruments to create an interlocking moment. The melodic embellishment is found in later musical moments where rhythmic energy creates interlocking gestures connecting the separate moments as coherent. Examples are found from bars 138 to 140 [4'30"-4'39"], 143 to 146 [4'41"-4'45"], and 184 [6'19"-6'20"].

At bar 18 [39"-40"], a musical moment is characterized by single pitch-repeated rhythmic embellishment in the marimba and viola. The repetitive rhythmic characteristic connects the following musical moments that are different in timbre and harmony: bars 86 to 89 [2'47"-2'54"], 91 to 92 [2'56-2'58"], 95 [3'01"3'05"], 163 to 166 [5'24"-5'33"], 168 [5'38"-5'39"], 169 [5'39"-5'40"], 174 [5'46"-5'48"], 176 to 177 [5'50"-5'53"], 180 to 181 [6'08"-6'15"], and 182 to 183 [6'15"-6'19"].

4.3.2.2.2 Oscillating Second

The oscillating second features throughout the work as a textural embellishment featured in various musical moments or used as the global structure for block form. The bars in which the oscillating second features are displayed below under section 4.3.5.1.3.

4.3.2.2.3 Descending Gesture

A rapid descending line acts as a tool to create a sense of motion. This gesture is used to characterize a musical moment, as well as embellishing the energetic texture. The descending gesture is used to start energetic motion at bars 26 to 27 [57"-1'03"] forming a musical moment. The energetic texture from bars 29 to 37 [1'05"-1'18"] is embellished by a descending gesture played as short rapid motives in different instruments. This descending motive returns to contribute to energetic texture from bars 64 to 68 [2'11-2'15"], 78 to 79 [2'34"-2'37'], 95 [3'03"-3'05"], 97 to 99, [3'06"-3'13"], 103 [3'20"], and 232 to 233 [7'57"-8'02"].

4.3.2.2.4 Ascending Gesture

The ascending gesture is used to embellish musical moments and creates motion in energetic textures. At bars 37 to 40 [1’18”-1’24”], the clarinet sustains A5 bringing a continuous texture in the foreground to start a different musical moment. At bar 39 the flute embellishes the musical moment with an ascending gesture, creating a beautiful bird-like trill, resulting in a sense of repose. Further ascending gestural embellishments occur at bars 77 [2’33”], 135 [4’25”], 172 to 174 [5’46”5’50”], 180 to 181 [6’08”-6’15”], and 203 to 204 [6’58”-7’02”].

At bars 150 to 162 [4’57”-5’24”], the ascending gesture dominates the energetic texture building in density and motion. This gesture serves the same purpose from bars 190 to 195 [6’32”-6’42”].

4.3.2.3 Orchestral Synthesis

Orchestral synthesis binds a musical moment together due to its inherent nature where multiple parts are fused. The effect of orchestral synthesis is that the listener perceives timbre from the combination of instrumental voices.

4.3.3 Gestalt as Trigger

A Gestalt is formed by the coherence of multiple parts and is characterized by a rapid short burst of energy. Recall Chapter 1, where the Gestalt grouping principle ‘common fate’ describes a group perceived as unified whole due to the similar onset time. Two different energetic motives, ascending and descending gestures, are combined to form a ‘bow Gestalt’ due to the principle of ‘common fate’. The Gestalt is used as a trigger to focus the listener’s attention onto the proceeding musical moment.

4.3.3.1 ‘Bow’ Gestalt

At bar 1 [0”-1”], a Gestalt trigger is formed to trigger the following sustained texture that forms a musical moment. The initial attack is played by a high rapid ascending arpeggio in the piano and a strike to the woodblock; this is followed by an ascending line in the first violin, flute and oboe, and ended by a descending line in the clarinet and second violin. The guiro adds a background trill that combines the sound of the rapid gestures. The multiple parts combine to form a ‘bow Gestalt’ as the onset time of each instrument is separated by a small amount of time. The energy jolts the listener’s attention into the following musical material. Similar ‘bow Gestalts’ are formed at bars 10 [21”-

22"], 28 [1'03"-1'04"], 32 to 33 [1'11"-1'12"], 40 [1'25"-1'27"], 42 [1'33"-1'34"], 45 [1'37"-1'38"], 54 to 55 [1'54"-1'57"], and 198 [6'48"-6'49"]. The flute's 'jet whistle' that produces harmonics at bar 10 forms a bow contour showing a strong presence in the foreground; the technique is used as a contributing element for the Gestalt triggers in a number of the above-mentioned bars.

4.3.3.2 Reverse Triggers

Reverse triggers are used in Section 1, sub-section c, to detract the listener's attention from sustained chords. The triggers appear after a sustained musical moment instead of before, acting as if the combination is in reverse. The triggers are characterized by rapid ricochet in the string and fast melodic lines from other instruments. They appear at bars 95 [3'01"-3'02"], 97 to 99 [3'06"-3'13"], and 103 [3'20-3'21"]. From bars 97 to 99, the ricochet technique dominates the texture of a short musical moment—that is, the trigger is extended into a musical moment.

4.3.4 Block form

Blocks are larger musical moments and the form is created by the juxtaposition of separate blocks, or the binding of similar blocks by way of continuous development. In some cases, energy levels remain the same or grow in a continuous fashion by elision from one block of texture to the next. In other cases, energy levels are changed in a discontinuous fashion, either increasing or changing to a sense of stasis.

4.3.4.1 Continuous Flow of Energy

From bars 149 to 157 [4'57"-5'15"], two larger musical moments as blocks are juxtaposed against each other. They are differentiated by a sudden harmonic shift at bar 154. The first block is thus from bars 149 to 153 [4'57"-5'06"], and the second from bars 154 to 157 [5'06"-5'15"]. The energy level within the layered texture remains high between the two blocks, with a large density of attacks. The noticeable change is of harmony, and not of texture or energy. This is thus a continuous progression of energy between two blocks. The harmonic shift is started by the horn and clarinet and followed by the trombone. The harmonic background changes from emphasis on E♭ towards F, the interval of a major second. This is the magnification of the oscillating second embellishment as two larger musical moments are juxtaposed.

Another continuous progression created through orchestral synthesis forms an acoustic 'a priori', found at bars 109 to 117 [3'30"-3'50"]. The nature of orchestral synthesis is explained further below in section 4.3.6. Both blocks are layered textures: in the first, the sustain is carried by multiphonics in the oboe, and in the second, the strings perform orchestral synthesis of the oboe multiphonic. The energetic texture switches from the strings in the first block to the woodwinds in the second. The progression is continuous due to the flow of timbre where the 'angle of viewing' changes (recall the sculpture analogy above). As with orchestral synthesis, the 're-synthesis' is not a copy, but instead a new timbre is created. This variation creates a sense of connection and continuous progression while the energy level is maintained in the background.

4.3.4.2 Continuous Flow of Energy through Elision

From bars 69 to 89 [2'15"-2'47"], different musical moments are juxtaposed against one another to create block form. From bars 69 to 74 [2'15"-2'27"], a layered texture forms the first block, with sustained harmonics in the strings and alternating trills in the clarinet. The energetic part of the texture is performed by light repetitive pitches in groups of two by the first violin. The repeated pitches create a sense of expectation. However, with each loop there is variation, which is explained further below in section 4.3.5. An ascending line in the flute at bar 74 forms a trigger into the next block from bars 75 to 79 [2'27"-2'37"]. This layered texture is characterized by a higher density in energy from the woodwinds. An accelerando and an increase in rhythmic density in bars 78 to 79 [2'34"-2'37"] creates momentum, which is carried into the next textural block. From bars 80 to 85 [2'37"-2'47"], the woodwinds rest and the strings begin rapid repetition of pitches alternating randomly at different times. The energy level moves in random waves of heightened energy with a constant drive beneath. The change between these textural blocks forms a continuous progression of energy through elision as the gap of increasing/decreasing energy level is not large enough to be perceived as discontinuous. The repetition of pitches and variations between looping connects the different blocks as similar material as they are juxtaposed against one another.

4.3.4.3 Discontinuous Change of Energy

From bars 94 to 108 [3'00"-3'30"], a section of block form is created by juxtaposed blocks of different textures, in that sustained textures are juxtaposed against blocks of energetic texture. This creates discontinuous progressions as energy levels moving between static and energetic. The blocks are found at bars 94 [3'00"-3'01"], 95 [3'01"-3'05"], 96 [3'05"-3'06"], 97 to 99 [3'06"-3'13"], 100 to 102 [3'13"-3'20"], and 103 to 108 [3'20"-3'30"].

4.3.5 Continuous Progression through Looping, Filtering and Harmony

A continuous progression occurs when changes in musical material occur through exponential growth instead of linear progression. Khumalo employs continuous change through looping, filtering and harmonic progression. Continuous change is used to present the same 'object' from different 'points of view'.

4.3.5.1 Looping

4.3.5.1.1 Melodic

In Khumalo's dissertation, he explains the looping used by Beat Furrer in *FAMA* as repetition of material, where 80% of the material remains the same and 20% is altered (2014:23). This allows the listener to maintain a sense of continuity through change. From bars 75 to 80 [2'27"-2'37"], the clarinet repeats a loop where the accents indicate each restart and there are slight changes with each repeat. Figure 4.1 indicates the number of times each pitch is repeated in each loop.[58] The original material's pattern is 2, 3, 5, 2, 1, and 3. In the first loop, the pattern remains the same, with one change: the last pitch E4 is repeated 5 times instead of 3. In the second loop, the last pitch E4 is only played once; the third loop is the same as the original. The last loop is entirely different from the previous patterns, however, and can be divided in half as a looped pattern of 4, 3, 1, and 4, 3, 2, showing a slight change within its content.

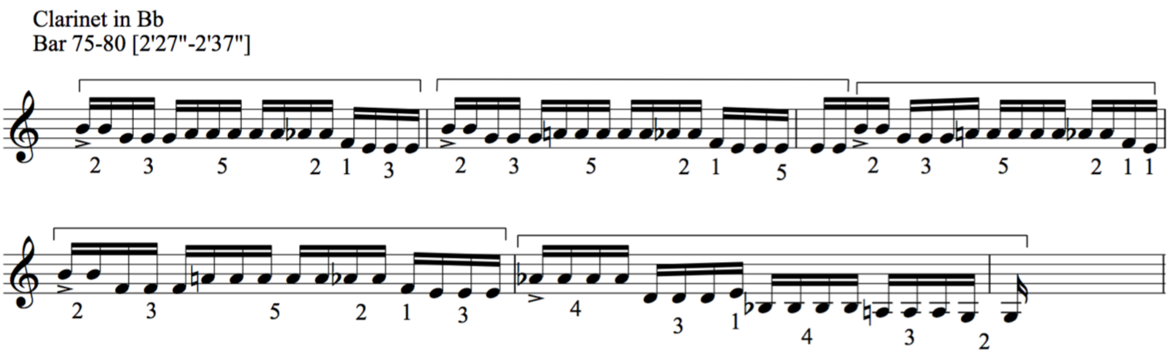


Figure 4.1 - Melodic looping with small changes in *Bells Die Out*

4.3.5.1.2 Rhythmic

In Section 1, sub-section b, from bars 69 to 74 [2'15"-2'26"], Khumalo loops the same rhythmic pattern with no easily visible pattern of pitch changes. Here the emphasis is on looping the two note

[58]Figures 4.1, 4.2 and 4.3 were compiled by the author.

rhythmic idea, where changes occur in the length of each pattern. As with the above example, each loop is demarcated by an accent, and the constant pulsating rhythm of 32nd quintuplets allows for groups of two to alternate between different pitches. Figure 4.2 displays the rhythmic pattern characterized by groups of two repeated pitches. The arrows indicate whether the change of pitch moves upwards or downwards, and the brackets demarcate each loop. Notice how the length of each loop changes: there is no clear pattern of ascending or descending contours between different loops, and there is no repeated ordering of pitches. The idea that remains the same is the constant rhythmic pattern of 2, maintaining a sense of continuity while other elements remain under constant change.

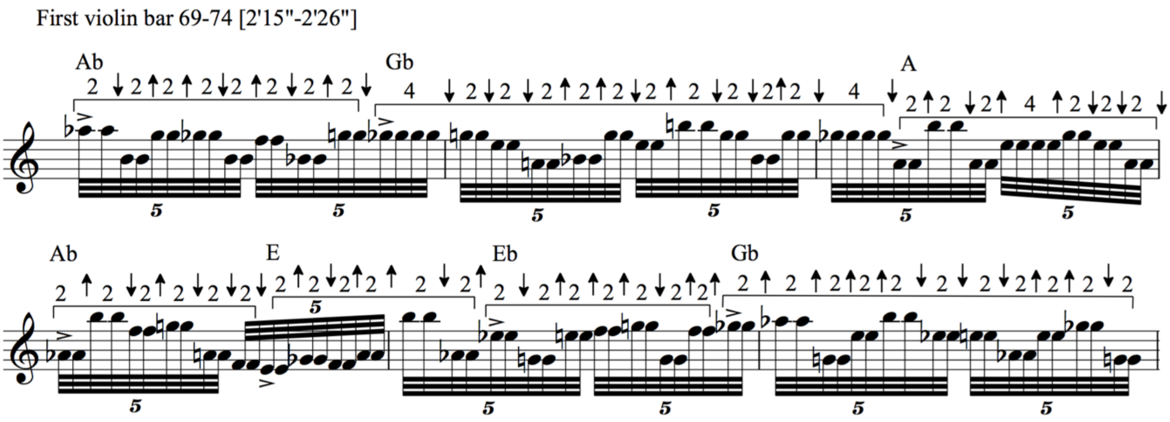


Figure 4.2 - Rhythmic looping with small changes in *Bells Die Out*

4.3.5.1.3 Oscillating Gesture

The oscillating gesture can be understood as a loop between two repeating pitches. The oscillating gesture returns in different forms throughout the work. Figure 4.3 presents each of the occasions the oscillating gesture is performed throughout the work. The speed of oscillation and/or the pitch content changes with each new form of the gesture. The gesture found from bars 142 to 144 [4’39”-4’33”] is the only case where the speed of oscillation does not remain constant, with each duration increasing in length.

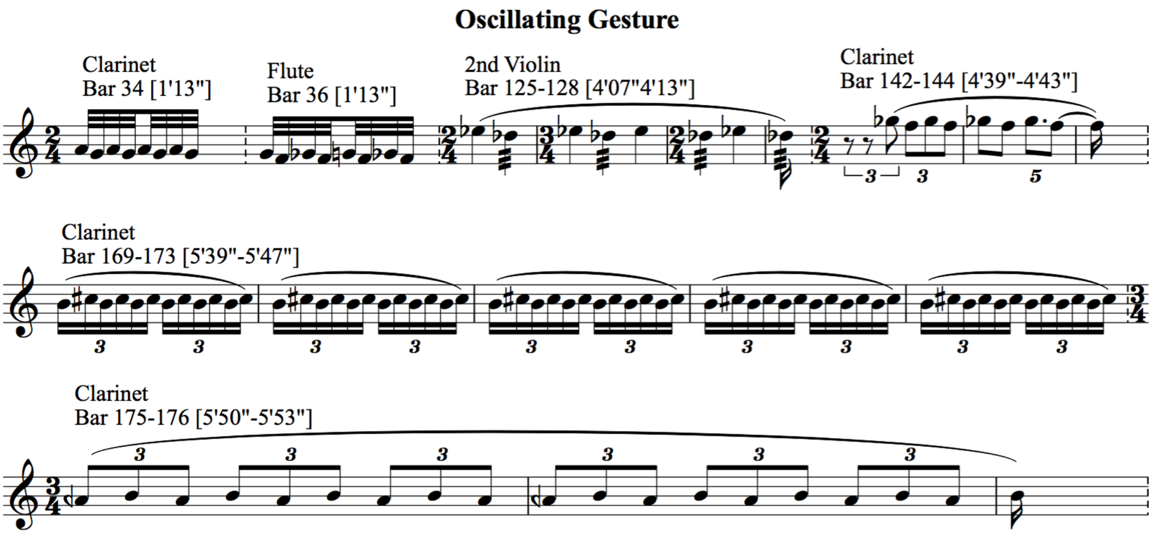


Figure 4.3 - The oscillating gesture in *Bells Die Out*

4.3.5.2 Filtering

Khumalo describes filtering as "the addition and reduction of instruments, as well as musical layers, including the use of sounds from different sound families, [which] can increase or decrease the level of complexity both on the vertical and horizontal dimension of music" (2014:21). In *Bells Die Out*, Khumalo makes use of filtering by increasing/decreasing musical layers, instruments, and harmony between musical moments/blocks, to create a continuous progression from simplicity to complexity or *vice versa*.

4.3.5.2.1 Movement Towards Complexity

From bars 37 to 44 [1'18"-1'36"], three similar musical moments separated by energetic Gestalt triggers and harmonic content form a continuous progression towards complexity through the addition of instruments and musical layers. Refer to Appendix C, which displays the change in orchestration from bar 37 to 44. The flute and violoncello remain constant, while the number of instruments increase between each musical moment. In the first and second musical moments, the strings feature as medium density and then increase to high density in the third moment. The piano and bass drum enter at high density in the third musical moment. In addition to the increase of instrumentation, musical layers are added or changed. The first moment contains sustained layers of the clarinet, artificial string harmonics with glissandi, and a sustained piano chord. In the second moment, a layer of Aeolian sounds and random high harmonics in the violoncello are added to sustained layers of the oboe, piano chord and artificial harmonics and glissandi in the strings. In the third moment, the bass drum tremolo and short piano chords are added. Refer to Appendix D, which displays the ascending line as the sustained A5 in the clarinet in the first musical moment changes to the oboe Bb5 in the second and F6 in the third, emphasizing a growth in tension and complexity. The indefinite high pitches and the bass drum extend the range to the outer vertical reaches. This can be understood as increasing the amount of frequencies through 'opening a filter' as the harmonic complexity and density of voices increase with each moment.

From bars 148 to 157 [4'53"-5'14"], a similar increase in instruments, musical layers and inharmonicity creates a continuous progression increasing horizontal and vertical density towards complexity. Refer to Appendix C, where the trombone remains constant through each change, and there is an increase in density of orchestration. From bars 154 to 157 the full ensemble is employed, however, the first and second violin play at a medium density. The increase in orchestration aids in the addition of musical layers, where the sustained voices and the density of energetic voices increases from bar 149 to 153. Appendix D displays the addition of harmonic voices from bar 148 to 153, increasing the vertical density. At bar 154, there is a harmonic shift towards the complex chord with two major 7ths between A^2-$G^{\flat 3}$, and $G^{\flat 3}$-G^4. The harmonic voices increase between bars 154 and 157, as the vertical density extends downwards with the addition of the bass drum (bars 156 to 157).

A similar increase in complexity occurs between bars 169 and 178 [5'39"-6'06"], towards the climactic moment where the full ensemble is employed at high density for a unique instance. The addition of the tam-tam aids in creating a complex global timbre at the climactic moment of bars 175 to 176.

4.3.5.2.2 Movement Towards Simplicity

From bars 198 to 231 [6'48"-7'57"], there is a movement away from the energetic texture towards a purely sustained texture. Aiding this progression to the sense of stasis is the reduction of instrumental voices, musical layers, and a direction towards harmonic simplicity. Refer to Appendix C, which displays the decrease in instruments and density. The instruments are juxtaposed against one another with the piccolo, oboe and trumpet (bars 208 to 210) contrasted with the oboe and clarinet (bars 211 to 212), and the piccolo and first violin (bars 213 to 217). Musical layers are reduced from energetic texture towards purely sustained voices. Appendix D displays the harmonic progression between bars 198 and 231. The pitch class $B^{\flat}$ remains constant from bars 198 to 214. This is coupled with $E^{\flat 5}$ and E^5 heard together from bars 199 to 200; $E^{\flat 5}$ at bar 201; E^5 from bars

208 to 210; and $E^{\flat 5}$ at bar 213. At bar 218, the moment of harmonic simplicity is reached when a chord of E^5, A^5, $C^{\sharp 7}$, and E^7 is performed by the piccolo, oboe, clarinet, and first violin, as displayed in Figure 4.4. At this moment, the vertical density reaches a unique moment of simplicity: a progression towards pure stasis, harmonic simplicity and minimal instrumental density.

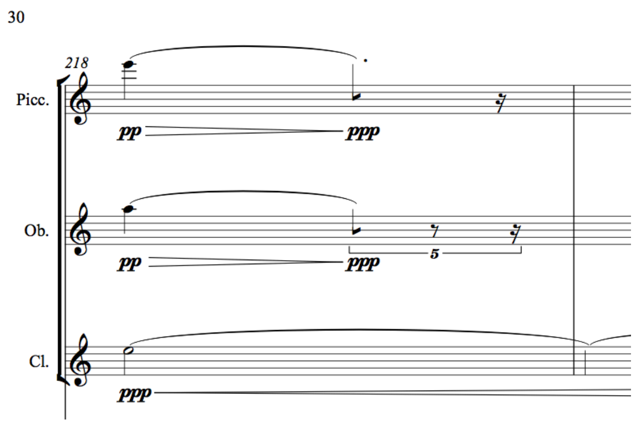


Figure 4.4 - A unique moment of harmonic simplicity in bar 208 of *Bells Die Out* (Khumalo, 2013a:30)

4.3.6 Orchestral Synthesis and the 'Ambiguity'

Recall the term *écriture liminale*, used by Grisey to refer to the ambiguity of perception between parameters such as timbre and harmony. Spectral composers employ this concept as a compositional technique by constructing harmony based on the inner details of a sound source's timbre. The perception of the listener should move between, or border on, the perception of hearing a chord and a global timbre.

Khumalo makes use of a variety of sound sources for spectral analysis, of which the multiphonic plays a noteworthy role in *Bells Die Out* (2016a:13-14). The technique appears throughout the work in the oboe and clarinet, with differing levels of intensity and complexity. The partial content of the oboe multiphonic performed from bar 109 to 113 [3'30"-3'39"] is orchestrated in the strings from bar 114 to 117 [3'39"-3'50"]. The oboe multiphonic precedes a new global timbre created by the strings, forming an acoustic 'a priori'. The reader is directed to Figure 4.5, the spectral analysis of the recording[59] of *Bells Die Out* processed through SPEAR, where the partials of the oboe multiphonic are approximated to equally tempered pitches as D^5, $E^{\flat 6}$, $B^{\flat 6}$, D^7, $E^{\flat 7}$, and G^7.[60] The staggered entries in the strings flow into a chord based on these partials. The result is a new chord with a similar sound. Appendix D displays the staggered entries in the strings from bar 114 to117,

[59] I processed this analysis to discover the partial content of the string instruments and how they contribute to orchestrating the partial content of the oboe multiphonic. More sections of the recording of *Bells Die Out* are processed through SPEAR and are presented below. All SPEAR processing represented in Chapter 4 are conducted by the author.
[60] SPEAR allows one to approximate the pitches to equal temperament. The approximation was done by myself.

and Figure 4.5 displays the result of the notated pitches together with each string's resulting overtones from end of bar 112 to bar 116 [3'37"-3'49"].

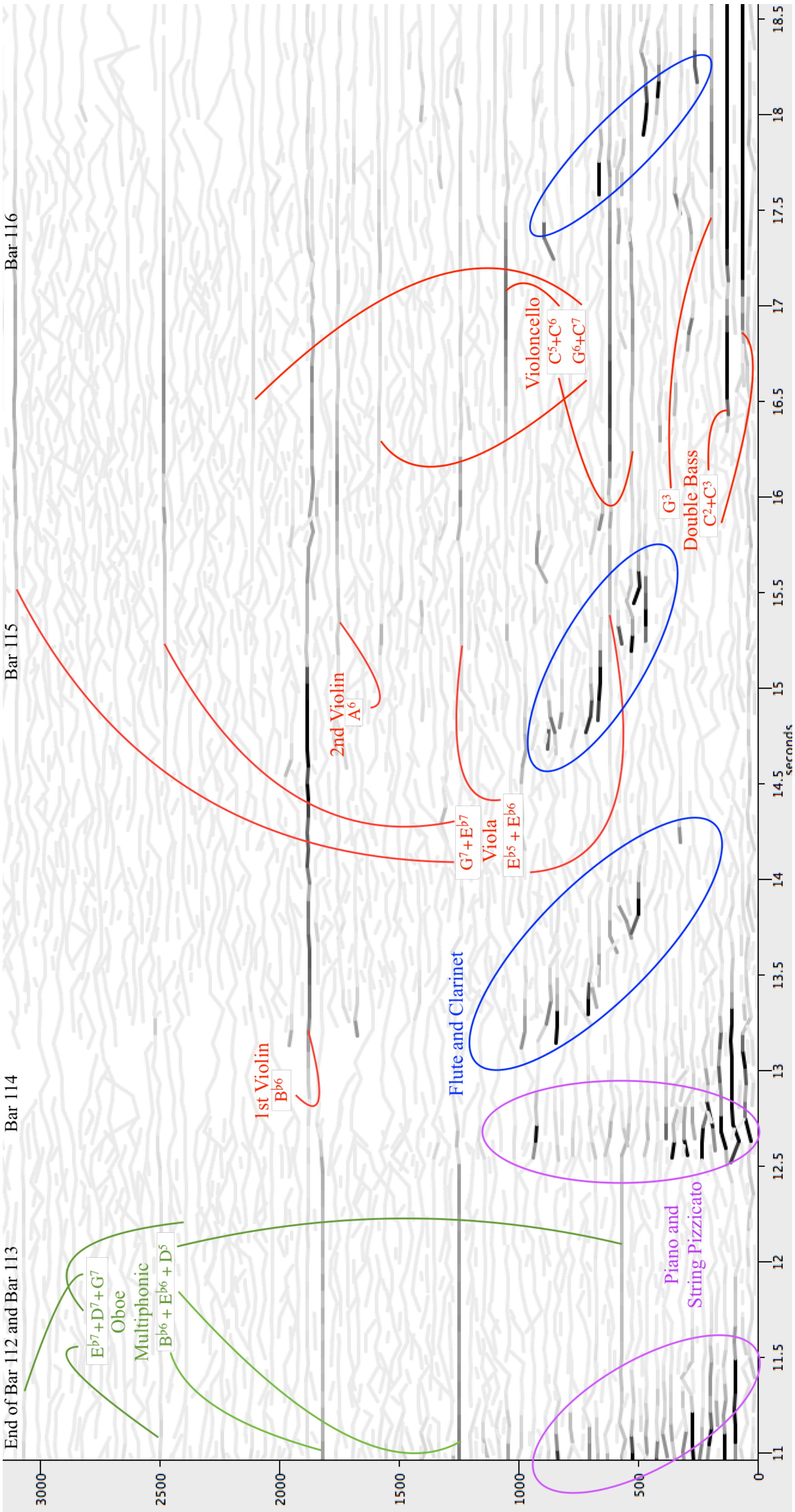


Figure 4.5 - Spectral analysis of the recording of *Bells Die Out* from bar 112-116 [3'37"-3'49"] processed with SPEAR

The first violin's entry, an artificial harmonic resulting in $B^{\flat 6}$, overlaps with the oboe multiphonic at the end of bar 112 and bar 113. The $B^{\flat 6}$ produced by the first violin imitates the $B^{\flat 6}$ partial of the oboe multiphonic (the violin's $B^{\flat 6}$ is slightly sharper). This creates a continuous transition between the oboe multiphonic and the first violin's sustain as the first violin's pitch merges with the multiphonic. The multiphonic then ends, and the first violin's $B^{\flat 6}$ remains in isolation. Note of the varying levels of amplitude of the partials shown by darker/lighter shadings. The darkest shading/largest amplitude for the oboe multiphonic is the $E^{\flat 6}$ partial. The first violin's entry on $B^{\flat 6}$ is barely noticeable, and the corresponding shading is very light.

Each staggered entry in the strings begins on a soft dynamic, transforming with a *crescendo*. The strength of each instrument's varying overtones evolves through the *crescendo*. For example, the double bass enters on C^2, however, the spectral analysis shows that the first overtone C^3 is prominent while C^2 is barely shown. As the double bass performs the *crescendo*, that C^2 starts to increase in amplitude and the second overtone G^3 becomes present. The viola enters on $E^{\flat 5}$ at a soft dynamic, and the overtones $E^{\flat 6}$, $E^{\flat 7}$ and G^7 all present small amplitudes. The *crescendo* increases the amplitude of $E^{\flat 5}$ in bar 115 to the darkest shading, while the overtone $E^{\flat 6}$ decreases in amplitude and $E^{\flat 7}$/G^7 increases in amplitude.

Other than the $B^{\flat 6}$ partial of the oboe multiphonic, Khumalo orchestrates the $E^{\flat 6}$, $E^{\flat 7}$ and G^7 partials at end of bar 114 in the viola. The viola plays with normal bowing creating the overtone series that covers the above mentioned partials. To create a new global timbre, Khumalo orchestrates for partials not present in the oboe multiphonic: the second violin on A^6, the violoncello on C^5 (with overtones C^6, G^6 and C^7), and the double bass on C^2 (with overtones C^3, G^3). For both the violoncello and the double bass, there are overtones easily visible in the spectral analysis such as E^7 in the violoncello and E^4 in the double bass. This is the result of orchestral synthesis, where each instrument contributes its own overtone series to the new fused global timbre.

At the moment where all staggered entries have occurred and the string instruments overlap, fusion of the multiple partials contributes to the sensation of a global timbre. Before and after this brief 'golden moment', the orchestration of partials is perceived as a chord presenting the ambiguity/*écriture liminale.*

4.3.7 Directionality - Momentum and Stasis

Each sound has a birth, life and death; sound is energy. The title *Bells Die Out* draws on this idea. Sound is presented in different levels of energy, duration and shape. Sounds are grouped with varying attacks, sustains and releases. Energy creates momentum, which leads to the tolerance of stasis. An analogy is that musical time can be compared to gravity. The more energetic force an object is shot into the air with, the longer the sustained flight will be. Musical time features a similar relationship: a large density of rhythmic energy creates many new events for the listener, whereas stasis is one event that carries over time. A high density of new events over time will create a need for the contrast of stasis.

4.3.7.1 Binary Forces

The piece opens with an energetic 'bow' Gestalt, triggering the first musical moment characterized by a sustain of approximately 10". The sustain is held by a tremolo in the viola and is layered with sparsely spread pizzicato attacks placed in random high and medium range. Figure 4.6 displays the two forces, dynamism/energy and stasis/sustain, that appear in binary form in the opening of *Bells Die Out.* These two forces drive listener's sense of directionality throughout the piece. The forces are expanded upon throughout the piece, where large energetic textures featuring polyphony/'micropolyphony' create the sense of momentum/forward drive for the listener and sustained textures the sense of stasis.

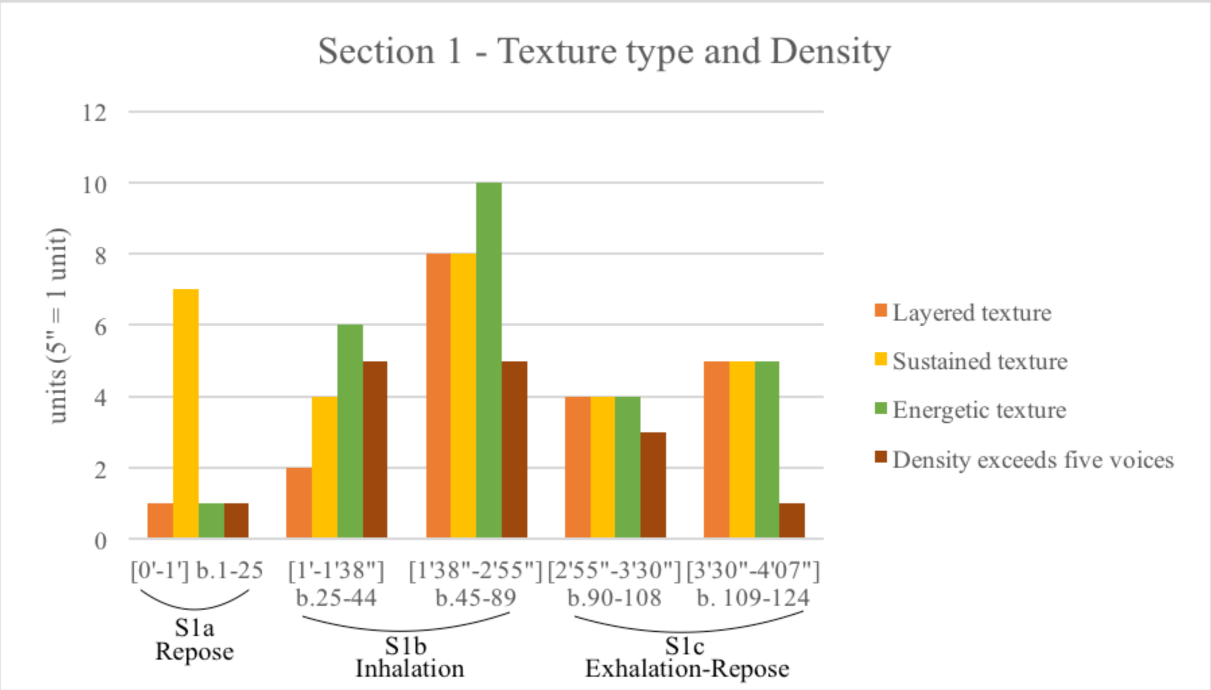
The energetic texture consists of polyphony/'micropolyphony' of voices, where a large number of attacks per second re-occur. Sustained textures consist of sustained voices where a once-off attack starts the sustain and the sound is carried over a length of time. The two texture types are regularly layered against one another, where the element featured most prominently in the foreground drives/pulls the listener in the relative direction: energy in the foreground drives forward momentum, and sustain in the foreground pulls toward stasis. The piece ends with a long section of stasis due to the strength of the energetic forces that drive momentum throughout the piece. The role of harmony adds a second dimension to direction, where continuous/discontinuous harmonic changes between simplicity and complexity aid in creating the sense of momentum or stasis. Grisey's theory of musical time explains the above-mentioned aspects of directionality and the relevance to orchestral synthesis and the listener's perception of time.

Figure 4.6 - The two forces of *Bells Die Out* presented in the opening section (Khumalo, 2013a:1)

4.3.7.2 Textural Forces

4.3.7.2.1 Global Direction

Refer to Figure 4.7, which displays the changes in level of texture type and density through each section of *Bells Die Out*. One unit of measurement is 5", where the constant use of a texture type for the 5" duration occurs. Where there are large number of attacks per second re-occurring for 5", this would measure as one unit for energetic texture on the texture type chart. The same principle applies for sustained textures where sustain lasts for 5". Where the textures are layered, their unit of measurement is counted for the individual texture type and are duplicated as a measurement for layered texture. The measurement for density applies to the number of instrumental voices involved in carrying a texture type. Where there are more than five instrumental voices for 5", one unit of measurement is counted for density.



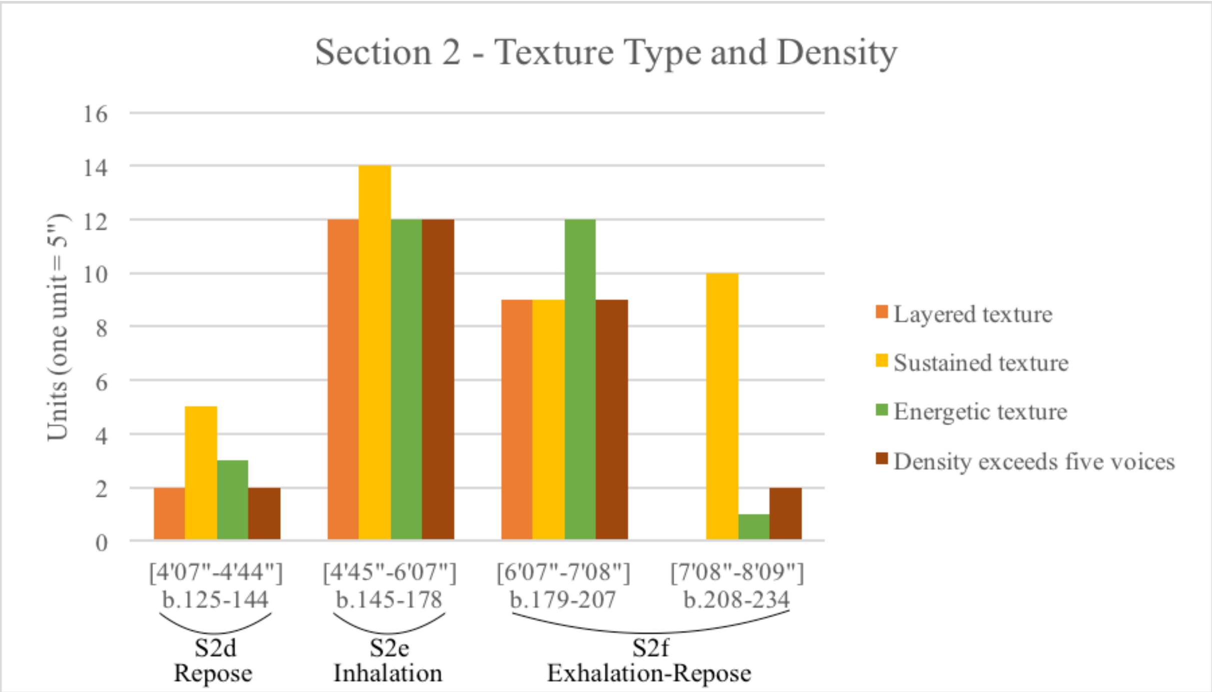


Figure 4.7 - Texture type and density chart for *Bells Die Out*

Texture types play a leading role in guiding the sense of directionality for the listener. An ascending to descending 'bow' for both energetic texture and density measurements is found in sections 1 to 2. Energetic texture and density ascend to ten and five units respectively for bars 49 to 85, and to twelve units for bars 154 to 178. At the end of the first section, energetic and sustained textures are layered against one another and density is reduced to 1 unit. At the end of the second section, sustained texture reaches ten units and both energetic texture and density are reduced to low values. This forms the skeleton for the movement from repose to inhalation and to exhalation. Repose is characterized by sustain and low density, inhalation by increasing levels of energetic textures and density, and exhalation by decreasing levels of energetic texture and density moving back towards repose.

Figure 4.8 displays the energetic texture and high density level in section 2, sub-section e. Note the high density of re-occurring attacks per second, and instrumental voices. The texture is layered with sustained voices and the dominant textural force in the foreground is energetic.

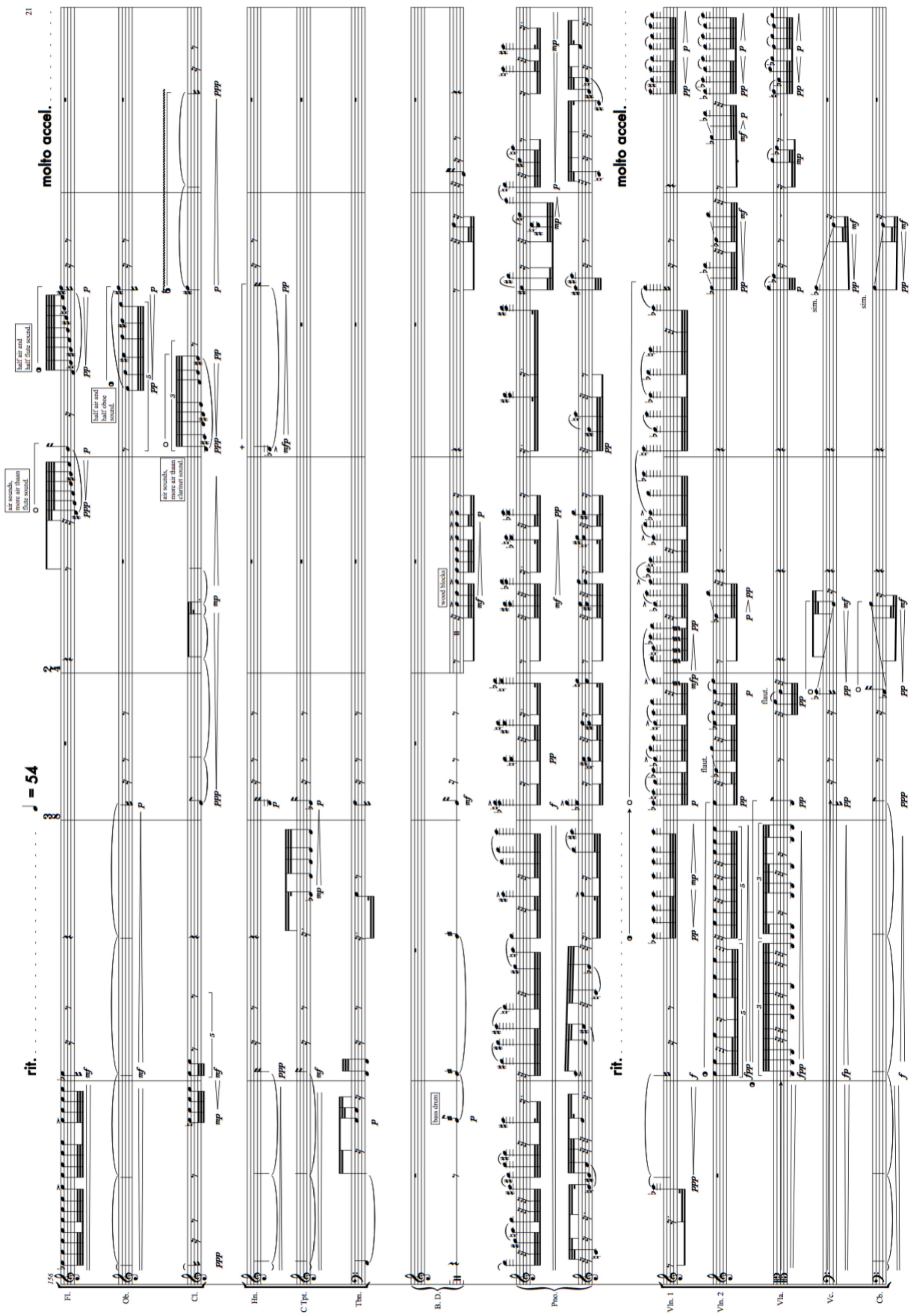


Figure 4.8 - Energetic texture and large density from bar 156-161 [5'08"-5'24"] in *Bells Die Out* (Khumalo, 2013a:21)

4.3.7.2.2 Textural Force in the Foreground

Between bars 26 and 36 [57"-1'18"], the energetic texture grows in density, driving momentum until bar 37 where the clarinet introduces a sustained A^5 in the foreground creating a pull towards stasis. The texture changes to dominantly sustained from bar 37 to 45 [1'18"-1'37"]. However, here movement towards inharmonicity maintains the sense of momentum (explained in section 4.3.7.3). This is an example of the textural forces driving or pulling towards momentum or stasis.

From bars 90 to 107 [2'55"-3'30"], momentum is in reverse because sustained textures (musical moments) are started without an attack, and form a *crescendo* into energetic textures (explained in section 4.3.3.2). The two texture types are juxtaposed as musical moments. There is a balance between isolated sustained and energetic textures, creating an ambiguity between stasis and momentum.

4.3.7.3 Harmonic Direction

The movement between harmonic simplicity/harmonicity and complexity/inharmonicity is carried through continuous changes and is discussed above in section 4.3.5.2. The changes aid the forces of momentum and stasis. The continuous change between harmonic simplicity towards complexity establishes a forward direction, whereas movement towards simplicity creates the sense of repose. The use of the multiphonics in the clarinet and oboe, as well as the timbre of the tam-tam, aids in establishing complexity. Where sustained textural forces are at play, movement towards harmonic complexity results in forward motion.

4.3.7.3.1 Multiphonics

From bar 25-53 [57"-1'54"] there is movement from harmonicity towards inharmonicity. Refer to Appendix D, where the opening bars up to bar 25 contain harmonic simplicity between focal pitches E^4, $E^{\flat 4}$ and $F^{\sharp 4}$. Take note that the 'bow' Gestalt triggers contain a higher level of complexity, strengthening the energetic level of the trigger. At bar 25, $E^{\flat 2}$ and E^3 are heard together for the first time, introducing the dissonant interval and inharmonicity. Further on, the sonorities become more complex. From bar 31 to bar 33, the sustained oboe multiphonic is layered with the energetic texture (see red coloured pitches in Appendix D). The harmonic content is dense. However, due to the energetic texture, the harmonic complexity remains sparse. In Figure 4.9, it can be seen that the spectral analysis indicates the partial content of the oboe multiphonic as $F^{\sharp 4}$, C^6, $F^{\sharp 6}$ and C^7; the piano's as E$^{\flat 3}$ (a resultant overtone from the played A$^{\flat 2}$); the clarinet's descending line from G^{4}-E$^{\flat 4}$ and the double bass's E^{4} with the resulting overtone E^{5}. Take note of the short sinusoids that give a representation of the energetic texture. Here is an example of the harmonic complexity where the three focal pitches from the opening section, E, E$^{\flat}$ and F$^{\sharp}$, are orchestrated together in vertical form to achieve harmonic complexity.

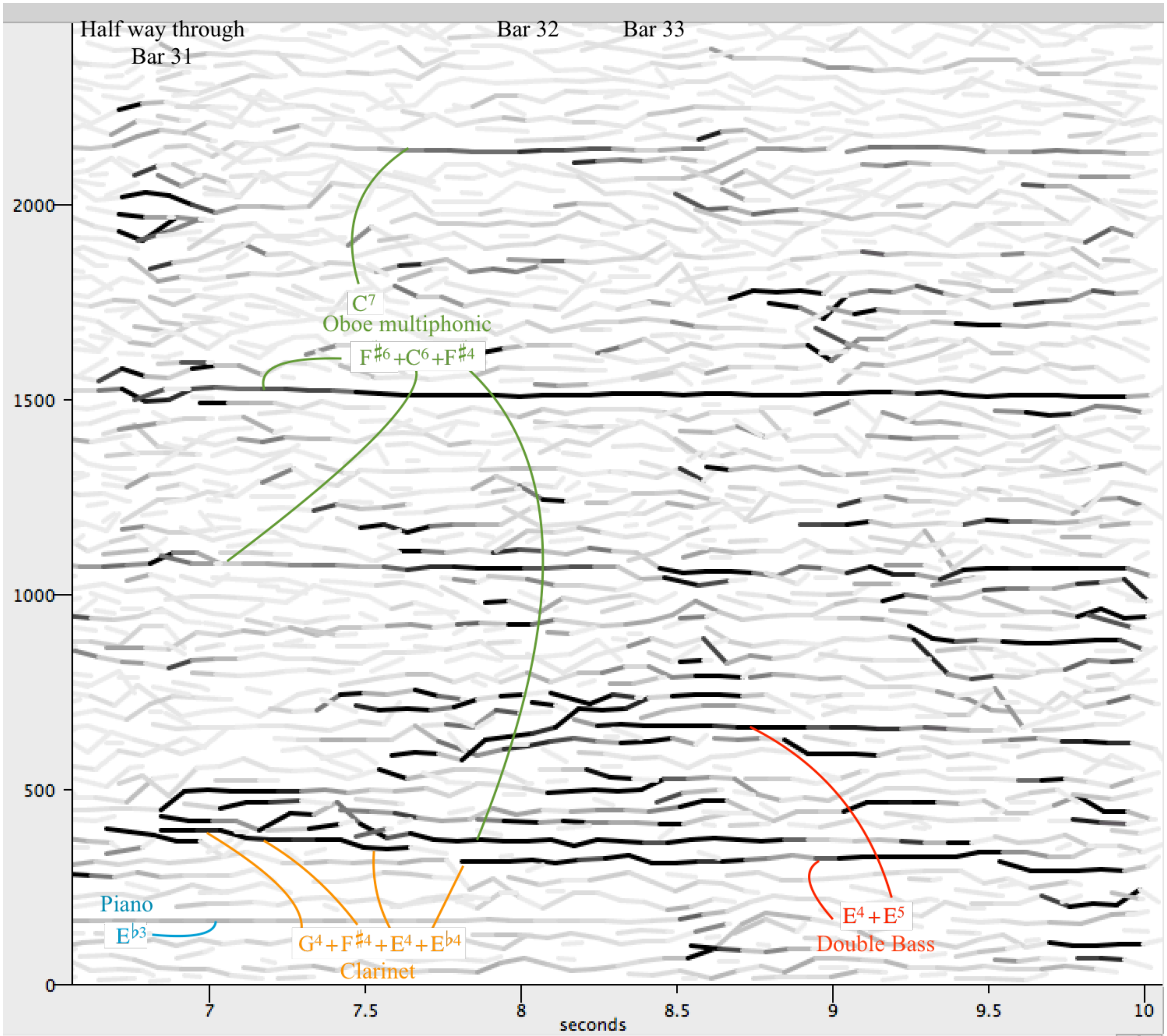


Figure 4.9 - Spectral analysis of the recording of *Bells Die Out* from bar 31-33 [1'10"-1'13"] processed with SPEAR

4.3.7.3.2 Tam-Tam

From bar 163 to 176 [5'24"-5'55"], a progression to inharmonicity occurs. Refer to Appendix D, which displays the inharmonic chord at bar 163. Here, E𝄲^{4}-E𝄳^{5}, B^{4}-B$^{\flat 5}$, form two major 7th intervals.

From bars 164 to 165, the major 7th interval changes to A𝄲^{3}–A$^{\flat 4}$. At bar 168, the major 7th interval is changed to an octave between E𝄲^{4}– E^5, while at bar 169 the major 7th returns between E^4 and E𝄳^{5}. From bar 170 to bar 174, the harmonic context pulls back towards simplicity, together with the periodic repetitions of the oscillating second in the clarinet. A tap to the wood block at the end of bar 174 triggers the sudden drop into an inharmonic chord, enveloped by the complex partial content of the tam-tam. Figure 4.10 displays the spectral analysis of the recording of the tam-tam's partial content. Take note of the 'swirling' contours of the sinusoid components.[61] The tam-tam produces a 'fundamental' of C^1 and fills in partials surrounding those pointed out in orchestration.[62] The instruments fade out with only the C^1 of the tam-tam and the chord in the strings remaining.

Refer to Appendix D, which displays the complex chord written from bar 180 to bar 181 [6'07"- 6'15"]. This includes an oboe multiphonic, tam-tam and bass drum, all combined. This is the peak of inharmonicity of the piece.

[61] This presents an example of the 'micropolyphony' of partials in a complex timbre.
[62] As the tam-tam does not produce harmonic overtones and rather inharmonic partials, there is no real fundamental. C1 is, however, the lowest sounding pitch with a large amplitude giving it bearing as a type of 'fundamental'.

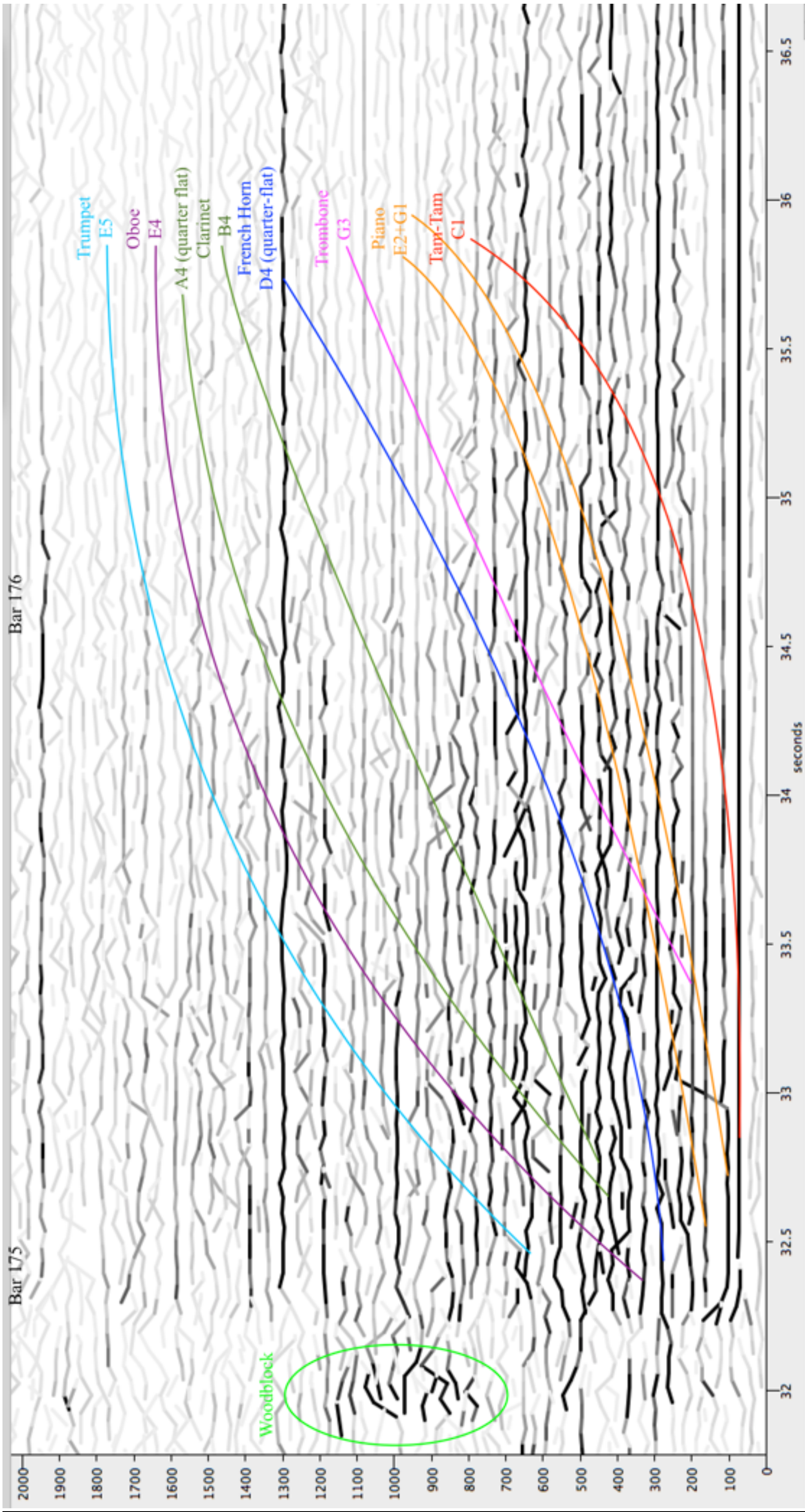


Figure 4.10 - Spectral analysis of the recording of *Bells Die Out* from bar 175 to 176 [5'50"-5'55"] processed with SPEAR

4.3.8 Application of Grisey's theory of Musical Time

4.3.8.1 Skeleton

4.3.8.1.1 Predictability

In the opening of the piece (the first repose section) there are five musical moments spanning 10", 6", 10", 7", 15" respectively – a macro 'fuzzy-periodic' pattern of long-short-long-short-long. The tremolo in the strings creates a sense of repetition and predictability for the listener, allowing for a sense of repose.

The next repose starts at bar 118, signalled by the periodic repetition of the violoncello $F\sharp^{5}$ natural harmonic. The rhythm that the violoncello plays is exactly repeated for each bar, creating the sense of predictability for the listener. The violoncello returns with the same pattern for the rest of the repose section (bars 134 to 142 [4'21"-4'43"]).

The final repose is reached at bars 203 and 204 [6'58"-7'02"], with the periodic repetition of a chord in the winds and brass creating expectation and harmonicity. The rest of the repose section is achieved through pre-audibility, and is discussed in section 4.3.8.2.

4.3.8.1.2 Dynamism

During the inhalation section, from bar 69 to 85 [2'15"-2'47"], a constant pulsating rhythm (first in the first violin from bar 69 to 74 [2'15"-2'27"], then in the winds from bar 75 to 79 [2'27"-2'37"], and lastly in the strings from bar 75 to 85 [2'37"-2'47"]) creates a sense of expectation. This is due to the rhythmic continuity. However, the looping of rhythmic patterns changes in length (refer to section 4.3.5.1), and the start of each loop with an accent arrives at unpredicted points in time. The balance between expectation and surprise allows for the sense of forward-driving dynamism.

In the second inhalation section from bar 145 to 162 [4'44"-5'24"], the number of attacks per second in the energetic texture gradually increases, first in the strings and piano from bar 149 to 153 [4'57"-5'06"], then including the winds and percussion from 156 to 160 [5'09"-5'20"], and lastly in an acceleration in tempo from 161 to 162 [5'20"-5'24"]. The gradual increase in rhythmic activity allows for the listener to sense the forward-driving direction.

4.3.8.1.3 Stasis – Discontinuous Dynamism

The final section from 218 to 226 [7’28”-7’57”] consists of only a sustained texture, without any new musical activity. There is no sense of predictability for the listener, and no view of the end of the sustained chord. The effect on the perception of musical time is stasis.

4.3.8.2 Flesh

As discussed in section 3.3.2.2, the flesh of time adds a second dimension to the perception of musical time, where timbre/‘the quality of sound’ fills up quantitative perception. The repose, inhalation and exhalation sections are prominently directed by the skeleton of time’s textural forces. The flesh of time’s forces are harmonic direction, orchestration, and the magnification of the lens of time towards expansion or contraction. Where the density of time is increased, orchestral synthesis is perceived as the macro recreation of a real-time timbre.

4.3.8.2.1 Density of Time Increased

Recall the discussion in section 4.3.6, on orchestral synthesis from bar 109 to 117 [3’30”-3’50”]. The oboe multiphonic is sustained for approximately 9”, and is layered with energetic texture. The oboe multiphonic remains in the background while the energetic texture dominates the foreground. At bar 112, the energetic texture stops and the sustained multiphonic grows into the foreground together with the overlapping first violin’s entry. The sustained orchestral synthesis then unfolds slowly, maintaining a strong sense of continuity and pre-audibility. The staggered entry of each new voice in the strings is from a soft dynamic, allowing for a coherent flow. The density of time is increased as the listener has a strong sense of pre-audibility from hearing the oboe multiphonic and the long unfolding synthesis. Therefore, the orchestral synthesis is perceived as a macro representation of the oboe multiphonic.

Other moments where the density of time is increased and orchestral synthesis forms a macro representation can be found from bar 148 to 157 [4’53”-5’15”], 163 to 166 [5’24”-5’33”], 169 to 178 [5’39”-6’07”], and 208 to 231 [7’08”-7’57”] (Refer to the Appendix C for the separate examples; note the continuous flow of orchestration maintaining a similar timbre). The last example, the static ending of the piece, is an exception to the constant flow of orchestration. This section creates the deepest expansion of the density of time throughout the piece as it is the longest section with purely sustained texture. The listener has no prediction of the end of the sustained sound, however, a strong sense of pre-audibility occurs due to the even flow of harmony and the same static pitch in the final sustain. The listener is able to tolerate such stasis due to the high level of dynamism occurring beforehand.

4.3.8.2.2 The loss of an 'Air Pocket' in Time

Where the density of time is increased, the strong sense of pre-audibility expands the length of the perception of 'the present'. Past events are joined with present events, allowing for an expanded perception. A sudden change to a salient event focuses the attention on the immediate present leaving behind the previous material as a distant memory. This is a sudden contraction in the lens for the density of time, and the result is the loss of an 'air pocket' in time (as discussed in section 3.3.2.2).

From bar 57 to 63 [1'58"-2'11"] the flowing chords in the winds, along with the constant tremolo in the strings, creates a sense of pre-audibility (see Appendix C, which displays the same orchestration). The density of time is increased as new events become recognizable to the listener. The sudden unexpected change that occurs from bar 64 to 68 [2'11"-2'15"] is a strong, salient moment due to the contrasting unison rhythmic pattern. This moment creates the loss of an 'air pocket' in time, as the density of time is suddenly decreased bringing the listeners attention directly to rhythmic pattern and *tutti* orchestration.

4.3.8.3 Skin

The skin of time refers to the memory of the listener accounting for the global perception of musical time. The listener's psychological factors determining perception are beyond the control of the composer. What is known is that a salient moment will have a lasting impact on long-term memory.

In the opening section, Khumalo clearly demarcates separate musical moments as groups of sound bound together by the coherence of multiple parts. This demarcation, by silence or a Gestalt trigger, has a lasting effect on the listener's memory (that of recognizing separate groups). This allows the listener to start forming a predictable structure when hearing a Gestalt trigger followed by a musical moment. Recall the Gestalt grouping principles in Chapter 1:

> Perception occurs through processing the configuration structure of an object that is already organized; recognizing the configuration based on the structure of the object combined with the "psychophysiological structure", or in other words, a predicted structure. (Reybrouck, 1997:58)

The structure of 'Gestalt trigger into a musical moment' starts to become a predicted structure and allows the listener to sense unity of grouping through blocks and musical moments throughout the piece.

4.3.8.4 A Macroscopic view of 'Musical Breathing'

Refer to Figure 4.11, a sonogram of the recording of *Bells Die Out* processed with Spek.[63] The opening section is characterized by sustained lines forming small groups of sustained texture. Activity increases with dense groups of energetic texture up to bar 69 [2'15"], where greater sustained lines are reached. From bar 80 to 118 [2'40"-3'35"], activity moves towards another sustained section. From bar 133 [4'20"] activity begins to build again until the area with the largest rhythmic density is reached from bar 149 to 182 [5'00"-6'15"]. The piece ends with the longest sustained texture starting at bar 208 to 230 [7'08"-7'57"]. This gives a graphical representation of how sustained and energetic forces govern the 'musical breathing' in *Bells Die Out.* The reader is directed to Appendices C and D, where a similar growth in orchestration and harmonic density is reflected.

[63] For further information, read *Spek: Acoustic Spectrum Analyzer* (Spek, 2016:1).

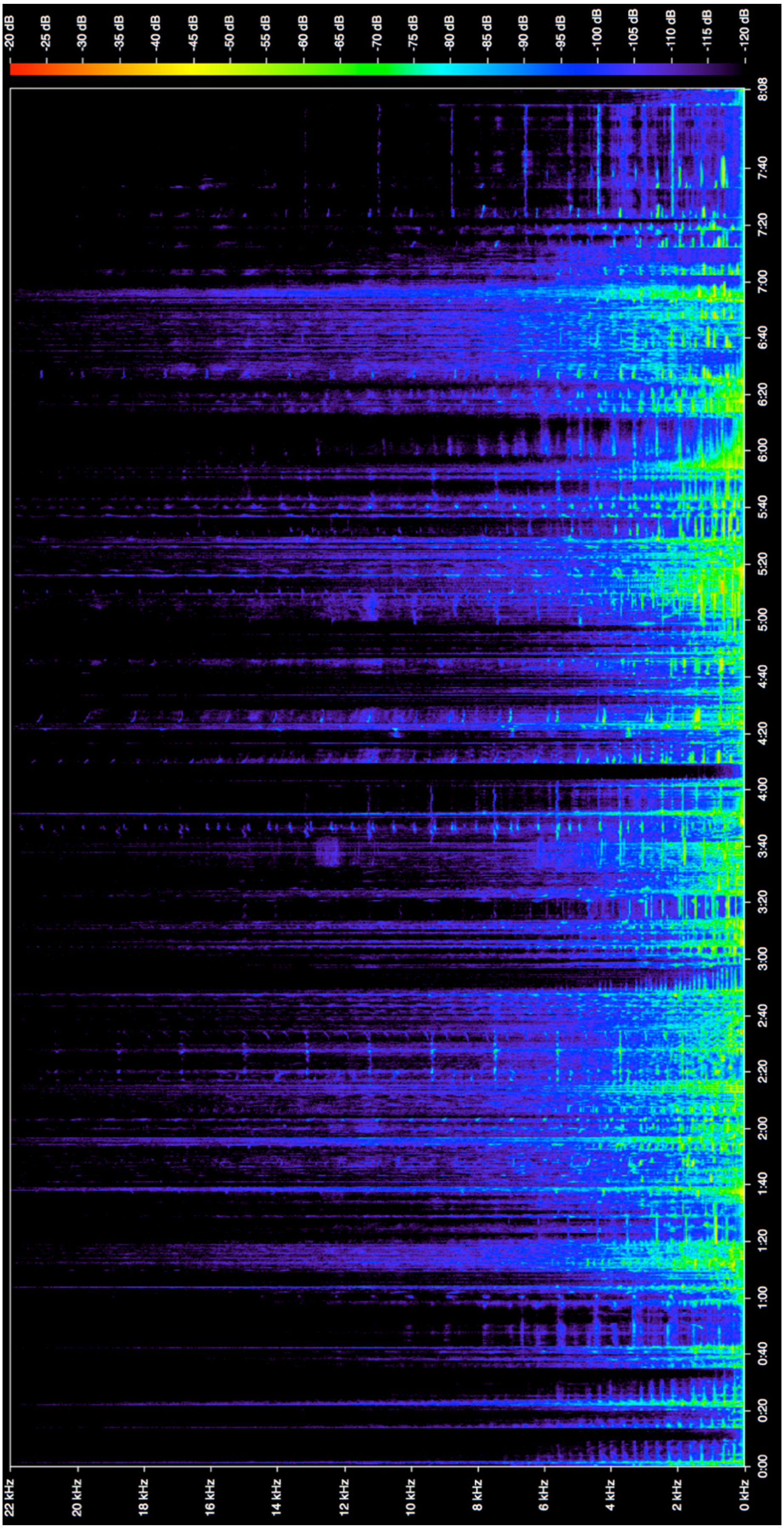


Figure 4.11 - Sonogram of the recording of *Bells Die Out* processed through SPEK

Chapter 5 - An Outlook on a Younger Generation of South African Spectral Composers – Miles Warrington and Roché van Tiddens

Before concluding, the works of two younger South African spectral composers, Miles Warrington and Roché van Tiddens, will be briefly presented. To what extent their music is connected to the French spectral tradition and how this influence will have a remaining effect on their aesthetic ideal, however, is a topic for further research.

5.1 Miles Warrington

Transcripts of interviews with Miles Warrington are included as Appendix E.

5.1.1 Background

Miles Warrington (b. 1977) began studying for a BMus at the University of KwaZulu Natal (UKZN) in 1996, graduating in 2000. Subsequently, Warrington completed a Master's degree in composition in 2005 under Jürgen Bräuninger (Warrington, 2016a:1). During his time at UKZN, Warrington became interested in electroacoustic music and started working with Digital Audio Workstations (DAWs) such as Cakewalk and DigiDesign (ibid.). He worked with granular synthesis, and applied sound manipulation techniques to recorded material in order to form an electronic work. In 2010, Warrington began a DMus at the University of Cape Town and started working with PureData, the 'sister' software to MaxMSP. He began working with live electronics, where acoustic instruments are combined with electronic manipulation, and completed his doctorate in 2016.

Since 1999, Warrington's music has been performed throughout South Africa, the most recent premiere being *MaRumba* (2004) for solo marimba, which was performed at the Grahamstown New Music South Africa Indaba. Other recent works include *Toccata* (2008) for piano, performed at the ATKV Piano Competition in Bloemfontein, *Para≈Meter* (2015) for flute and live electronics, performed in Stellenbosch, and *emanation-re-imagined-emanation* (2015), performed by the Cape Philharmonic Orchestra as part of the *Kompos!mposium*, Stellenbosch. His music will reach international ears in 2016 with his first acousmatic work *Across||Lines* (2016) for an 8 channel speaker system, due for performance at the New York Electroacoustic Music Festival.

During his doctoral studies, Warrington first made use of spectral analysis as the source for pitch material to be performed by an acoustic instrument in his composition *In-Gest* (2015) for violin and electronics (Warrington, 2016b:15). This was inspired by the harmonic possibilities found through electronic exploration (2015a:1). Electronic composition allows for durational and harmonic possibilities that can involve a complex density of frequencies. Warrington also began to show an interest in psychoacoustics, focusing on the perception of musical gestures (Warrington, 2015a:6). His DMus thesis presents the possibilities of the composer as technologist through studying musical gesture, cognitive musicology, computer vision technologies, and object-orientated programming (2015b:ii). One of the aims of his research was to develop technology in order to create an interactive environment between composer, performer and technologist (2015b:2). The composition, *In-Gest* (2013), is presented in his thesis as an example of a composer investigating the compositional process while acting as a technologist or collaborating with a technologist (2015b:14).

Of Warrington's DMus portfolio of compositions, *In-Gest* (2013) and *Umsipha* (2015) for orchestra make use of spectral analysis. Afterwards, Warrington composed the spectral piece *emanation-re-imagined-emanation* (2015).

5.1.2 *In-Gest* (2013) for violin and electronics

Warrington focuses on the perception of musical gesture in his thesis, and defines a human gesture as a means of communication through feeling, idea, and intention. He defines a musical gesture as a "compositional element… that embodies some form of meaning or abstract communication through sound" (Warrington, 2015b:9-10). He deals with the perception of the listener in understanding the meaning conveyed through a musical gesture. The title of the piece is a play on words that couples to 'ingest' with 'gesture', and represents the listener taking in (understanding the communication) of the human, musical and instrumental gestures (2015a:3).

Warrington presents two 'gesture signification models A and B' that define the creative process of the composer. In 'gesture signification model B', the composer first imagines a sound in relation to a human gesture, and then traces the sound in order to notate that musical gesture. The player then reads the notation and performs the musical gesture. The movement of the performer's body parts then creates the instrumental gesture (Warrington, 2015b:57).

Seven separate gestural sheets are presented in *In-Gest*: *Walk*, *Up*, *Down*, *Waltz*, *Float*, *Slow* and *Fast* (Warrington, 2015c:13-21). Each sheet contains a different musical gesture performed by the violin, together with the interaction from the electronic part run through PureData and an action tracker. Warrington developed an action tracker with PureData that tracks the fingertips of the violinist through a camera system (2015a:1). The software for the camera system is based on facial recognition software. The action tracker picks up the timing between fingertip movements from the violin as ‘procedural events’ in PureData, which then triggers elements from the electronic score (2015b:110).

The first gestural sheet, *Walk*, contains an example of spectral composition. Warrington recorded himself walking on gravel, and then processed the recording through SPEAR to extract certain partials out of the sound. Figure 5.1 displays the score for the first sheet, where a screen-shot of the spectral analysis graphic is presented in the electronic score. The extracted partials are given to the violin to play in the order of ‘foot 1 - heel - foot 2 - heel’ ($A^{\sharp 4}$-C^{5}-$A^{\sharp 4}$-A^{4}).

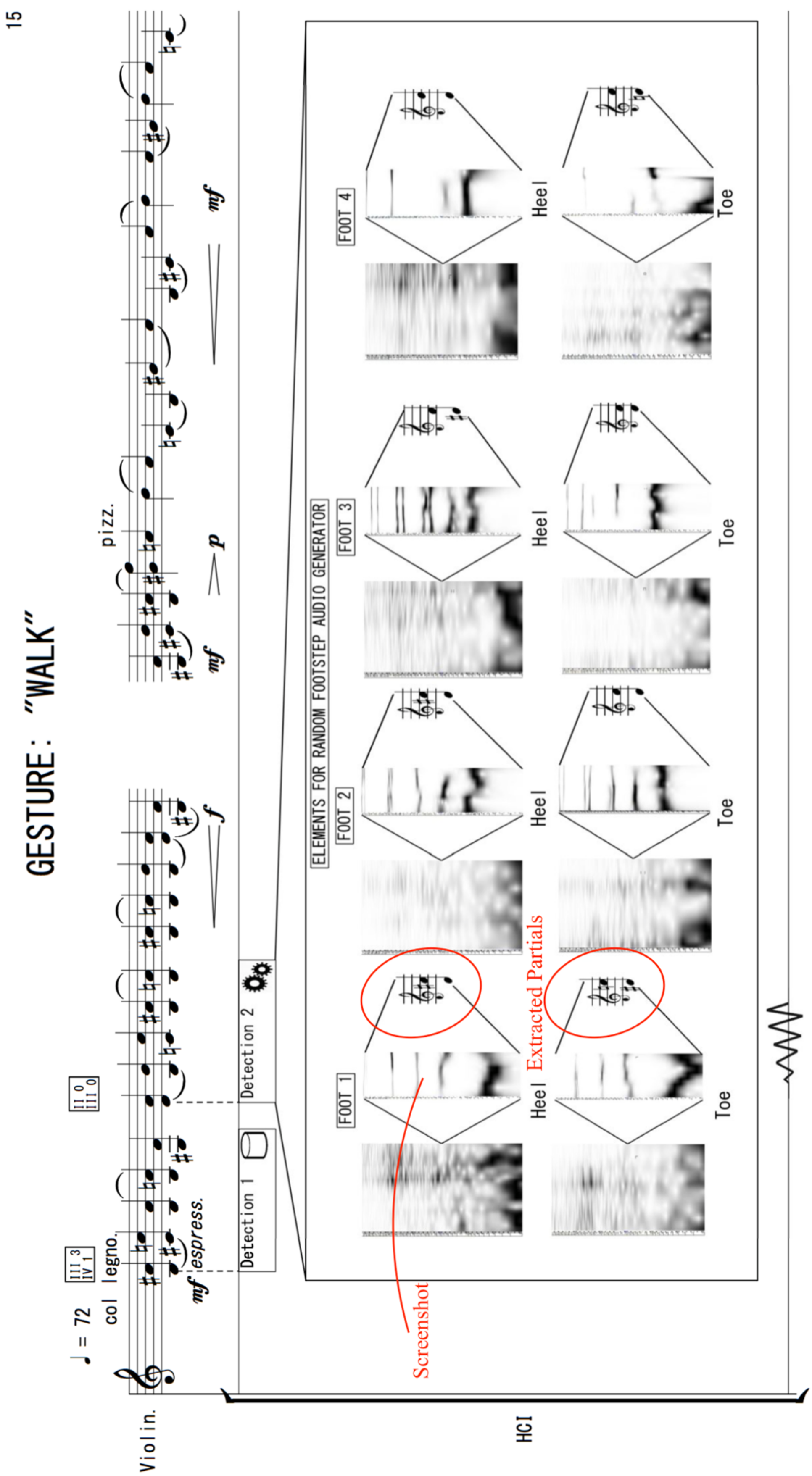


Figure 5.1 - Spectral analysis composition found in the gestural sheet 'Walk' from the score *In-Gest* (Warrington, 2015c:15)

The electronic part is then triggered by the action tracker through the timing of 'procedural events' to play back certain partials specified as selected frequencies. The result is the combination of the violin's timbre playing the extracted partials from the actual sound of walking, and the electronic part playing back these same partials at triggered events determined by the action tracker. The timed events create a 'random walk' between chords of the electronic part (Warrington, 2015b:119).

Warrington writes that *In-Gest* is the result of discovering meaning in electroacoustic composition by making use of gestures that are recognizable. These gestures form the "something to hold onto factor" as new abstract levels of expression are reached (2015b:150). Warrington delves into the music-making process by tracking the actual gestures of the acoustic performer. He also delves into the sound of the human gesture, 'walking', through spectral analysis partial extraction. The result is a musical gesture intrinsically related to both the human gesture and instrumental gesture.

5.1.3 *emanation-re-imagined-emanation* (2015) for orchestra

Warrington writes in the programme notes for *emanation-re-imagined-emanation* that the piece was inspired by the spectral harmonies in the electroacoustic piece, *The Continuum of Emanation from the One* for electronics by Dimitris Kariofilis (Warrington, 2015e:1). The recording of *The Continuum of Emanation from the One* was processed through the spectral analysis/sonogram software Sonic Visualizer. By working with 20 second snapshots, Warrington could analyse the frequency content of the different sections, and extract MIDI information for specific pitches and durations (2016b:16). He then went about orchestrating the frequency content in order to create a global sound that differed from the form and structure of the original piece. Extended techniques, such as multiphonics, feature in order to create harmonic complexity, resembling the dense harmonic material of Kariofilis's piece.

Figure 5.2 displays a screen-shot of Sonic Visualizer, used to extract partials for *emanation-re-imagined-emanation*. The *x*-axis represents time, the *y*-axis frequency, and coloured areas represent sonic material with varying amplitude levels (refer to the colour prism for the decibel level found on the top left corner of Figure 5.2).[64] The composer can hover the mouse cursor over the coloured areas to view the specific frequency content/decibel level at certain moments in time. The spectral analysis shows a dense cluster of frequency in red (higher decibels) forming an ascending and descending curve, moving towards a green area (lower decibels).

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[64] Sonic Visualizer does not present sinusoids as SPEAR does, but rather displays a coloured sonogram of spectral findings.

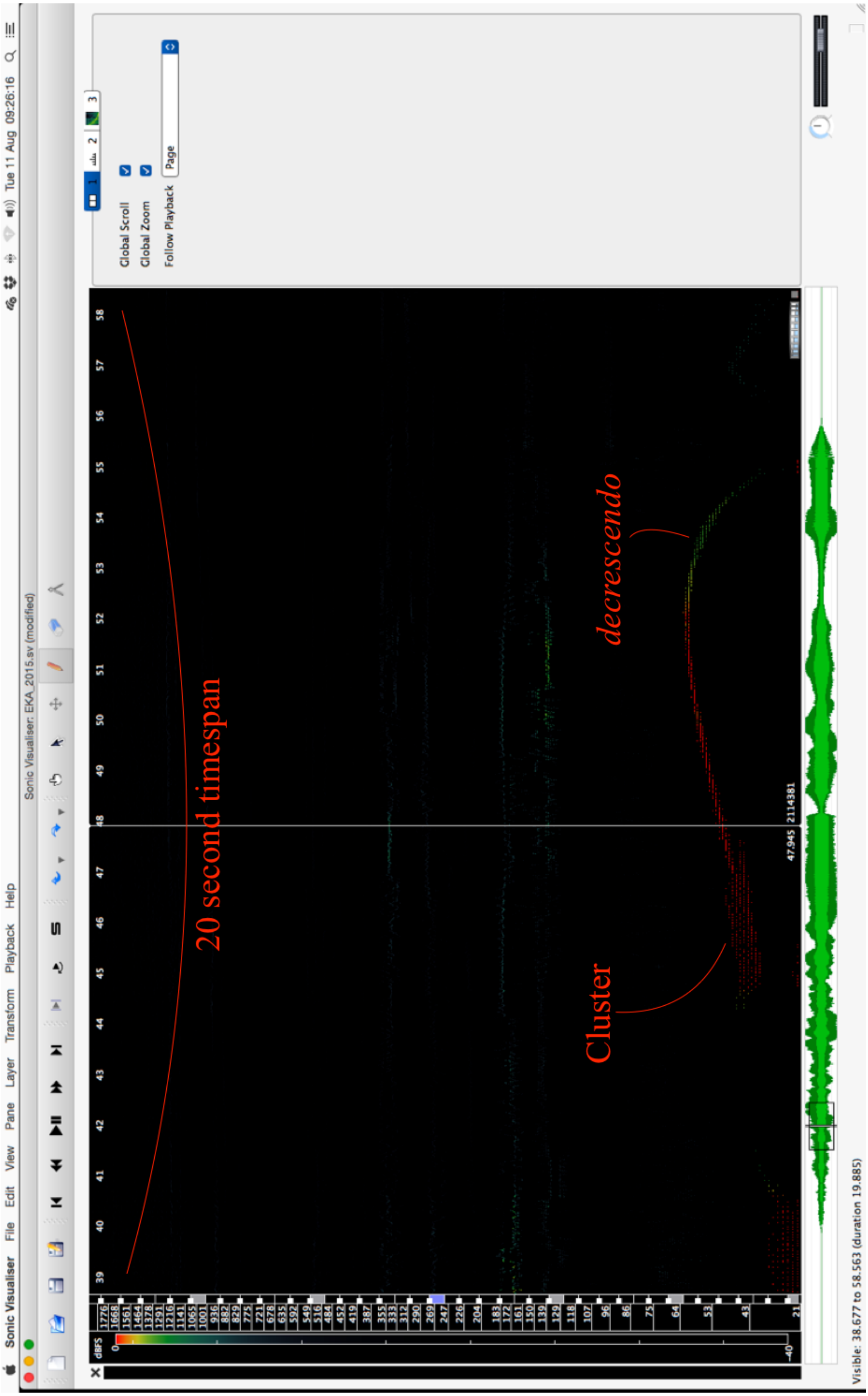

Figure 5.2 - A screenshot taken of Sonic Visualizer while extracting partials for *emanation-re-imagined-emanation* (Warrington, 2015d)

emanation-re-imagined-emanation makes use of *glissandi* in the strings in order to orchestrate the red-coloured sweeping line. Figure 5.3 displays the *glissandi* written for the divided violoncellos and double basses from bar 20-25. A wide cluster separated by three semitones, E^1-F^1 and $E_{\ddagger}^{2}$-$F^{\sharp 2}$ forms an ascending *glissandi* to a narrower cluster separated by quarter tones, G_{d}^{2}-G^2 and $G_{\ddagger}^{3}$-$G^{\sharp 3}$. The descending *glissandi* then form a *decrescendo* towards unison $C^{\sharp 1/2}$.

Figure 5.3 - An example of the orchestration of spectral findings in bar 20 to 25 of *emanation-re-imagined-emanation* (Warrington, 2015e:4)

5.2 Roché van Tiddens

5.2.1 Background

I began composition studies at Stellenbosch University under Hans Roosenschoon in 2012, and completed a BMus in 2014. My music has been performed in South Africa since 2013, with the most recent performances being *VerlorenVlei* 1st movement for orchestra, chosen to be performed by the Cape Philharmonic Orchestra at the *Kompos!mposium*, Stellenbosch, 2015; *Praying Mantis I* (2015) for two harps, two guitars and live electronics, performed in Stellenbosch in 2015; *Praying Mantis II* (2015) for symphonic wind band, performed by the University of Stellenbosch Symphonic Wind Ensemble in Stellenbosch in 2015; *Praying Mantis III* (2015) for brass quintet, performed by the brass quintet at the International Society for Contemporary Music's (ISCM) World Music Days in Tongyeong, South Korea, in 2016.

In 2014, I became interested in spectralism after studying scores of the well-known spectral composer Kaija Saariaho. I composed *VerlorenVlei* (2014) for orchestra based on spectral analysis findings, from field recordings taken on a farm in the Western Cape, South Africa. The piece formed part of my undergraduate portfolio.

The research presented in this thesis has allowed me to discover different spectral techniques and theories. I have attempted to apply them to the works *Praying Mantis I*, *II* and *III*. The works are grouped under the same name, due to similarities in compositional approach. *VerlorenVlei* provides an example of spectral writing only after a brief familiarisation with the tradition, whereas *Praying Mantis I*, *II* and *III* are composed from a more informed perspective. The above-mentioned works are included in my Master's composition portfolio.

5.2.2 *VerlorenVlei* (2014, revised 2015) for orchestra

Field recordings such as that of the sea, wind, marsh-land at night, fire, birds, farm machinery and animals, were made and spectrally analysed through SPEAR. The work was then composed as three movements, with the first representing 'pure nature' by only including the recordings of the sea, wind, marsh-land at night, and fire. The second movement was based only on birds, and the third on the farm machinery, animals, and a farm worker's folk song. The first movement was focused on writing sound-mass texture with the use of *senza misura* sections, to allow the complexity of voices to fuse into a mass perception. The second was focused on Ligeti's concept of 'micropolyphony', by orchestrating the 'micropolyphony' found in the partial content of the 'bird call' sound sources.

As mentioned before, I discovered the relationship of the two texture types to spectralism from reading Besharse's dissertation *The Role of Texture in French Spectral Music* (2009).

Figure 5.4 displays a spectral analysis sketch of the recording of wind, processed with SPEAR. The partial content was discovered by hovering the mouse cursor over individual sinusoids, to reveal the precise frequency and equally tempered pitches. The form of the section was then sketched in real time, shown by Figure 5.5, where instrumentation, density, and length of each contour were calculated. The result was a quasi-real time emulation of the wind recording, only now with an orchestration resulting in a new global timbre. An example from the score is displayed in Figure 5.6. Notice how the spectral material displays a 'micropolyphony' of partials, and how the orchestration aims at re-creating this complexity in a magnified form.

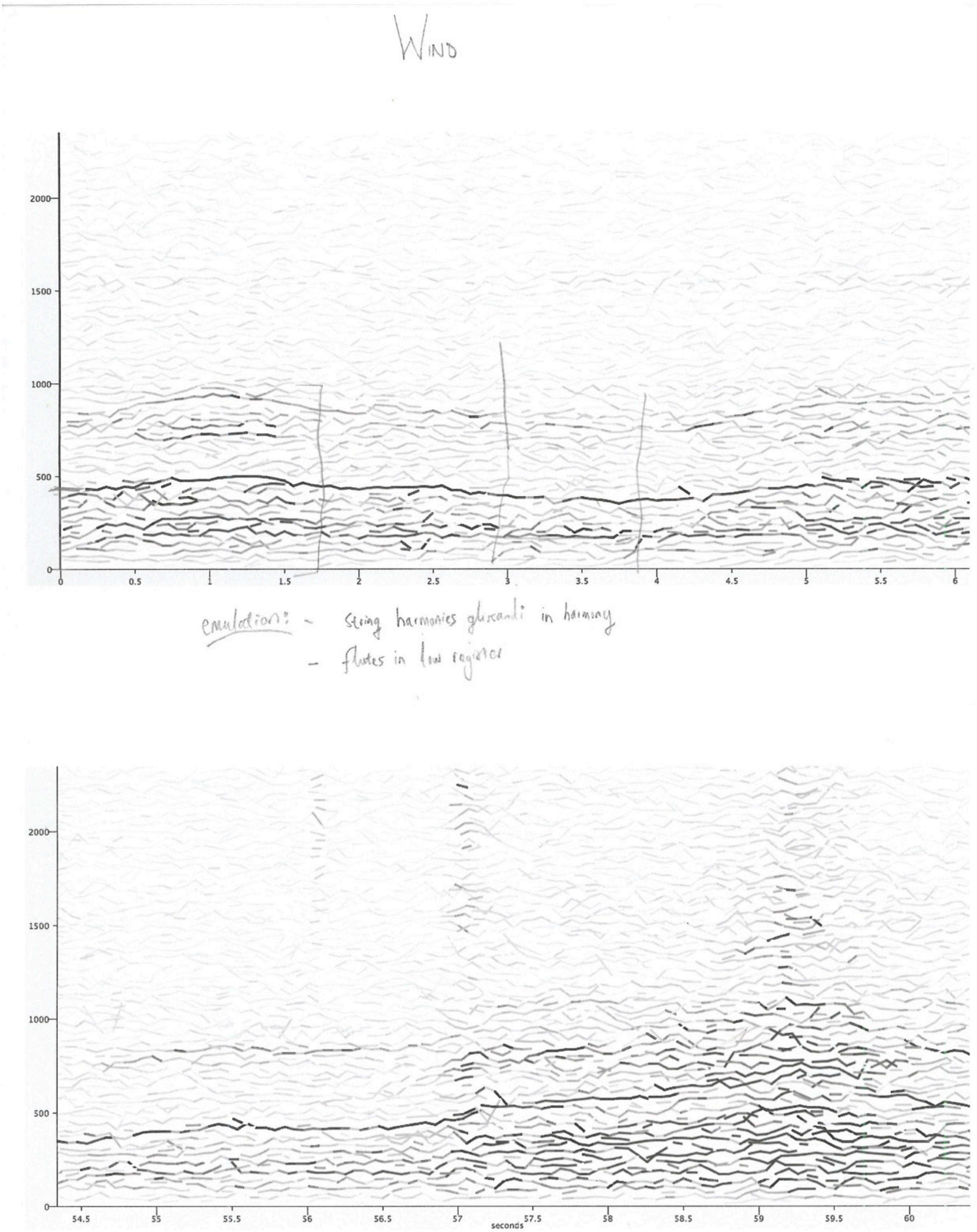

Figure 5.4 - Spectral analysis of the recording of wind processed through SPEAR using in *VerlorenVlei* (Van Tiddens, 2014)

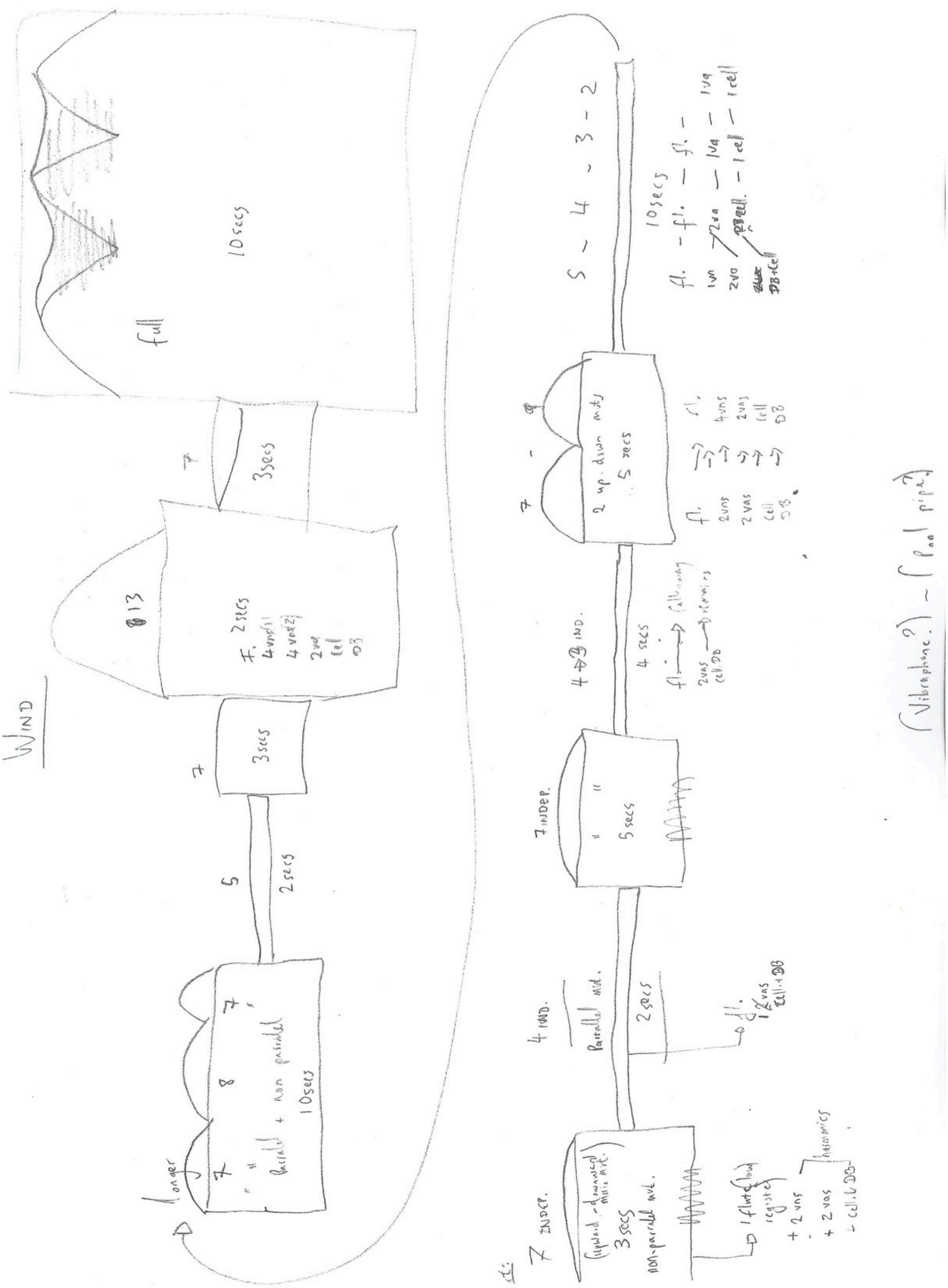

Figure 5.5 - Sketch for calculating the instrumentation, density, length of each wind climax in *VerlorenVlei* (Van Tiddens, 2014)

Figure 5.6 - Bar 47-55 of *VerlorenVlei* (Van Tiddens, 2015a)

5.2.3 *Praying Mantis I, II and III* (2015)

5.2.3.1 *Praying Mantis I* (2015) for two harps, two guitars and live electronics

Praying Mantis I, written without metre, is based on the spectral analysis of water recordings. These recordings include the sound of droplets, as well as swishing and pouring water. Droplets provided melodic material, while the swishing and pouring showed harmonic and textural complexity. The principle that connects the three *Praying Mantis* pieces is working with foreground and background material. A musical idea that is first in the foreground, is later moved to the background while new ideas take the foreground position. The aim is to allow the sub-conscious memory of foreground material to remain strong as it fades into the background. The piece works through different textural sections, and the plucked instruments are employed to create large sustained sound-mass textures. The part for live electronics aids in presenting the recordings (after manipulation) of water that were spectrally analysed, in order to establish a connection with the acoustic 'a priori'. Refer to Figure 5.7 for an example from the score.

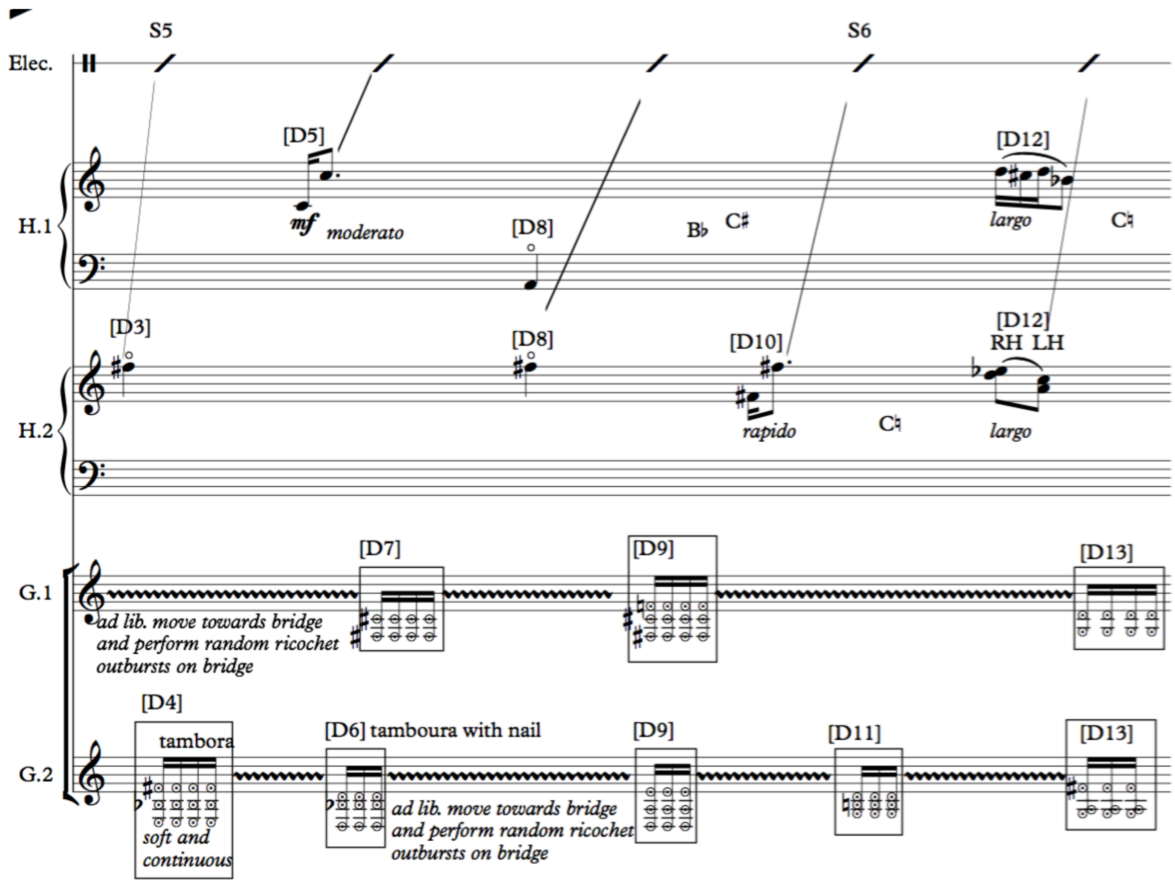

Figure 5.7 - An example from the score of *Praying Mantis I* (Van Tiddens, 2015b:5)

5.2.3.2 *Praying Mantis II* (2015) for symphonic wind band

Praying Mantis II is based on the spectral analysis of a cymbal swell. Figure 5.8 displays the spectral analysis of a *crescendo* cymbal swell, processed via SPEAR (Van Tiddens, 2015). The swell is reflected in different magnifications of time throughout the piece. An example is on the macro scale, the global form of the piece forms a large version of the *crescendo*, moving towards extreme density of harmonic and rhythmic activity. It then fades out.

Figure 5.9 displays the sketch I made, from which partial content was read off the SPEAR diagram and notated with a broad idea of temporal flow. The sketch was then orchestrated, and an example is found from bar 10-16 of the score, as displayed in Figure 5.10. Bar 10-16 is a magnified representation of the spectral detail present at the start of the cymbal swell (shown by Figure 5.8), because the material is presented slower than real time.

Figure 5.11 displays a sonogram of a live recording taken from a concert in 2015, processed through Spek. Between 2'00 and 3'15", the growth in harmonic and rhythmic density is displayed forming the idea of 'inhalation'.

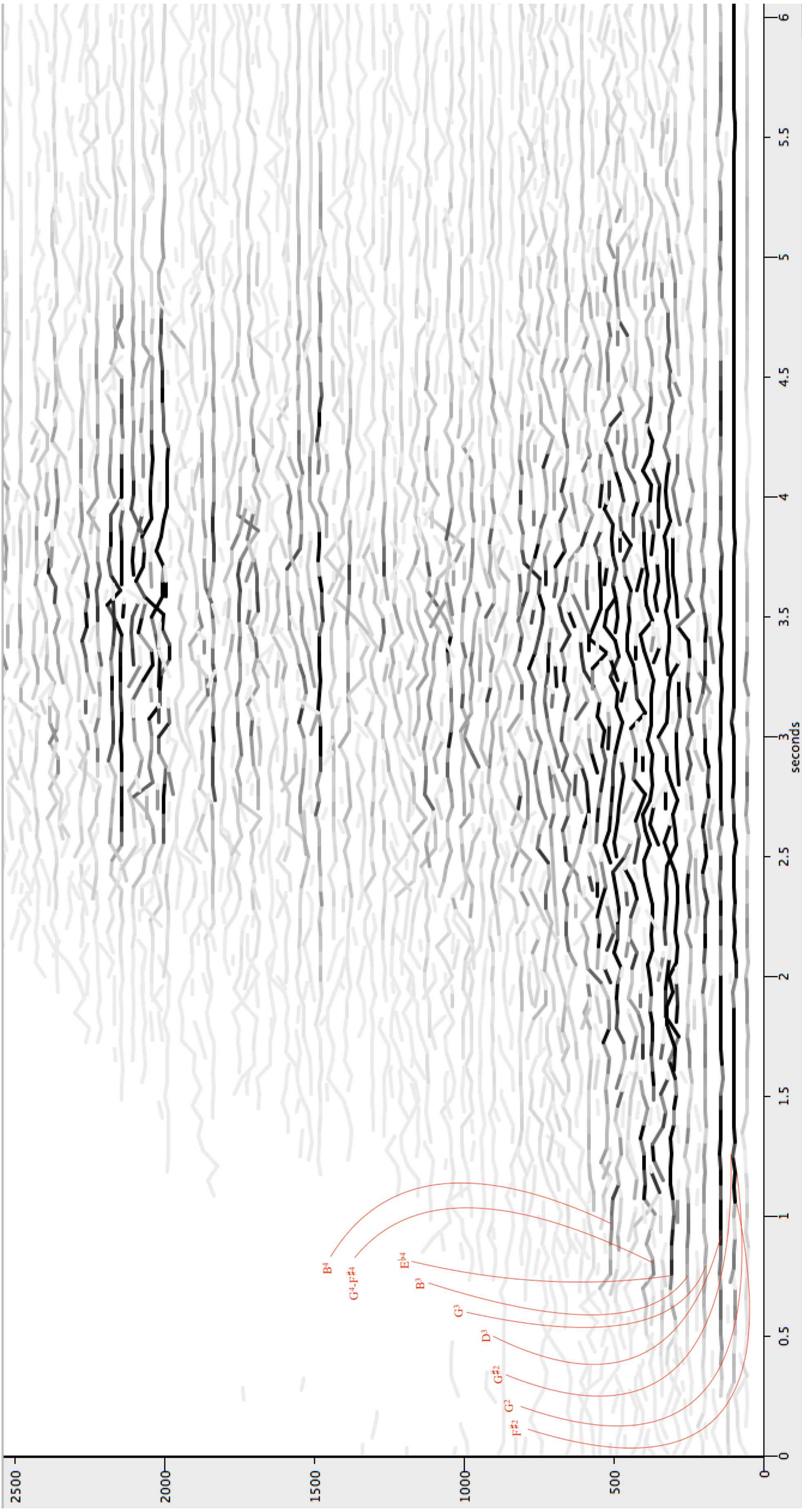

Figure 5.8- Spectral analysis of the cymbal swell processed through SPEAR (Van Tiddens, 2015c)

Figure 5.9 - A sketch where the spectral detail is transcribed into music notation (Van Tiddens, 2015b)

Figure 5.10 - A macro representation of the spectral material in bar 10-16 of *Praying Mantis II* (Van Tiddens, 2015d:2)

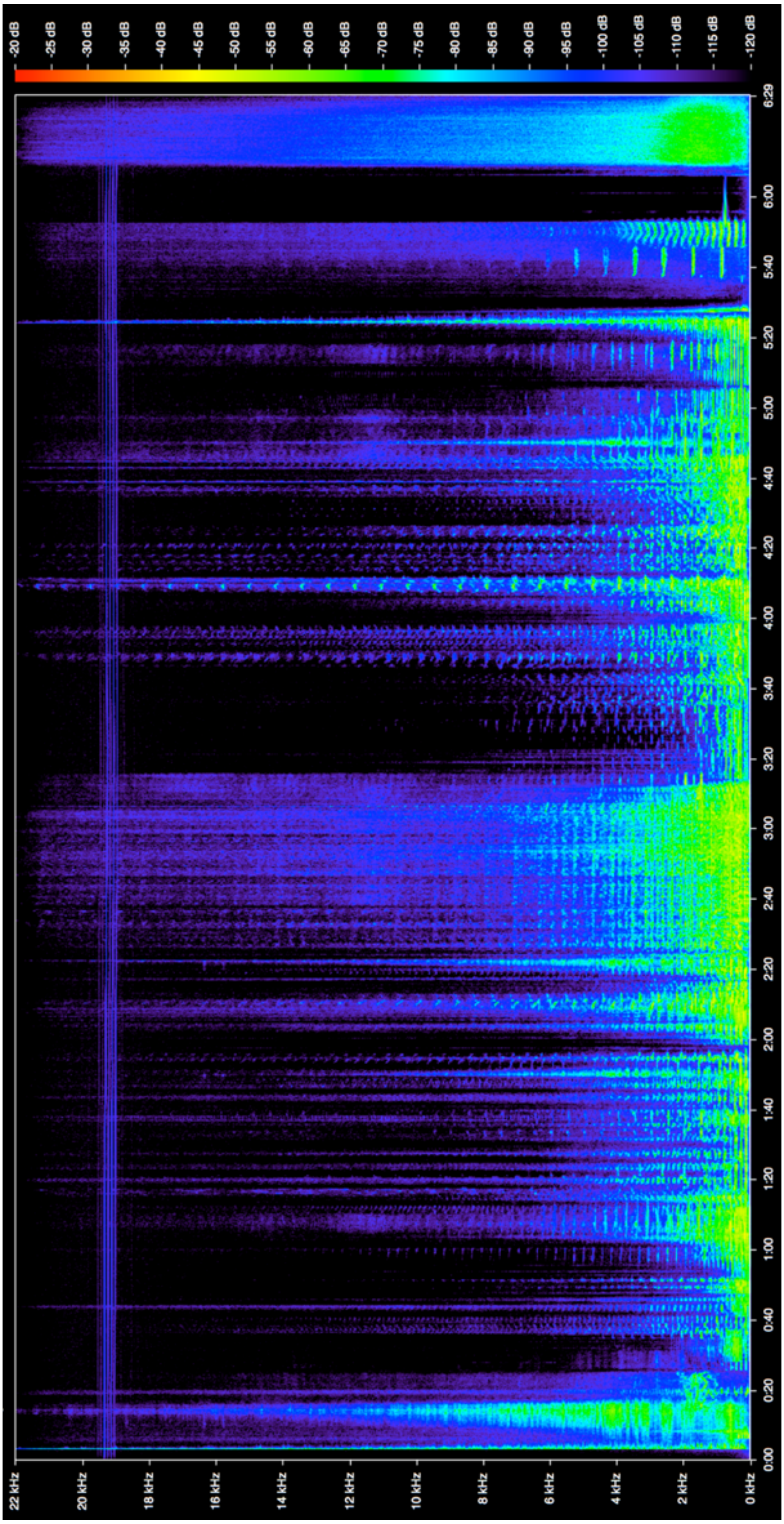

Figure 5.11 - A sonogram of the recording of *Praying Mantis II* processed through SPEK

5.2.3.4 *Praying Mantis III* (2015) for brass quintet

Praying Mantis III is based on the same spectral material utilized in *Praying Mantis II* (the cymbal swell). However, it follows a different layout of form, in that the piece moves between sustained and energetic texture. The energetic textures are characterized by unpredictability due to complex rhythmic changes. The idea of moving between different levels of foreground and background material remains as the foundational principle of the work. Refer to Figure 5.13 for an example from the score, where similar pitches from the spectral analysis of the cymbal swell are used.

Figure 5.12 - An example of bar 7 to 11 of *Praying Mantis III* (Van Tiddens, 2015e:2)

5.3 Conclusion

The South African composer, Andile Khumalo, studied under Tristan Murail and other leading composers in the field of spectral music and psychoacoustics. Therefore, the potential existed for the result of a musical analysis of *Bells Die Out* (2013) to relate to spectral principles. From this the author has drawn the following connections between the French spectral tradition and a South African 'spectral' composer:

- the use of spectral analysis of a sound source to construct orchestral synthesis. The listener experiences the fusion of multiple pitches into a single phenomenon of timbre. This is referred to by the spectral composers as 'écriture liminale'.
- the relationship between structure and the perception of time. Khumalo makes use of 'musical breathing' as pointed out in Grisey's theory on time.
- the use of the continuous over linear progressions as pointed out by Murail. Khumalo makes use of continuous progressions between blocks of textures. The sense of directionality results from these progressions.
- the sculptor with a 'block of ice'. Khumalo worked with the spectrum as a sound source that can be 'viewed' from different angles. The changing of 'angles' is achieved through the changing of gestalt sound perceptions.

5.3.1 Summary of Chapter 1 – 5

- Chapter 1: The nature of acoustics (periodic/aperiodic complex sound waves) and psychoacoustics forms the foundation for spectral composition. The Gestalt perception of sound accounts for main spectral philosophy, *écriture liminale* (ambiguity of perception).
- Chapter 2: The historical development towards spectralism is firstly rooted in the sound-mass electronically influenced instrumental music of Ligeti, where the 'inner-fabric' of sound is stretched out to create a globally perceived timbre. Secondly, the spectral composers' teacher, Messiaen, enforced the ideas of writing out the inner-details of timbre as an acoustic chord. Thirdly, Stockhausen brought forward further ideas from working in the electronic studio, such as the idea of periodicity and aperiodicity (as related to acoustics), in addition to working with the idea of a 'continuum between parameters'. Other composers, such as Scelsi and Varése, also had an impact on the ideas of working with sound itself.
- Chapter 3: Gérard Grisey and Tristan Murail share the same philosophy on spectralism in their focus on the listener's perception of time, 'musical breathing', and continuous

development by changing perspective on the instrumental 'block of ice'. Furthermore, these composers share similar techniques of orchestral synthesis, acoustic 'a priori', and continuous development achieved through calculations of ring modulation, frequency modulation and the distortion of the overtone series.

- Chapter 4: The South African composer Andile Khumalo's piece, *Bells Die Out* (2013) was analysed in order to determine whether a connection to the French spectral tradition could be established. It was discovered that Khumalo works with the listener's perception, 'musical breathing', and changing perspective on the 'block of ice'. Furthermore, Khumalo's makes use of techniques such as orchestral synthesis, acoustic 'a priori' and continuous development through filtering and looping.
- Chapter 5: The music of a younger generation of spectral composers is briefly presented. Both Warrington and van Tiddens make use of spectral techniques. To what extent their music connects to the French spectral tradition could be a topic for further research.

The argument that runs through the thesis begins with connecting the nature of acoustics and psychoacoustics, such as the periodic/aperiodic complex waves and Gestalt grouping principles, and the continuum of parameters proposed by Stockhausen. Stockhausen's theories are connected to the spectral composers' theories that focus on the listener's perception. Furthermore, other mid-20th century composers focused on varying methods of writing music based on the 'inner-nature' of sound, creating an artistic grounding that connects the spectral composers. The theoretical background of the spectral composers then connects to the spectral ideas of Khumalo's (as found in *Bells Die Out*), such as the use of Gestalt grouping principles and the listener's perception of time. The drawn-out 'web' remains rooted in the use of the inner-details of sound and the listener's perception in order to conclude that there is indeed a South African spectral composer: Andile Khumalo.

5.3.2 Further Research

The following topics are recommended for further research: the connection between the younger generation of spectral composers, such as Kaija Saariaho and Philip Hurel, and the music of Andile Khumalo; the connection between the music of Marco Stroppa and Khumalo; further investigation into spectral techniques used by Khumalo in his pieces but not discussed in this thesis; the connection between the music of Miles Warrington and the French spectral tradition; the connection between the music of Roché van Tiddens and the French spectral tradition; the idea of an African approach to spectral composition; Psychoacoustics, psychology of hearing and Grisey's theory on musical time.

5.3.3 Final Thoughts

As a composer my interest in spectral composition encouraged an investigation into the techniques and philosophies of spectral composers. The use of psychoacoustics as a compositional parameter was discovered as forming the so-called 'attitude' of spectral music. This research facilitated an informed approach in the works composed for the practical component of my Master's degree, a composition portfolio of approximately 60 minutes of music. Furthermore, research into the music of Andile Khumalo, in order to ascertain a connection to the French spectral tradition, furthered my knowledge of spectral composition and psychoacoustic concepts.

Spectral composition involves a variety of techniques available to composers today, due to vast developments in technology and sound analysis tools. The future of spectral composition will include further technological development, allowing the carving and crafting the inner-details of sound to form a meaningful musical work. In the present author's opinion, a spectral composer should bear in mind the French spectral tradition, in that working with the listener's perception of time and exploring the world of sound is of paramount importance.

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Discography (Appendix F)

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Sheet Music and Musical Sketches (Appendix B and others)

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Interviews (Appendices A and E)

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Khumalo, A. W. 2016a. Telephonic interview, 11 March. Stellenbosch.

Warrington, M. 2015a. Interview, 4 June. Rondebosch, Cape Town.

Warrington, M. 2016b. Telephonic interview, 15 March, Stellenbosch.

Appendix A – Interviews with Andile Khumalo

Interview with composer Andile Khumalo on the 17th of July 2015 at the South African College of Music, Cape Town

RvT: So your music is based on the phenomenon of sound?

AK: When I was doing my undergraduate, I was interested in something that was different. In my third year I came across Schönberg and Berg, whom at the time I thought was quite strange, but strange in refreshing way. So, I really started at that time, of course had no idea about the sound as such but I knew that I wanted to write something that was not necessarily based on these traditional harmonic progressions. <u>There was already a conceptualized idea of sound as a unified body</u>. Where you don't break the clear background, foreground, you perceive the whole sound as a unified body. So, the 12-tone music I started to write had started to break some of the elements, although at that time the presence of foreground vs. background was still strong as it was the only thing I knew, but the idea of sound was already started. When I went to Germany it started to make sense of what I was really feeling, and I became more conscious of what I was doing, and yes, the <u>development of sound as a complex phenomenon developed strong while I was there</u>.

RvT: I am going to jump straight into it. Spectral music, how big a part is that of your music?

AK: I did tell you a little bit in our emails of the different concepts of spectralism and was referring you to different composers, the reason being that when people think of spectral music they think only of Gerard Grisey, or Tristan Murail, who have a very specific concept of what spectralism is, and yes of course, one must also remember that when they started actually writing at that time for spectralism, they were really concerned that people started to perceive the sound as such. There was a strong presence of really almost presenting all the time the spectrum, and different sequences of the spectrum. So if you listen to Grisey for example, the *Prologue,* it is different sequences of different spectrum. But, Tristan Murail says, the idea towards spectralism for him is not the aesthetic, but is an attitude, so many that the spectralism and techniques are compositional tool for him and does define the resulting aesthetical sound, meaning that we can use spectral ideas and techniques and produce music that is different to what Murail and Grisey's music sounds like. That's why there are different variations of what people perceive as spectral music and spectral composer.
<u>Yes, in my music I use the ideas of spectralism, but it is more of working around sound,</u> same way

as I incorporate some of the techniques from Lachenmann, and Führer, based on the idea of sound as well. Analysis of the spectrum is sometimes used to map and give shape to the sound itself. Because, of course, sound does not only consist of pitches, frequencies, or spectrum of overtones, also consists of the way you produce that sound, so the gesture or action towards that sound. The liveliness that shapes that sound, as sound moves, the different frequencies come to life, others disappear all of that depends on how I attack the sound which is of course the action. In all, my music that is orchestrated. There are different pieces that I have written in the past. I wonder if when I was in Stellenbosch I played the quartet for viola, oboe, marimba and piano, which of course deals with the action, but this action is mapped within the spectral shape within the gestures. So the gesture and spectrum is inseparable.

RvT: So basically, you use spectral analysis as a compositional tool quite regularly, in all your music, since you found your voice?

AK: I don't know if I have found my voice. But I am still looking, it is a dangerous thing to find your voice, we all aim for, but once you found your voice it means people identify your work and that is how they expect to hear in your next work which means you are trapped into how you sound like and what you should always sound like, there is an interesting thing in finding your voice, but also a danger, as you would then find it hard to move in to other different directions, without losing what people think and perceive of your work.

RvT: So you are always being free, and not putting yourself in a box, you always trying to move towards something new or and find new things for yourself.

AK: I remember I was listening to a Japanese conductor, and he said something that was really important to me, they asked him, you have recorded many recordings, some of them with different orchestras playing Beethoven, what motivates you at age of 70 to continue making new recordings, and he said that what motivates me, is the look and need for perfection, I know that I will never be able to reach that super perfection because once I have reached that there is no need for me to continue to be a musician. So that is the want to do what you have already done, and feel like you can do it better, and give a different perspective you perhaps were not able to give ten years ago of the same music is what drives him, and is what drives me as a composer, I know that I will never get to that perfect state, and I am happy that I will never get to that state because that is what drives me to the composition, and push it to a different level, or a different perspective than the one composition I did before, because if I get to the perfect state, then there will be no need for me to continue. So I don't know if that answers your question [laughs].

RvT: [laughs]…So, with bringing this back to Africa , Hans Roosenschoon is my supervisor and I was interested in researching spectral music, and my first idea was to research water and how it interacts as a sound source, and he recommended researching spectralism in South Africa, and that pushed me towards building a South African approach to spectralism, and so after what we spoke about today [composer panel at SASRIM 2015], it has cleared up a lot to do with whether we can formulate a South African approach or not. I was happy to have asked is there a South African style, and what came out is if there is, it is diverse, and to me that is good enough. So I don't think I am going to focus my research towards finding a South Africa approach, or theorizing a South African approach to spectralism, because my first idea was to see if South African composers have spectrally analysed the bow music, and that would be a South African approach because it is bow music, but Tristan Murail could analyse the bow music, and would that then make him a South African spectral composer, for example his piece *Les Esprit des Dunes*, uses Mongolian overtone singing, and does that now make him a Mongolian composer?

AK: …Exactly…

RvT: What I am going to limit my research to, is see which South African composers have used spectral music and then put a few of my own contributions in as well. So we don't have to talk too much about the African side, but I would love to hear how you have used traditional music.

AK: Before I get to that, also something which is good to consider, is that even when people use the ideas of spectralism, is it conscious to them? Is the idea of spectralism conscious to them? Because if one talks spectralism, then it is almost saying serialism, the fact that you are using 12 tones, does not mean that you are writing serialistic because serialism has connotations in terms of how you organise that chromaticism, or atonality, whereas people can write atonality without writing serialistic techniques. The same with the idea of spectralism, are there people aware of that there is the idea spectralism, and what is it that associated them to spectralism. So my, it is very difficult to get hold of scores or recording from people if I don't know them. I listened to Rob Fokkens's CD. We spoke about this as well, but the idea of spectralism for him, is something that is conscious within him, and the idea of development of a traditional instrument, is something that has explicitly come through in his music. But, you could question music that projects the idea of spectral concepts, and people that have used the instrument without considering this aspect, what aspect are they considering when using this instrument? I don't know if that is important?

For me, as I was saying in the talk [composer panel at SASRIM 2015], that my approach is quite different, and close to that of Murail, I believe if I want to contribute to South African music, I can learn from the concepts let's say for example of melodic construction, of the mouth bow music for example in relation to how it relates to the spectrum, to combine those two is interesting, but quite frankly it does not serve the purpose to assimilate my music to the sounding music associated with mouth bow music. What could be interesting for example, is to imagine the concept mouth bow music, within a bigger scope almost like an amplified mouth bow music that is visual, so analyse it how it works, and then write as if one is hearing a super big mouth bow music played by the orchestra and to amplify the mouth bow music. For me that is artistically creative, to give perceptions of something that is not there, and does not exist before, and then it is quite related to what we heard before.

RvT: That is something I am very interested in, yes…

AK: That is for me how I can relate to some of our heritage. But it does not interest me to use an African instrument in my music, just for the sake of using an African instrument to just say I am African, it doesn't make sense. Same way as to, my music also has a lot of rhythmic patterns, but the complexity of it is quite different to what one would understand from African music, and yet the complexity itself comes from exactly the interplay and interlocking processing that one associates with the panpipe music of the Venda people. There's quite a lot of techniques that one finds in my music that is not close to our own compositional techniques that finds in traditional music, and yet the music does not have to sound like the traditional music.

RvT: Have you had a look at or do you know of the Conference that was held in Istanbul, the Spectral music conference?

AK: No I was not aware of it, simply because I am not a musicologist…[laughs]…but I thought that was interesting. I remember when I was overseas and we were talking about spectralism, I said to my professor, you know this is not new to me, if you listen to Xhosa woman, they sing undertones, which is reverse spectral. I can't do it because I am not trained, but they do this, and someone recognised this when they were listening to women. We have the same concept here, but people have not written about it because they do not understand what it actually is. I find the paper was interesting in trying to show that some of the developments we talking about has already existed in the so called primitive cultures. In my interview with Fokkens, I said I am interested to know from him which influence is more important, because for me the idea of spectralism is very closely related to bow music, so if someone is inspired by mouth bow music and also at the same time has knowledge of spectral music where do you say there's a division between the two because actually there isn't, the only division being a technique, so the result and analysis is the same stuff. Those things for me are quite interesting to point out that some recent development in analysis is something that has already existed in traditional music, and in South Africa is something that has not been developed quite well, in a sense that when people talk about traditional music they always emphasise primitiveness and rhythm, it is there but it is not the only thing, these two kinds of music have a high level of complexity that a lot of people don't understand and hence they not able to engage with yet. And that is something that one can go further and engage with complexity that deep down really what is so interesting about this music and also what is important the cultural meaning and so on, so that is why I was saying for me to just take an instrument and use it, is not interesting for me.

RvT: Another interesting thing about spectralism, which I think sets it apart from just using sound analysis, is the knowledge of psychoacoustics, or the effect of perception.

AK: Absolutely…

RvT: …the Gestalt…

AK: …exactly…

RvT: …and how our brain makes sense of the many frequencies to hear one timbred tone…

AK: …exactly…

RvT: Do you work with those concepts in your composition? Do you think of how to work with listener and how to, not necessarily play different tricks on their mind, but to make it interesting by working with their perception?

AK: I would say that something that many people would not openly admit, to be a composer is to learn to manipulate the audience and how they should listen. In order to do that you should learn how one listens. Without that you cannot manipulate. That means you should know exactly how the sound is projected, and there are certain parts of the sound that should definitely be in the foreground. In earlier music that was easy because you had the melody and accompaniment so it was clear, it started to get complicated with polyphony, and fugues, where all voices are present and complex. Why did people perceive it as complex? It became complex because suddenly all voices were at the same level and the ear could not decide which one to follow, and that is why it is complex, and that is why some music of the 1950s did not work and people moved away from it so quickly, because it didn't create a clear sense of how they should listen. The condensing of music where everything was always on the same level, one dimensional, yet at the same time, a lot of things were coming. <u>That is what is important about the Gestalt: how you categorise your sounds, so that I as the listener don't have to be explained to what is the most important one. I can immediately hear, and follow how from that sound connects to everything else that is surrounding it. I can only do that if I have a hierarchy that structures sound. In the same way that hierarchy needs to exist in the structure of the whole piece otherwise there's no sense of directionality and if there is no sense I feel lost, and get irritated… because then I feel am I stupid to not know what is going on? You need to be able to clearly define for the listener how you are starting, what is important, how you are moving, and how you are getting there.</u> In the same way that if you are presenting a paper if it is not structured and not clear cut of the most important point, and the alignment, it is not clear and frustrating to the reader. Which is why I am saying that a composer has to learn to manipulate how people listen.

RvT: Do you also work with timbre, so if you have say an analysis of a wood block going "dadada" then you look at the timbre, and recreate it so that there is a connection to what is just heard and what follows.

AK: <u>In spectral music for example we talk sometimes about the visual instrument, which is the recreation through shadows and foreshadows of physical instruments that sometimes exist or don't exist, magnification or amplification of certain instruments through orchestration, or sometimes through different shaping of that and that creates different shadows of itself. Yes, I do create, and that is one of the things to create a connection, it is not the only way, but it is a technique to create a sense of connection.</u>

RvT: So it is perception, you creating something new, that would never have existed before…

AK: By the way it is not something new…

RvT: It is not entirely new…

AK: Yes, it is not entirely new, because if you analyse Ravel's Bolero, the idea of spectralism starts there, or Ravel's ideas…

RvT: Because what you have heard, slowly starts becoming more and more, because the first time you heard the melody, the overtones were present, but you just heard it as one instrument, now there's five instruments playing, maybe pitched on those instruments, and you are hearing a new timbre whole.

AK: It would be useful to look at that piece orchestral-wise. The idea is to create this big crescendo, which started from one instrument, into this big instrument at the end, because it is a succession. After 15mins you don't feel bored, so what is it that he does, for me have a feel that the music is going forward, but it isn't quite changing.

RvT: It is almost like it is going deeper…

AK: Exactly! That it is a point! It is almost as if you are putting a microscope from the beginning instrument, which is so small, the more you put the microscope the more complex it becomes, and so yes that is exactly the point. And of course that idea you find quite often in different works, in my works it is close to the idea of Gestalt right, because the Gestalt, you can't present it in a very similar way the whole time because otherwise it does not remain interesting. You have to present different perspectives of the very same gesture in different formats all the time, so how do you do that, it is not theme and variation, it is absolutely different. So how does one work with these things and develop it.

RvT: So I think I am going to focus a lot on your music for my research, if that is okay with you.

AK: Sure.

RvT: I will also focus on Rob Fokkens music as well. But I am not going to be too worried about formulating a South African approach. I have read a lot of articles on spectralism, and so I feel like I can learn a lot from your music. Would I be able to look at your scores?

AK: That is a down side of music, because people never have enough time to practice to give you a performance you are proud of and that you can distribute. I have two scores, *Cry Out* and the Quartet, which I feel were brilliant performances, some of the few I am proud of. One could do that.

When I did my undergraduate, I composed a piece based on *ughubu* and bow music, it contained the basic elements of what bow music is. That was one of my very first piece. Chris van Rhyn, wrote his dissertation on that piece, and the African interpretation of song, and the writing of a song. Another guy, from the States, did a dissertation on *Cry Out*. Fokkens has released a CD of his works, you should have a look at it. And of course I would give you the scores, that is no problem.

RvT: Thank you so much for that, I appreciate your time.

AK: No problem.

RvT: Since I sent you the email I have been thinking about more things… we spoke about the psychoacoustic aspect now, and I mentioned Cornelia Fales and her research into the Barundian music in the email. I don't know if it is one hundred percent important to include the ethnomusicological influence in music, it is an interesting thing, although I am not sure if it is necessary to zoom on it entirely and single out everyone who's done that, and conclude that they are the ones that form a South African approach because they connect to traditional music.

AK: Like I said in the panel, I mean, it could be interesting to hear, how do you think that music actually, mimics aspects to that side of ethnomusicology, I wouldn't have an answer right now. It adds a part to your research, how do you contextualize this music. and the complex should be broader, it should, because Robert and myself we don't only exist in the context of South Africa, we have a global presence. That is for me the most importance existence.

RvT: And you are two of few composers who are fully aware of spectralism, which means it has not touched South African soil properly.

AK: No, I don't think so and people don't understand. The second thing, that one needs to talk about is the difficulty of performance of this music. In South Africa, most people have difficulty performing new music, music just using 12 pitches of the chromatic scale. Spectralism involves much smaller sub-division of the octaves, which is called micro tonality, you can go so small as an eighth of a semitone, the smaller sub-divisions the more you get closer to the frequency. The semitone is an average of the frequency, and the closer you get to the real frequencies and you put those together, that is when we start to hear the sound as a colour…

RvT: And it is how those frequencies evolve…

AK: Yes, and that comes with the difficulty of execution. So if it is not performed properly…

RvT: Then it doesn't have the effect…

AK: Then it doesn't have the effect it sounds clumsy and bad, and it should rather not be performed…

RvT: [laughs]

AK: Yes, no seriously, I prefer to not have it performed. For example, last week, or two weeks ago, I had a concert in Stellenbosch, and it was so badly performed that I cancelled the upcoming concert in Johannesburg. It doesn't do you any good to have a bad performance. So how does one then effectively increase the possibility of performance taking into consideration the lack of training given to performances, or ability to perform micro tonality. And that is why of you listen to Tristan Murail's music, you will hear a lot of use of electronics in relation to acoustic instruments. The electronics are there to compliment the live instruments in order to really provide what the live instruments cannot do easily. And that is what the difficulty and the challenge is when you dealing with the music that involves not only micro tonality in terms of just microtones, but micro tonality in relation to the sound. Also a problem in dealing with the sound, the intonation needs to be sensitive to what the sound should sound like, rather than just playing the pitch. Again, like I said earlier on, the sound does not only involve pitch, but how I attack it, the way I project it, dynamics, and also sometimes how I position the instrument in order to produce a certain effect.

RvT: That is very interesting.

AK: And that is one of the difficulties problem that we will be dealing with for a few years before we can be in a position to not only talk about spectralism, but also hear it in an effective and true sense and honest way.

Interview with composer Andile Khumalo held over Skype on the 11th of March 2016

AK: Last week was a big conference, the international bow conference in Durban. It went very well and will result in a very creative exercise for South Africa.

RvT: Was this for bow music composition? What did you present in your paper?

AK: I presented a new approach of how one can possibly also approach bow music in terms of spectralism. How can one use those ideas to develop new works that are partially inspired by bow music?

RvT: That sounds interesting.

AK: I can forward it to you. My paper will be published by the middle of this year.

RvT: I am focusing on *Bells Die Out* and I want to work through three points: biographical info, the context of *Bells Die Out* and spectral writing and where spectralism came in, and then zoom into the work on *Bells Die out* the use of spectralism and multiphonics. When did you start studying in Durban? What years were you at school? When did you start composition with Jürgen Bräuninger, and when did you go over to Germany to Stuttgart? When did you go to Columbia?

AK: I started at UND (then formally known as the University of Natal) in 1998 and finished in 2001. I went directly to Germany, first as an exchange for a year, and then I started studying my Master's which was in 2003 up to April 2007. I then started my PhD in New York in September 2007 and defended in 2013 to complete the degree.

RvT: I just want to clear something up about your time at Columbia. On the Wits University website, it says that you studied under Prof. George Lewis, but I have also read that you studied under the guidance of Tristan Murail and Fabien Lévy.

AK: What happened is I had a concert in 2006 in Berlin and at that concert Fabien Lévy was in the audience and he liked my music and invited me to come and study in Columbia.

RvT: Which piece was performed?

AK: *Brüc(h)ke for flute, clarinet, cello and piano*. That was performed by the Ensemble Mosaic. Another connection is that Fabien Lévy also studied under Marco Stroppa. I went to Columbia through the invitation to apply. I heard that Tristan Murail was there and was accepted. It is difficult to get in because usually there are about a thousand applicants and people apply to different institutions and I just applied for the one because it was an invitation. Then I went there and studied with both Fabien Lévy and Tristan Murail and Fabien left because he got a job in Germany and so I continued with Tristan Murail who then retired in 2010 or 2011. Then I started working with George Lewis. The two people who were in the defence of my PhD was Fred Lerdahl, an important theorist in America and talks about the idea of Gestalt which is an aspect that is important in my music in terms of organizing sound with the structure of a hierarchy. He writes about music cognition of how we hear sound in relation to what we have heard before. Another person who was important in my defence is George Frederick Haas, who replaced Tristan Murail in Columbia. The piece which my dissertation is based on, Beat Furrer's FAMA, was composed at the same time when Frederick Haas was in Austria working at the same institution. Haas wrote another piece reflecting on the same principles brought up in my dissertation. Frederick Haas is also an important spectral composer.

RvT: When was the first time you used spectral analysis in your compositions? With which piece specifically?

AK: I really can't remember…

RvT: When you were in Germany? Or in South Africa?

AK: It would have been while I was in Germany. I properly started to focus on spectralism when I started working with Tristan Murail. But the ideas of spectralism I was introduced to by Marco Stroppa. What I learnt the most from Marco Stroppa was the idea of using sound as a resource for composition: the 'sound space'. If you look at *Bells Die Out*, you have different moments coming back and each time it comes back it is in a different state, and the context it comes in is actually different. This refines the way in which we perceive it. The opening five bars of *Bells Die Out* is actually what the whole piece is based on but it is always presented in different versions. The idea is if you look at a sculptor: an important person, Markus Reitz, a Swiss sculptor, and the same sculpture and through the change of position you view it from, you perceive a different idea and different meaning of the same sculpture that itself doesn't change. And that is the same idea of space, if you are in a place at particular point in the space you hear the sound differently than at a different point. All these things are connected to how the partials of a sound source are distributed. This is where spectralism for me and the idea of Gestalt actually combines.

RvT: That is exactly what I was thinking.

AK: This is something that I learnt from Marco Stroppa.

RvT: So spectral thinking started with your pieces composed while in Germany. *Cry Out* and *Shades of Words* are more recent pieces that also present spectral writing and use of Gestalt. When did you start to think of concepts such as inhalation and exhalation?

AK: There is a piece for guitar and electronic, ...*Trotz allem nichts*..... is the first piece where I consciously worked with the ideas of inhalation and exhalation. The idea of spectralism already in *Iso(r)* where the resonances were filtered out of the piano's sound were distributed towards the cello and piano. At that stage it was not very precise because I did not use technology and was working with the ear. But the ideas had already started in that piece.

RvT: When did you start using technology and what software have you used?

AK: I started using software with Marco Stroppa and learnt OpenMusic and AudioSculpt. CSound was for me too technical to understand. I also started a bit with MaxMSP.

RvT: What did you do with MaxMSP?

AK: You would normally use it for live electronics, I didn't use it that much because I never quite used electronics at all in Stuttgart. I don't use it but know it. In New York I used Logic Pro, Pro Tools and SPEAR. I use SPEAR, OpenMusic and AudioSculpt. SPEAR and AudioSculpt have similar functions.

RvT: Which software did you use for *Bells Die Out?*

AK: I used the three of them, AudioSculpt, OpenMusic and SPEAR. There were some moments where I just wanted to see the durations of the sounds and manipulate them visually with SPEAR.

RvT: Which sounds did you analyse? Many different or one type of sound?

AK: It was one type of sound but I really can't remember which sound it was. I started writing the piece in 2012. Through different filters I was dealing with the same sound.

RvT: I processed the recording of *Bells Die Out* through SPEAR and this moment where the oboe multiphonic (bar 112 to 116) is orchestrated in the strings. You must have spectrally analysed the sound of the oboe multiphonic?

AK: Yes.

RvT: Was this the main sound source for the composition?

AK: I don't remember…

RvT: The problem with multiphonics is that the notation will always be interpreted differently by the performer.

AK: Absolutely.

RvT: Did you work with the Wet Ink Ensemble to make sure that what they going to play will be the multiphonics that you were looking for specifically?

AK: Yes, we had a week of rehearsals, and they are a very good ensemble, by the time I got to New York they were already practicing it. The work we did was to refine very specific sounds. The multiphonic took a couple of different tries before I got the ones I need. The musicians were great, they realised before I arrived that the sound of the ensemble matched the multiphonics. The player tried to get a multiphonic close to that produced by the ensemble. You are right, the ensemble is a magnification of the multiphonics.

RvT: Before you got to the ensemble how did you analyse the sound sample of the multiphonics. Did you work with a sound sample from the internet? How did you spectrally analyse before writing out the notes?

AK: There are two ways in which I work. I have a sound database with different multiphonics of all the woodwinds. From that I took a sound, that is the easiest for me with a clean recording.

RvT: Which other sounds did you analyse in *Bells Die Out?*

AK: Like I said I don't remember, it was a long time ago.

RvT: Did you work with SPEAR in a temporary way, analysing and then deleting the sketches?

AK: Yes.

RvT: I worked the same way at times. Do you remember any ideas from spectral analysis? Finding a microscopic thing and bringing that to the macro? For example, an ascending partial that you then use as the ascending gesture throughout the score?

AK: It's very difficult to remember. The idea I remember was to orchestrate the 'sound', so not just the frequencies as pitches, but the different things that are in the sound itself. Like the exhalation in the middle part, (makes whistling sounds), these are the sounds you perceive if you were to zoom into a flute sound before the sound is produced (attack portion). These are the very high partials that are produced in the sound itself before it fully appears. Those things were orchestrated as part of the whole sound. But I really can't remember what sound it was. That also brings me to the next point you asked, I remember when I was with Tristan Murail talking about the idea of spectralism versus sound, what he told me is that we can analyse the sound as much as we want but at the end of the day what matters the most is your ear. So sometimes he would sit at the piano with all of his analyses and would play through them all and some of the chords he would define as the colour that he feels defines them. And then he manipulates or shifts them from the original spectrum. So there are moments where the sound is based on my ear, but the formation of the sound is based on the analysis of the spectrum.

RvT: I completely understand. That is exactly what I looking for.

AK: (reads a question from Roché) I totally agree with you on the idea of *Gestalt trigger* and *musical moments* are absolutely a part of the piece as well.

RvT: I mention looping and continuous development through looping.

AK: The idea of looping was also in *Iso(r)* first performed in Stellenbosch. The idea of looping is an integral part of this work. By the way it is not necessarily loop, but the idea of…

RvT: Repetition?

AK: No not repetition, it is the same object with a different perception the second time you hear it. It is the idea of perception. These ideas evolved through different pieces and that looping already started as early as 2004.

Appendix B - Score (Bells Die Out (2013)) - Khumalo

Andile Khumalo

Bells die out

For ensemble

[2013]

Instrumentation

Flute [piccolo]
Oboe
Clarinet

Horn
Trumpet [with straight and harmony mute]
Trombone [with straight mute]

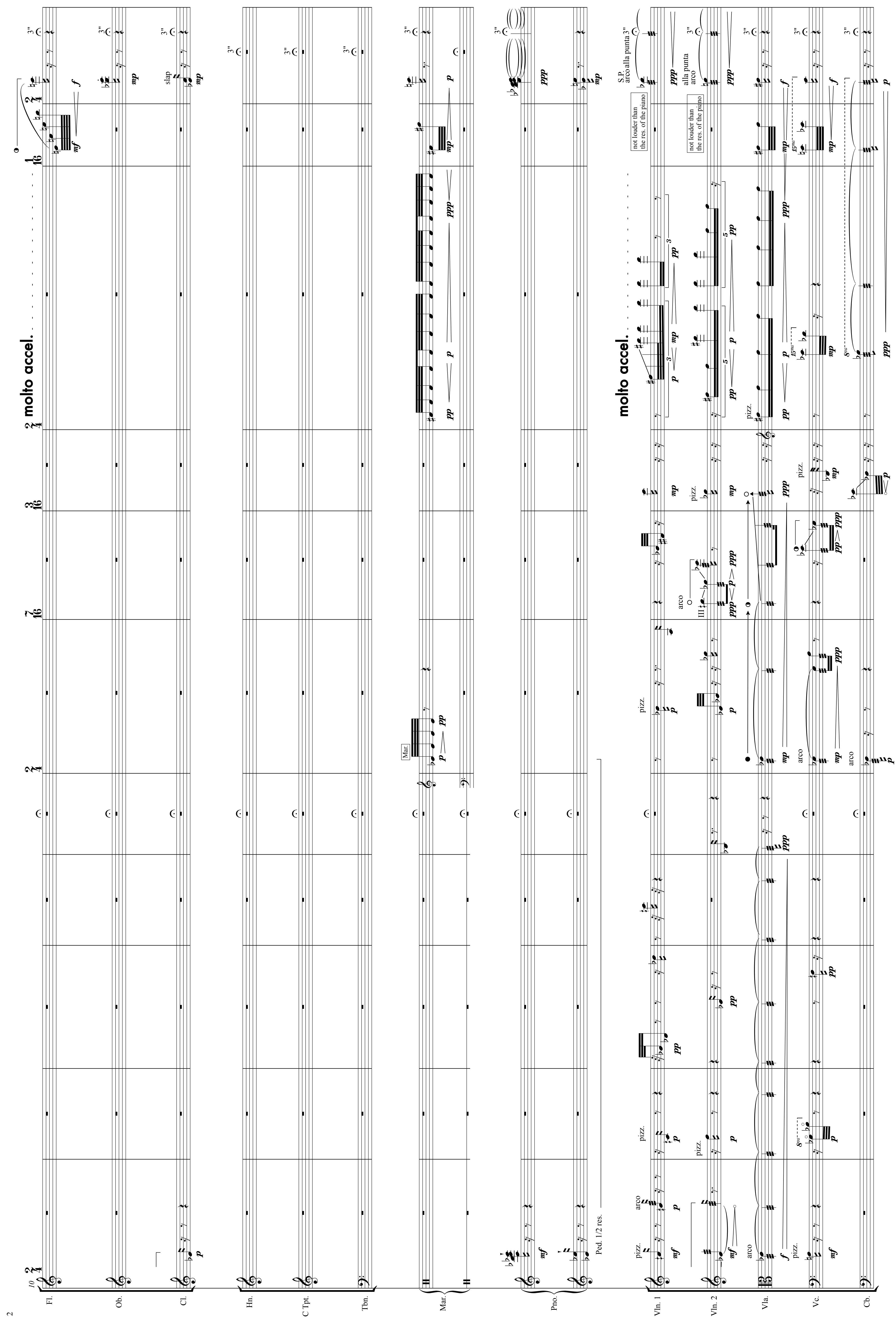
Percussion
- Marimba
- Wood blocks [5 different sizes from high to low]
- Tam-tam
- Bass drum
- Guiro

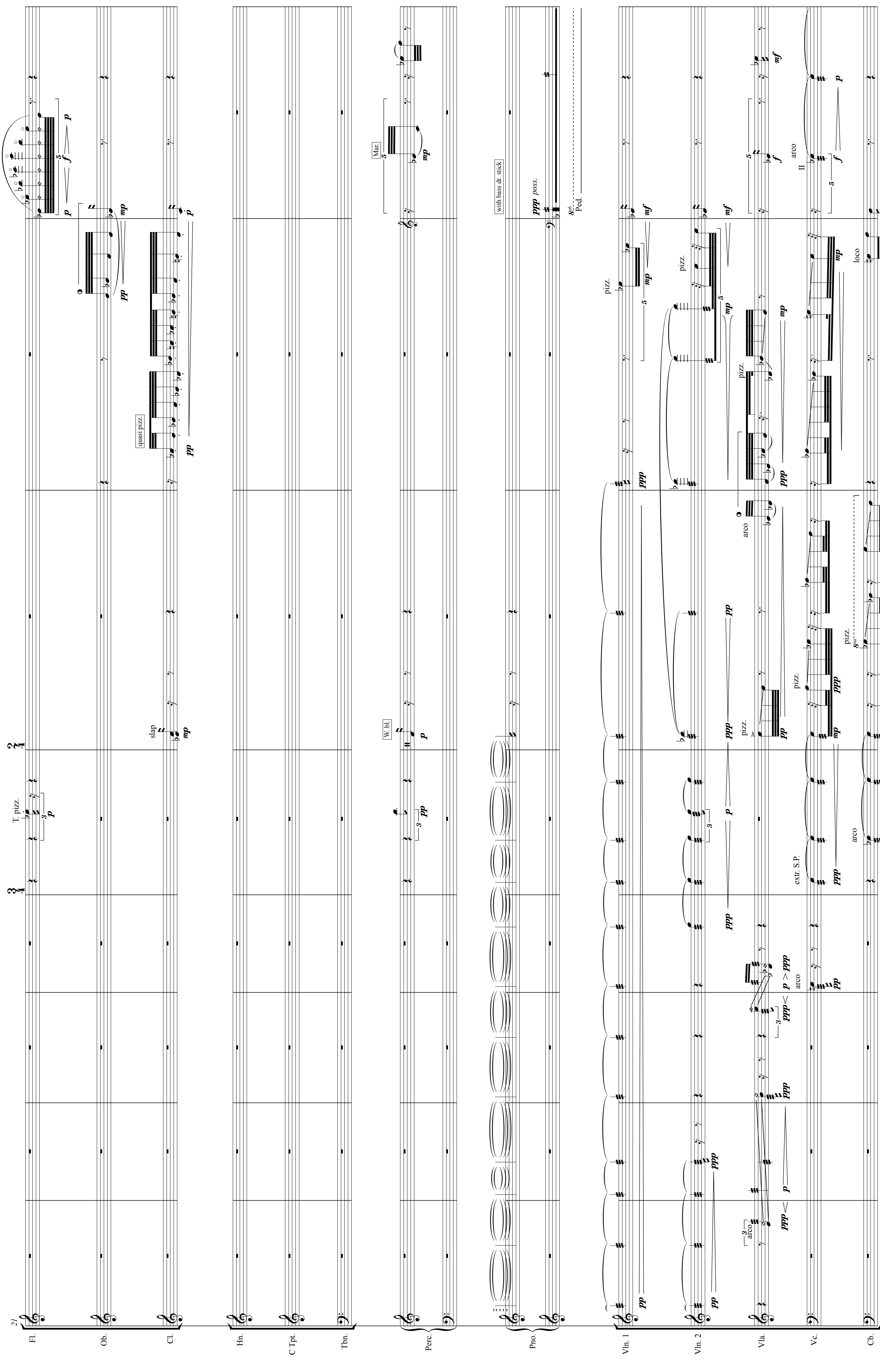
Piano [with bass drum stick]

2 Violins
Viola
Cello
Contrabass

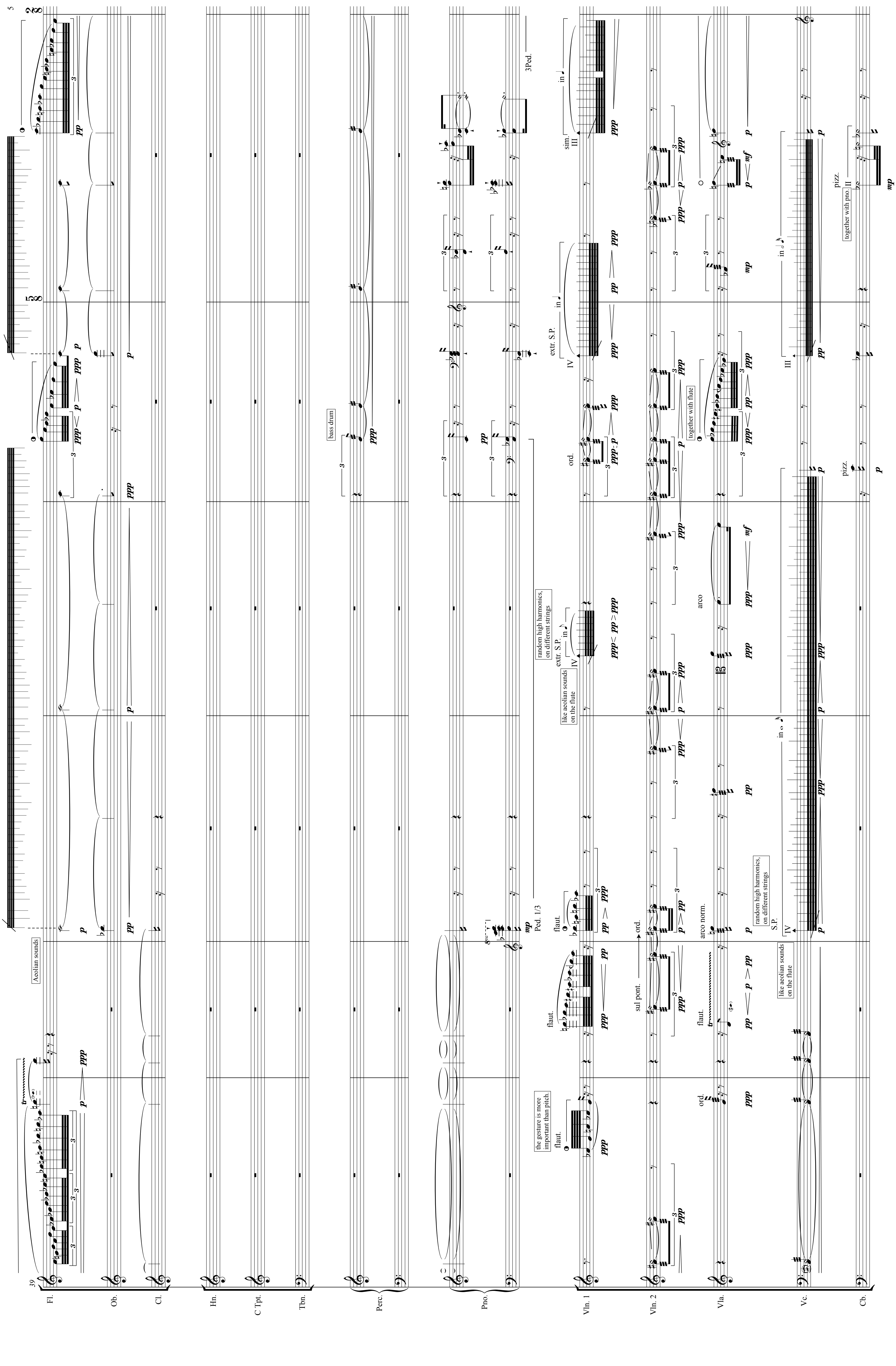
Bells die out

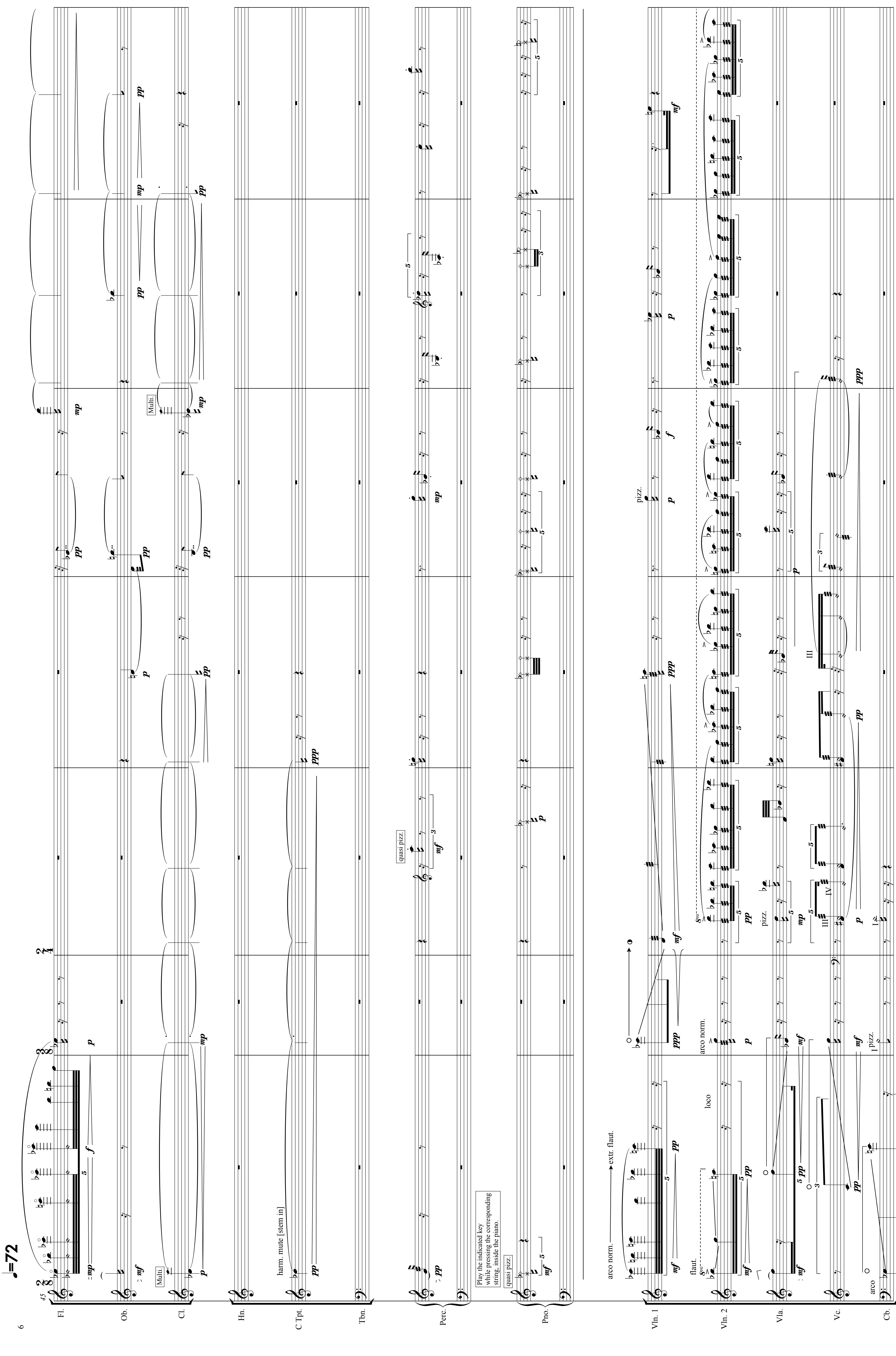
Andile Khumalo

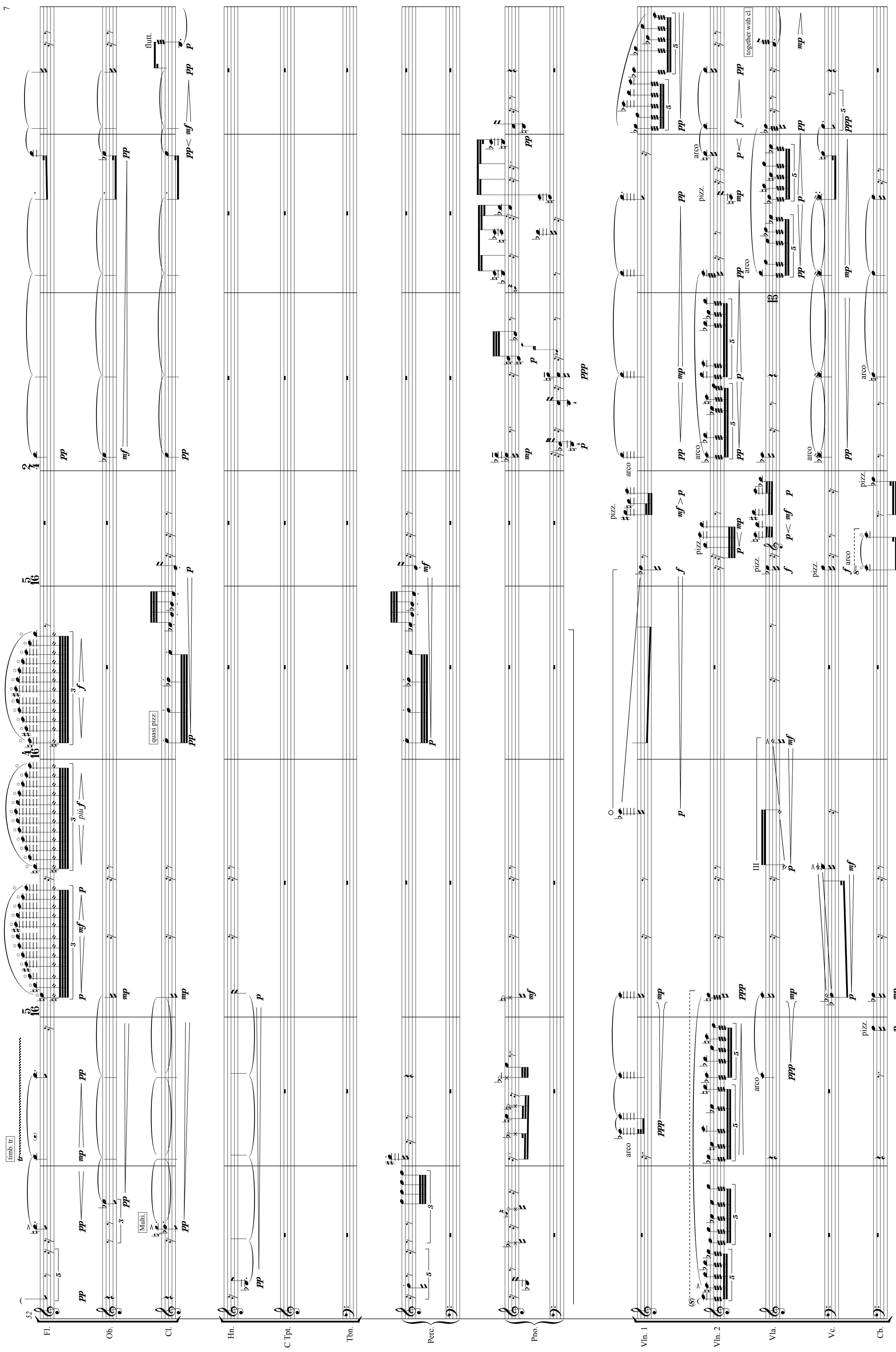

2
molto accel.
Fl.
Ob.
Cl.
slap
Hn.
C Tpt.
Tbn.
Mar.
Pno.
Ped. 1/2 res.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.
pizz.
arco
III
not louder than the res. of the piano
S.P. arco alla punta 3"
alla punta arco

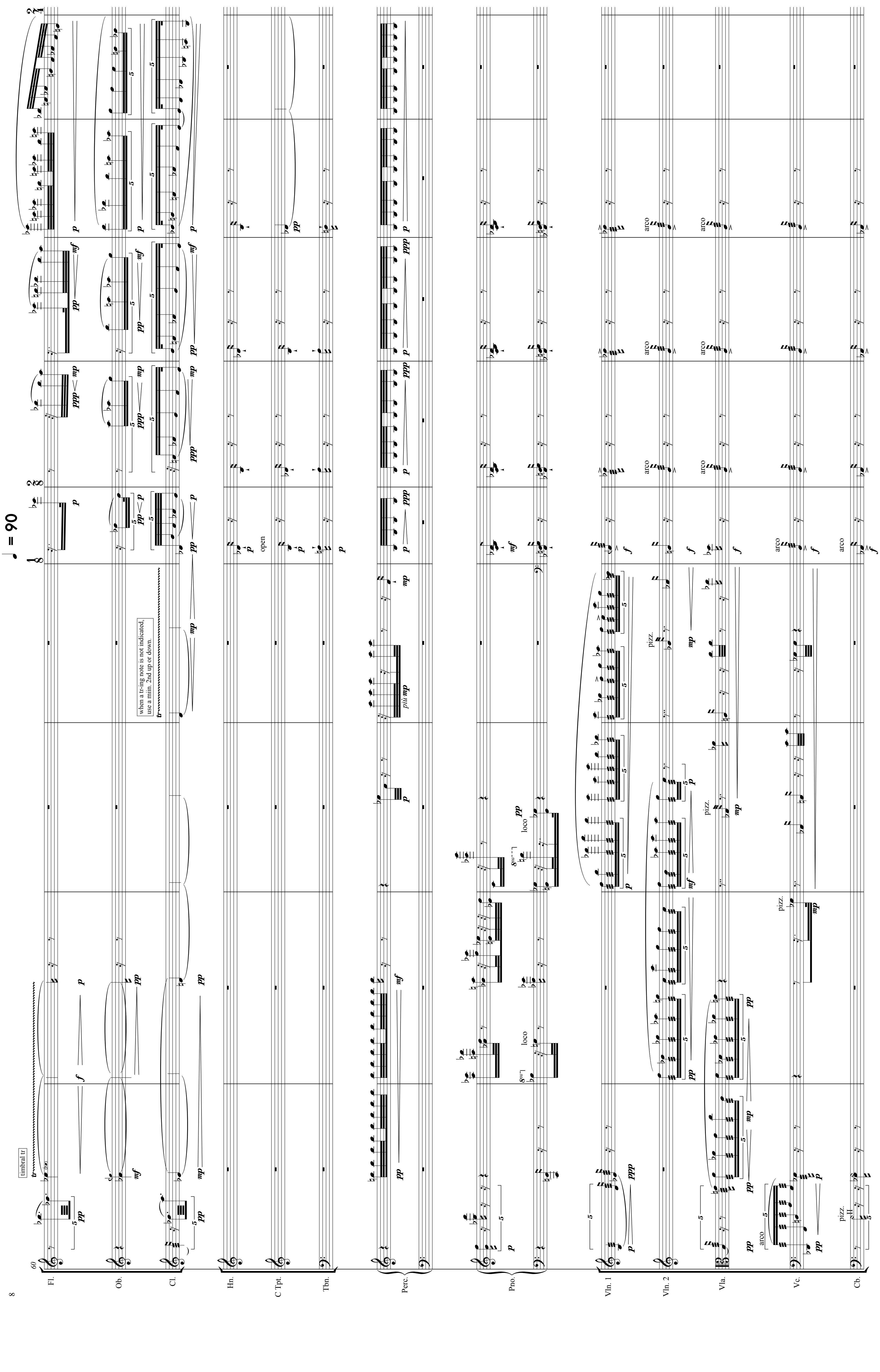

Fl.
Ob.
Cl.
Hn.
C Tpt.
Tbn.
Perc.
Pno.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.
T. pizz.
slap
quasi pizz.
W. bl.
Mar.
with bass dr. stick
poss.
Ped.
pizz.
arco
extr. S.P.
loco


29
Fl.
Ob.
Cl.
Hn.
C Tpt.
Tbn.
Perc.
Pno.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.
♩ = 81
♩ = 45
Multi.
quasi pizz.
air sounds
not louder than pno.
arco
pizz.
flaut.
arco norm.
sim.
extr. S.P.
sul pont.
loco
ord.
blend with the pno.
together with piano

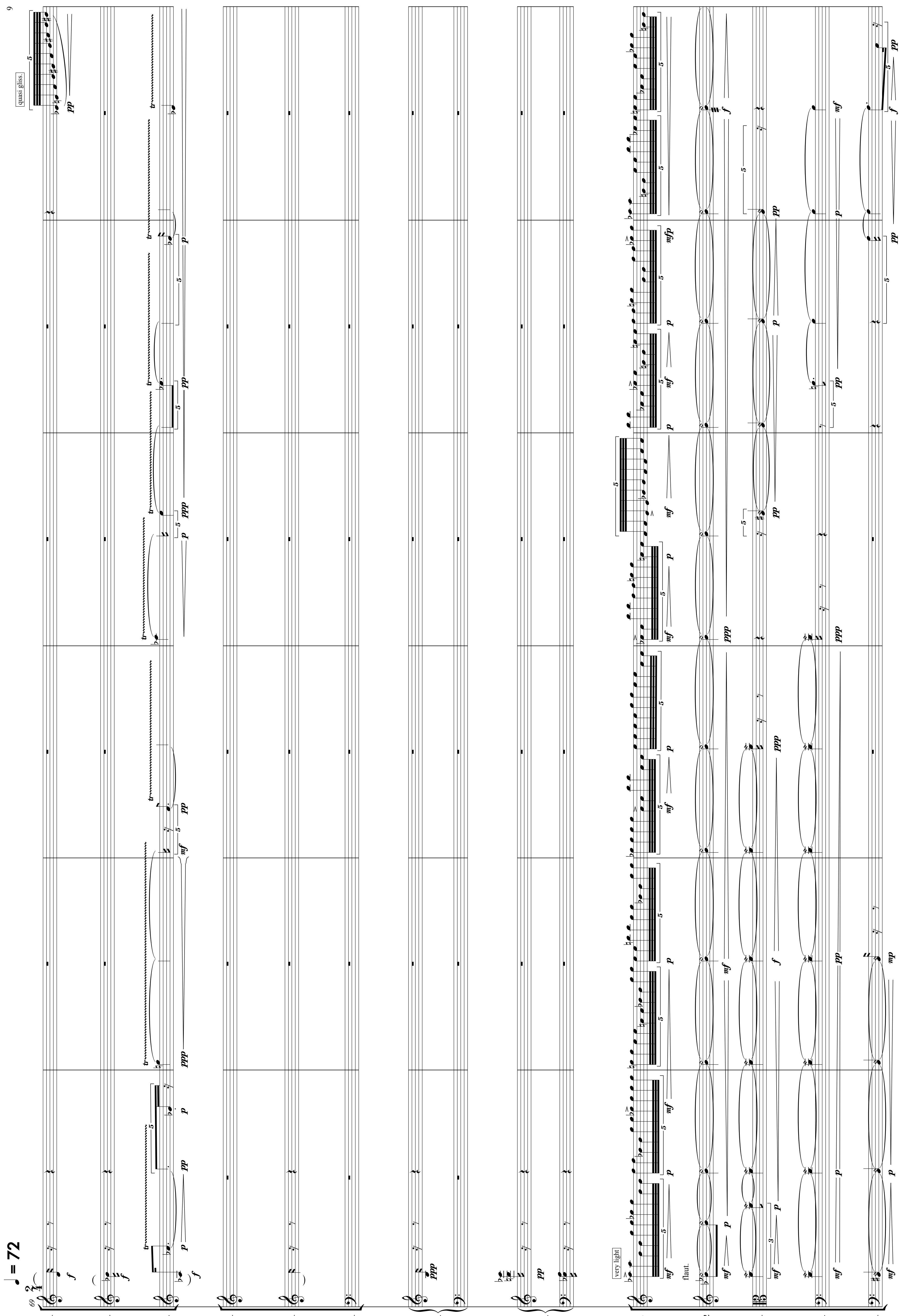

♩ = 60
Fl.
Ob.
Cl.
Hn.
C Tpt.
Tbn.
Perc.
Pno.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.
Aeolian sounds
bass drum
the gesture is more important than pitch.
flaut.
sul pont.
ord.
arco norm.
like aeolian sounds on the flute
random high harmonics, on different strings
S.P.
extr. S.P.
together with flute
arco
pizz.
together with pno.
sim.
Ped. 1/3
3Ped.

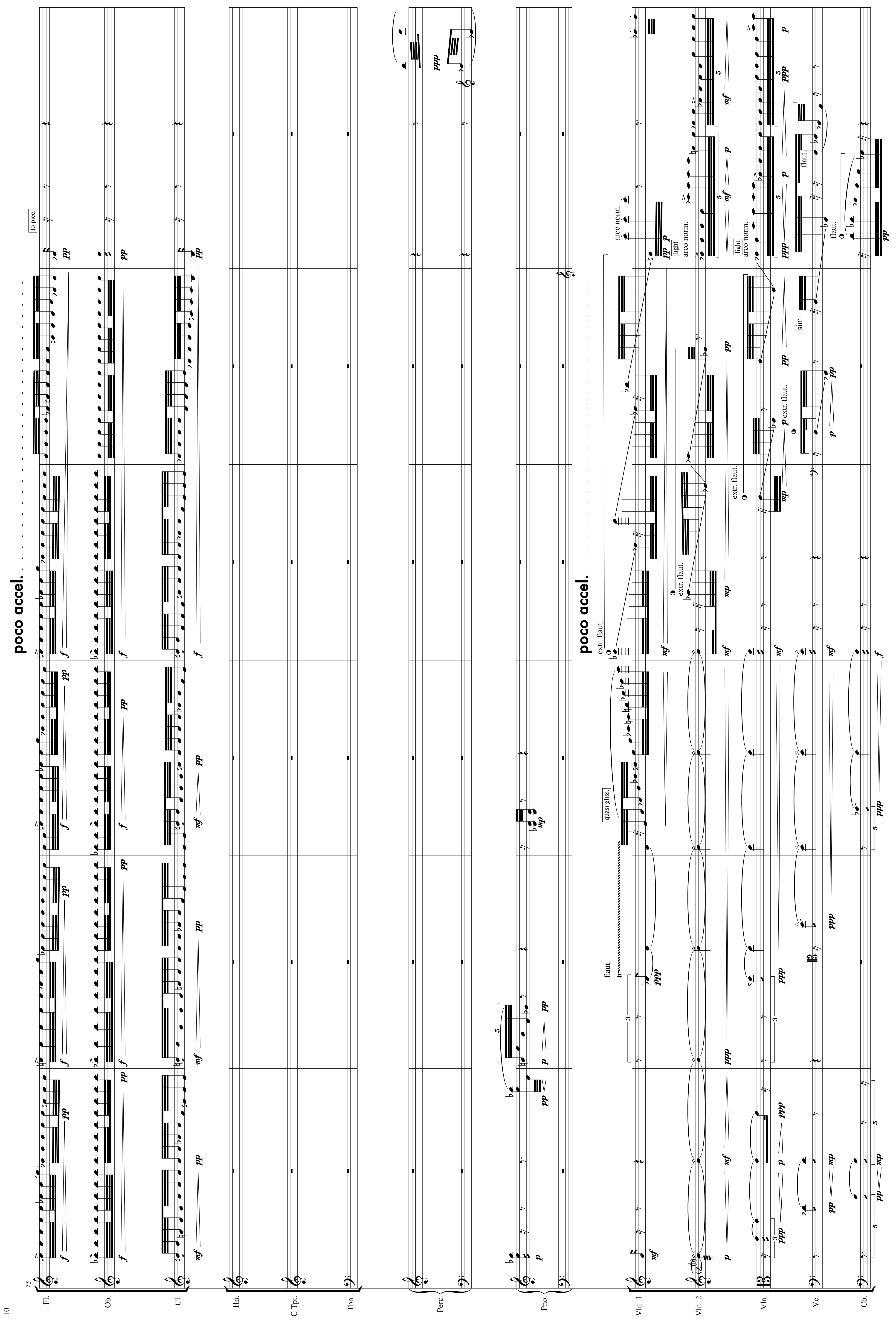

6
♩=72
Fl.
Ob.
Cl.
Multi.
Hn.
C Tpt.
harm. mute [stem in]
Tbn.
Perc.
quasi pizz.
Play the indicated key
while pressing the corresponding
string, inside the piano.
Pno.
Vln. 1
arco norm.
extr. flaut.
pizz.
Vln. 2
flaut.
loco
arco norm.
Vla.
pizz.
Vc.
Cb.
arco
pizz.

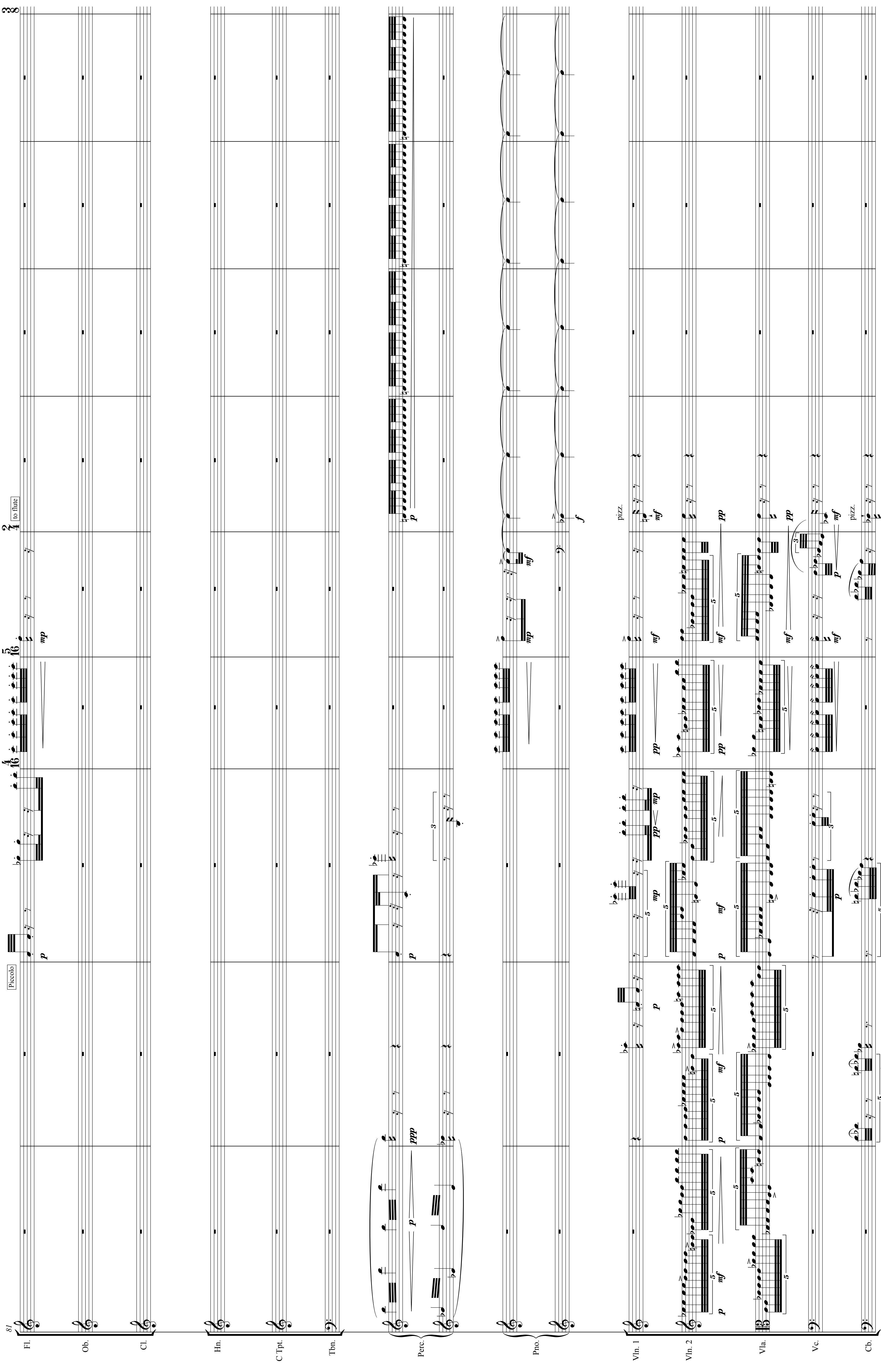

7
52
Fl.
Ob.
Cl.
Hn.
C Tpt.
Tbn.
Perc.
Pno.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.
timb. tr.
Multi.
quasi pizz.
flutt.
together with cl.
pizz.
arco



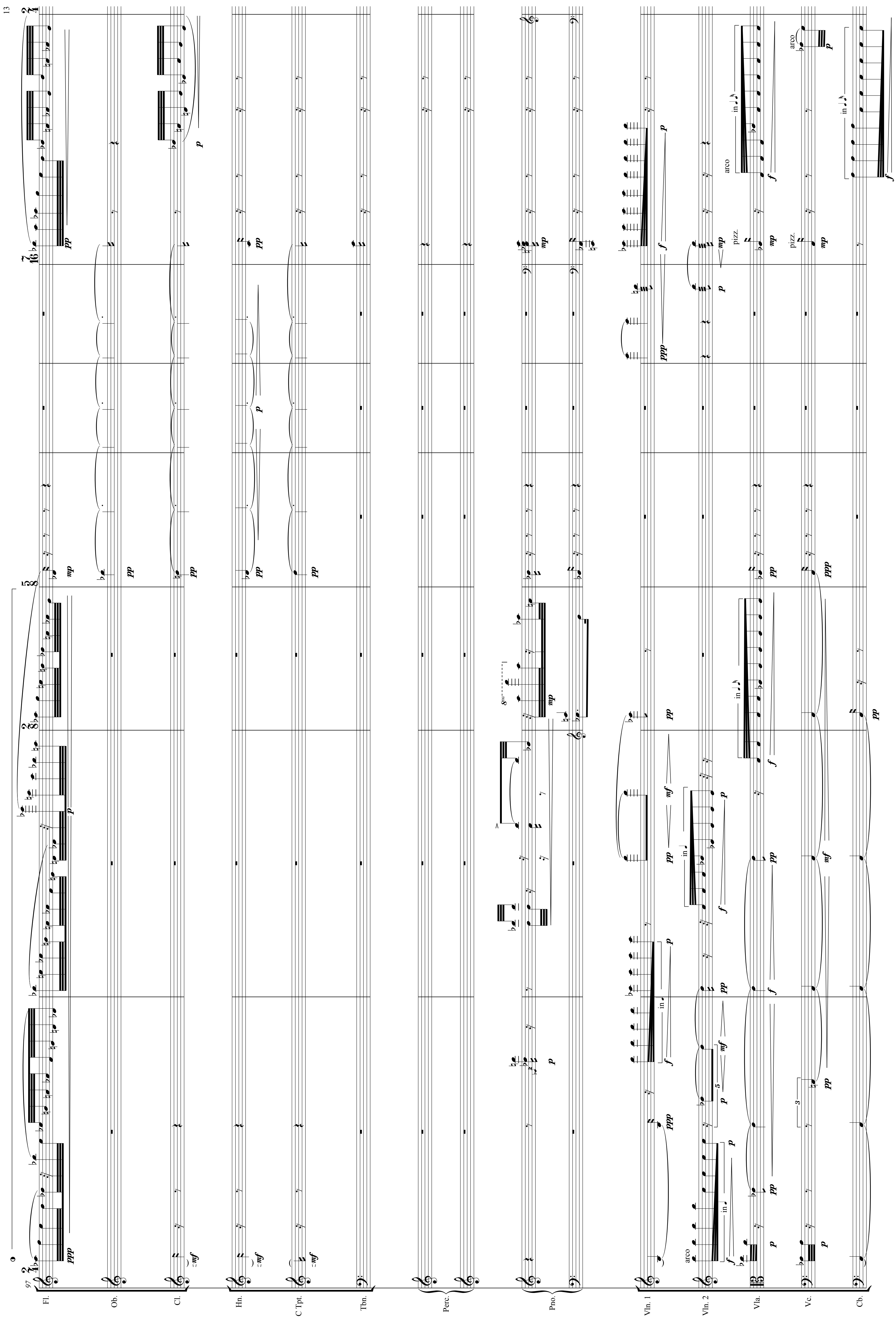
♩ = 90
timbral tr
when a tr-ing note is not indicated, use a min. 2nd up or down.
open
loco
arco
pizz.
Fl.
Ob.
Cl.
Hn.
C Tpt.
Tbn.
Perc.
Pno.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.


♩ = 72
69
quasi gliss.
very light
flaut.
Fl.
Ob.
Cl.
Hn.
C Tpt.
Tbn.
Perc.
Pno.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.

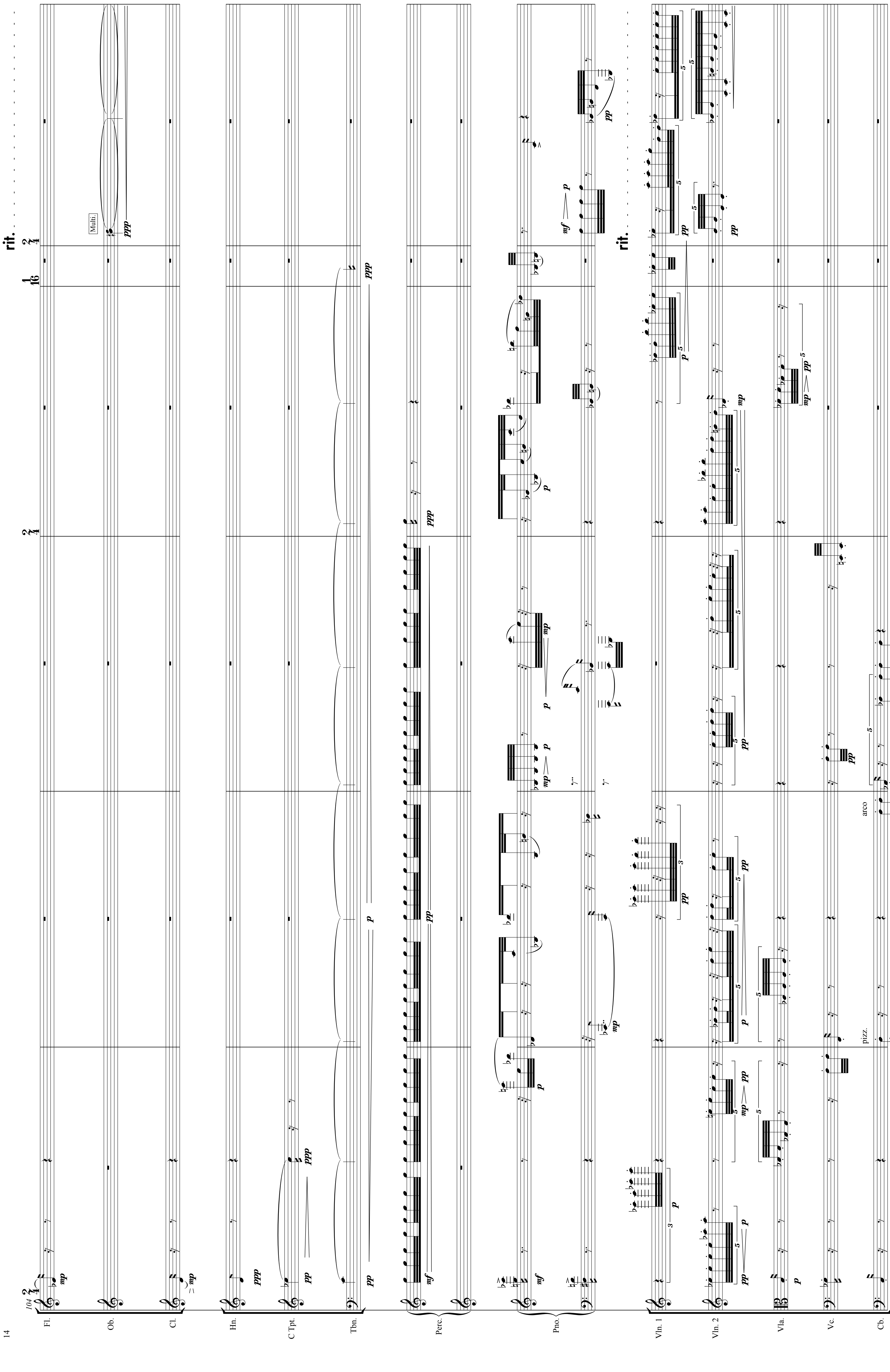

10
75
Fl.
Ob.
Cl.
Hn.
C Tpt.
Tbn.
Perc.
Pno.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.
poco accel.
to picc.
poco accel.
flaut.
quasi gliss.
extr. flaut.
arco norm.
light
sim.

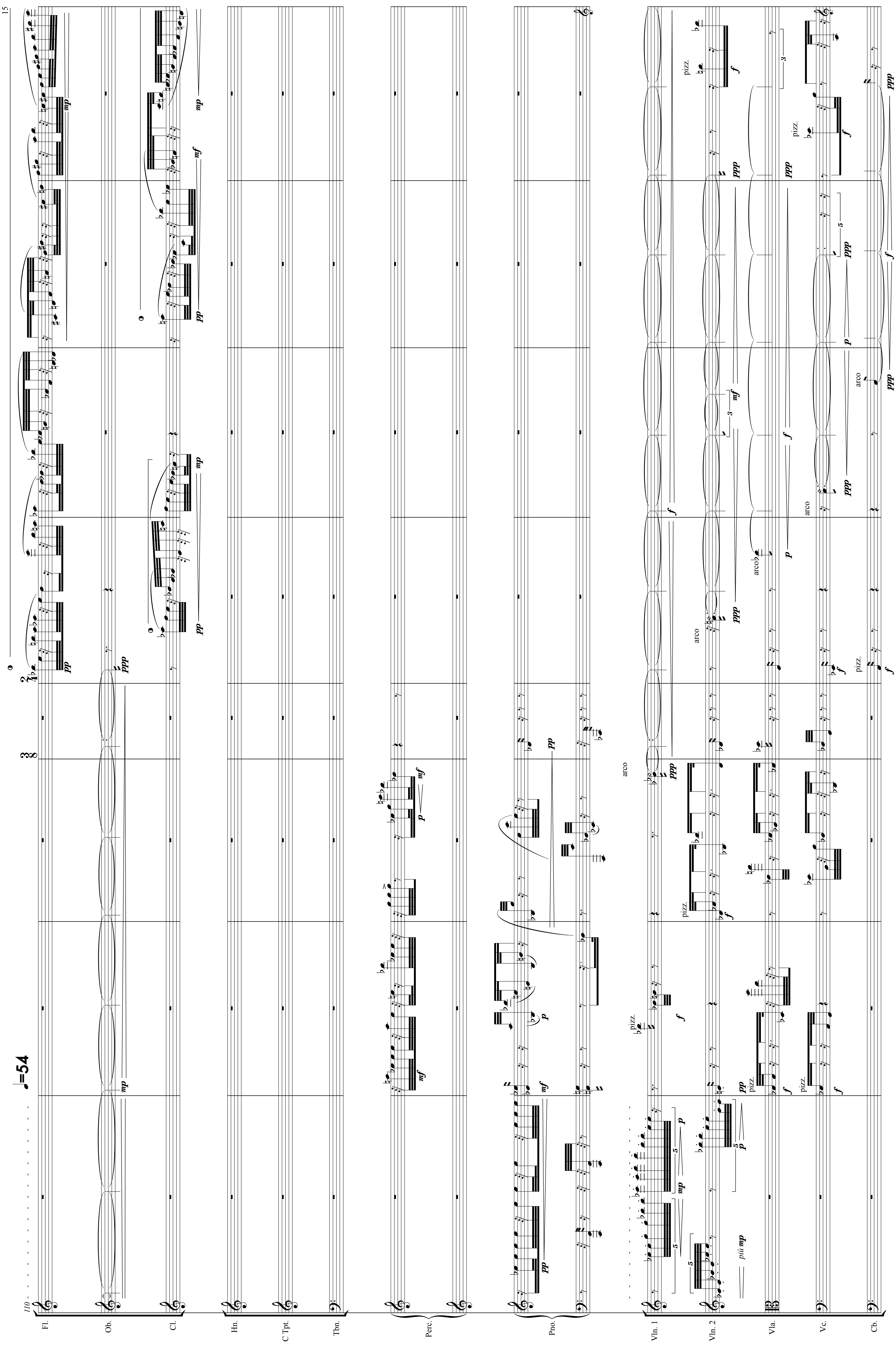

11
81
Fl.
Ob.
Cl.
Hn.
C Tpt.
Tbn.
Perc.
Pno.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.
Piccolo
to flute
pizz.
pizz.

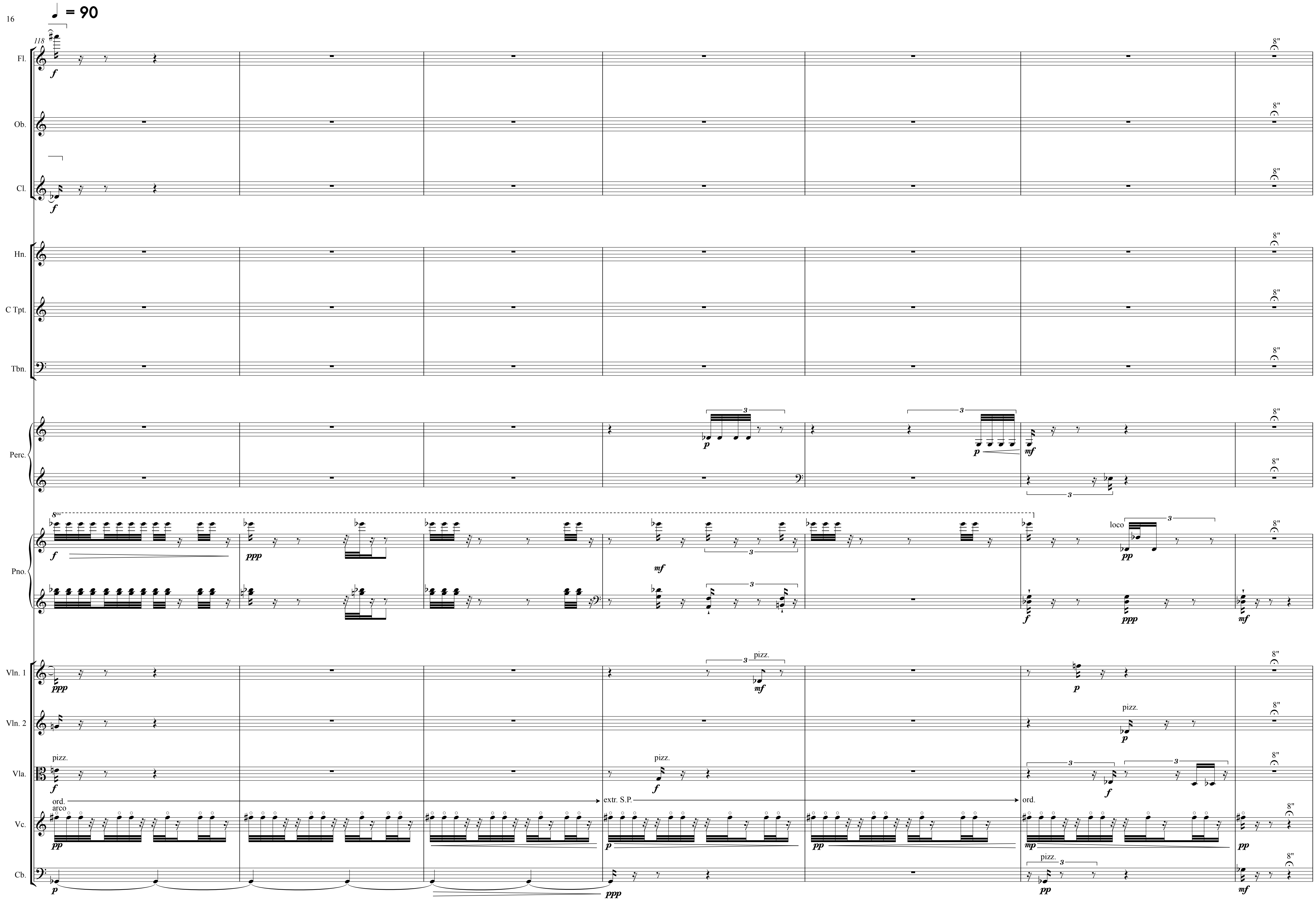

flute
Fl.
Ob.
Cl.
Hn.
C Tpt.
Tbn.
Perc.
Pno.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.
harm. mute
u.c.
pizz.
arco
con legno
extr. S.P.
in
together with viola

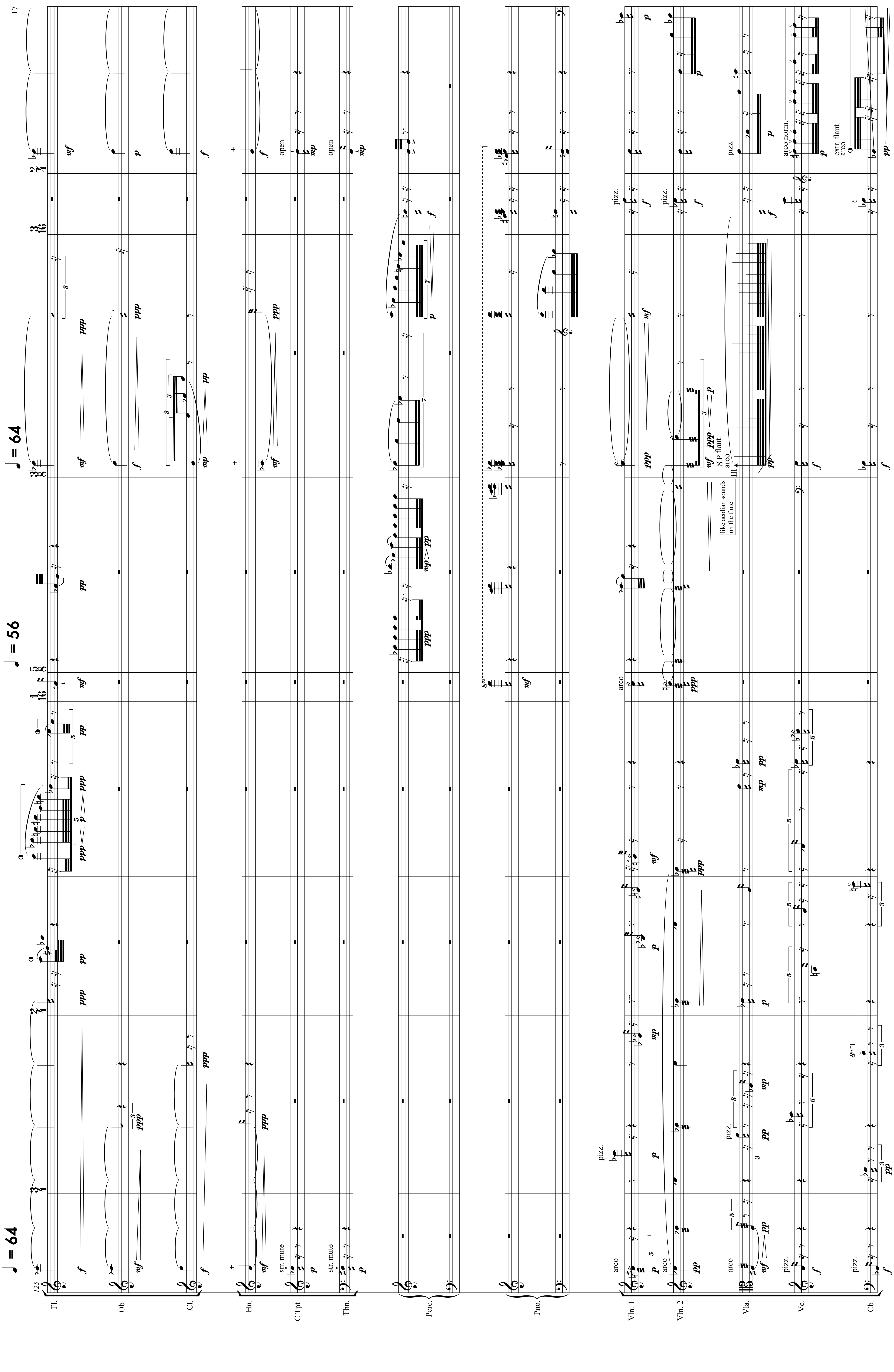

13
97
Fl.
Ob.
Cl.
Hn.
C Tpt.
Tbn.
Perc.
Pno.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.
arco
pizz.

14

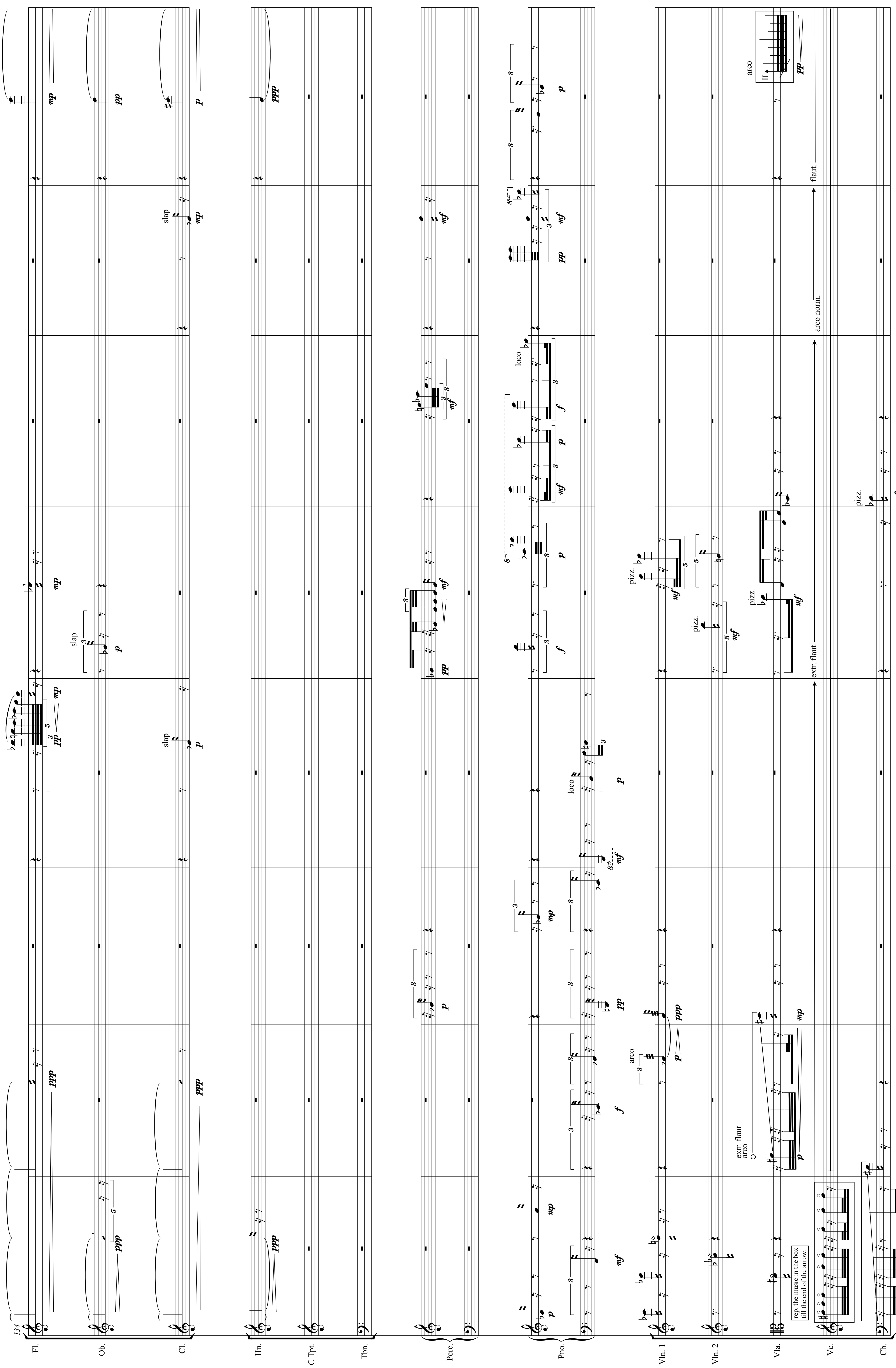

104
rit.
Multi.
pizz.
arco
Fl.
Ob.
Cl.
Hn.
C Tpt.
Tbn.
Perc.
Pno.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.

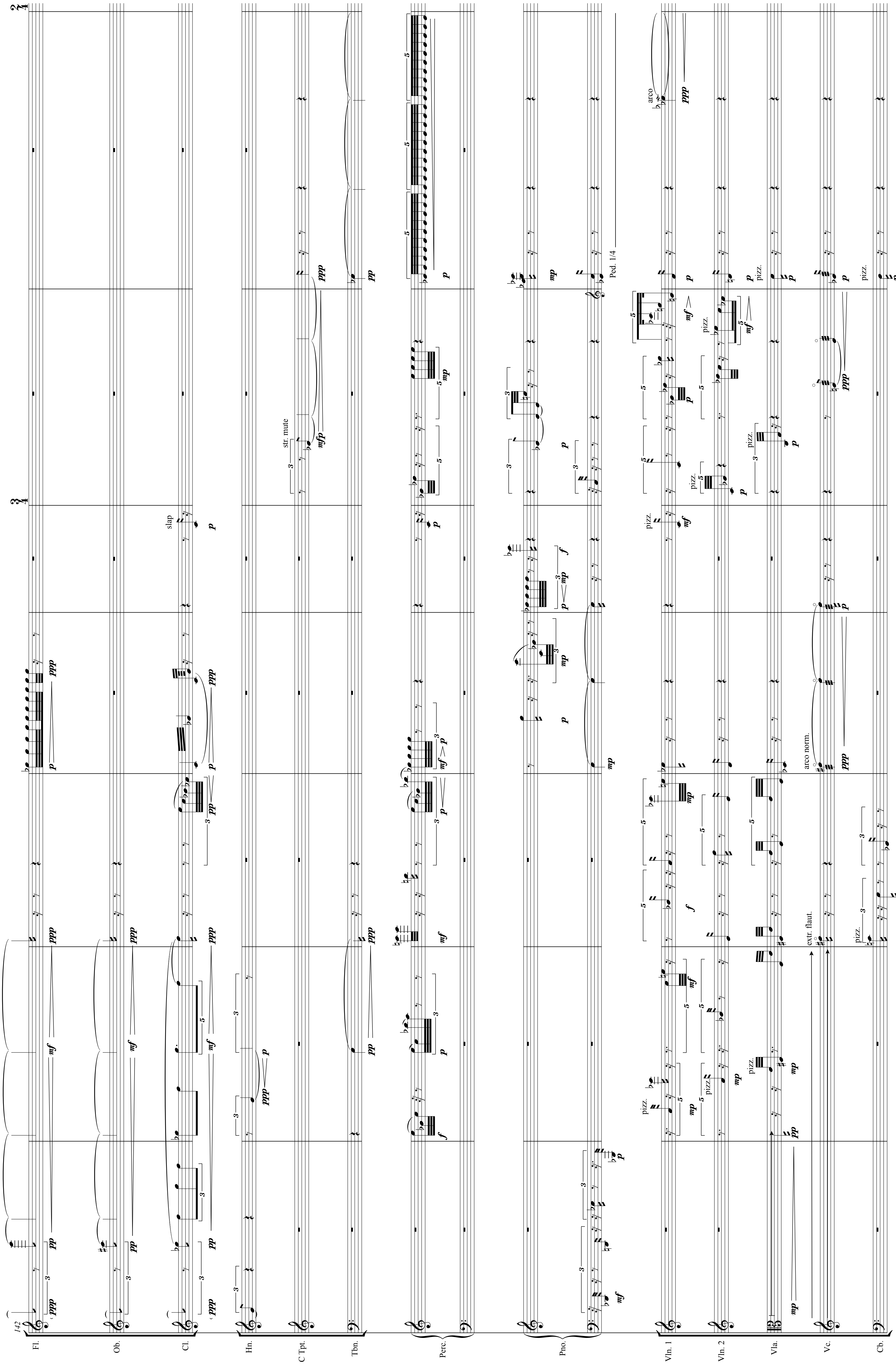

15
♩=54
110
Fl.
Ob.
Cl.
Hn.
C Tpt.
Tbn.
Perc.
Pno.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.
pizz.
arco

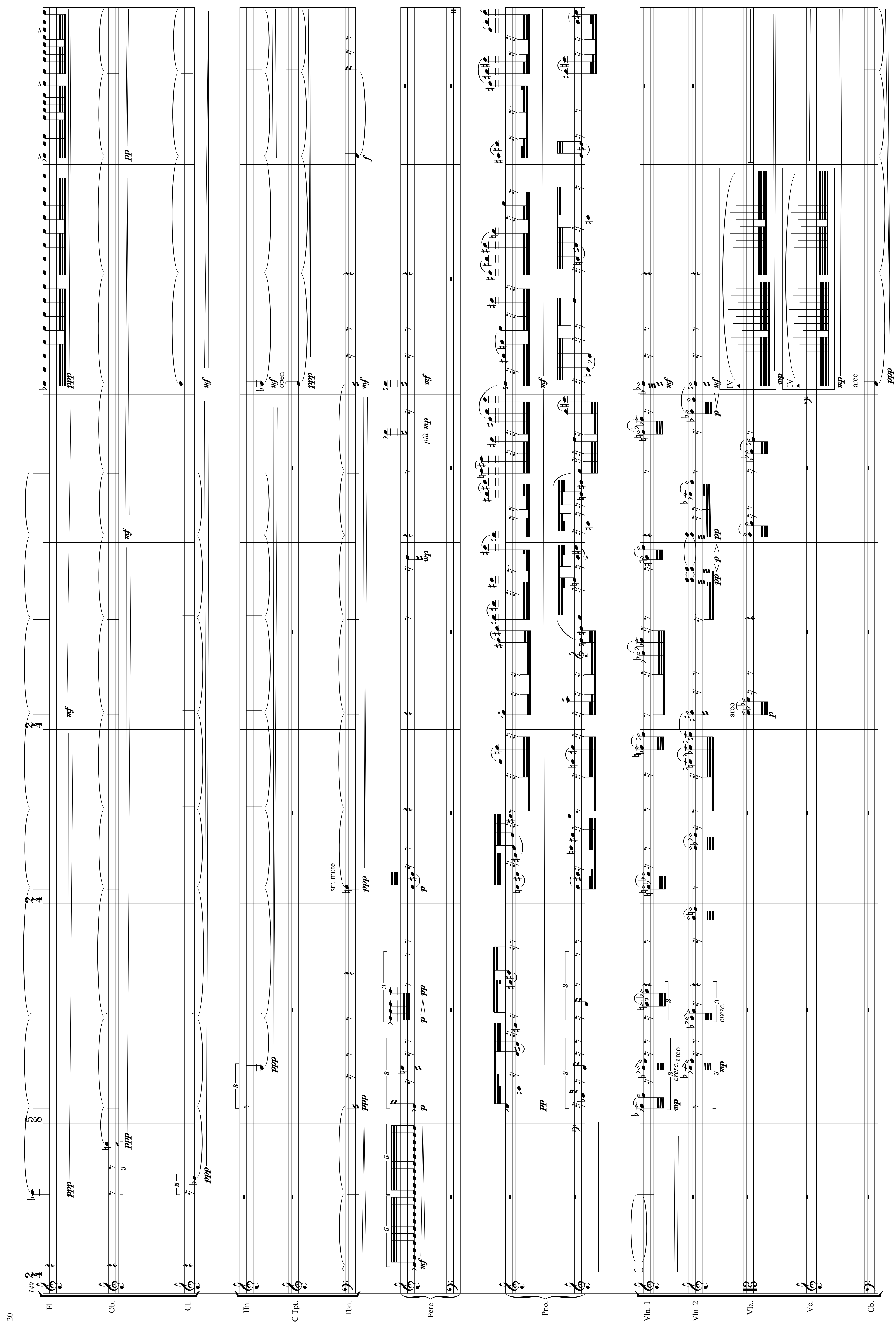

♩ = 90
118
Fl.
Ob.
Cl.
Hn.
C Tpt.
Tbn.
Perc.
Pno.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.
8"
8va
loco
pizz.
ord.
arco
extr. S.P.
f
ppp
mf
pp
p
mp



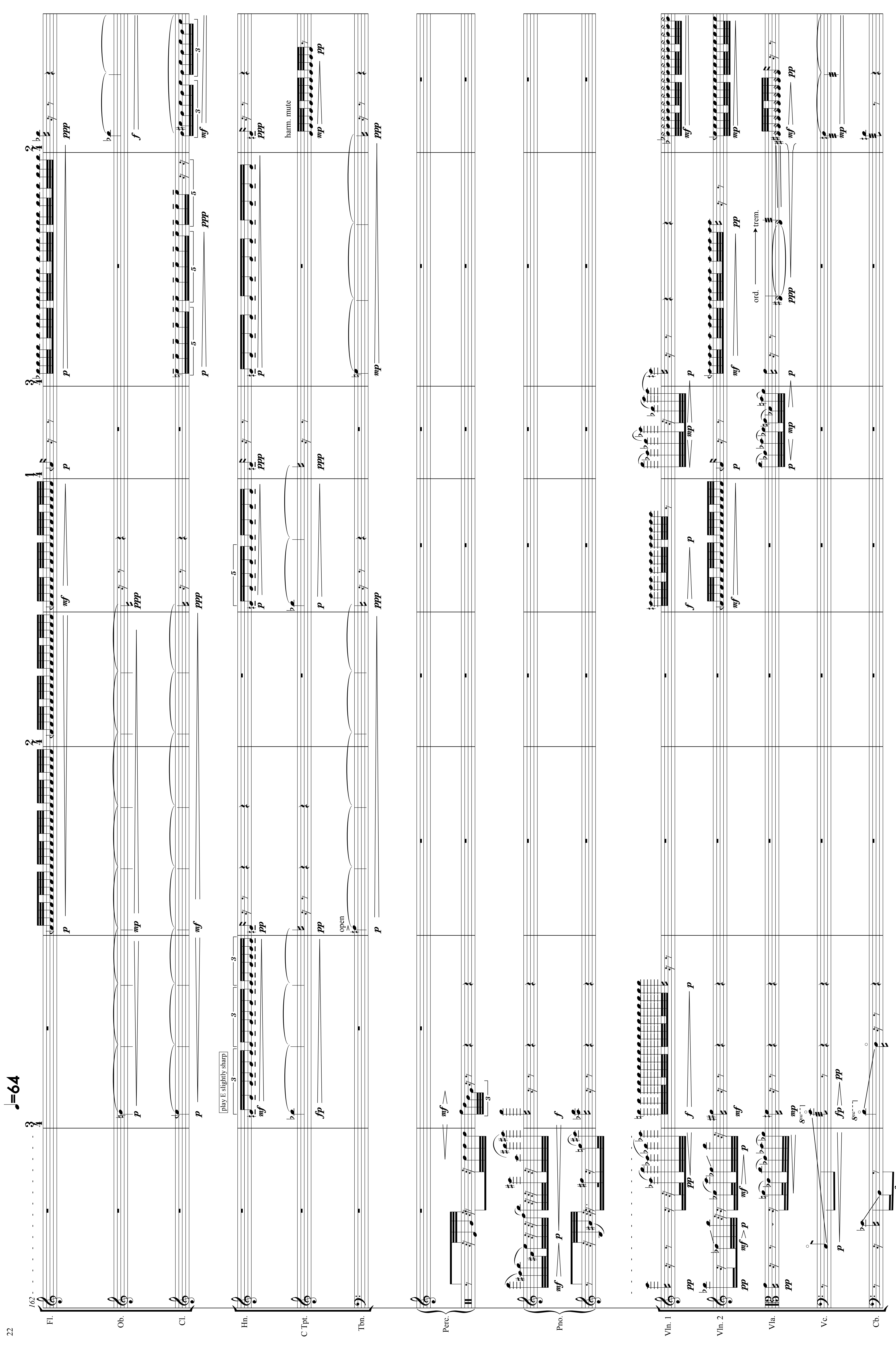
♩ = 64
♩ = 56
♩ = 64
125
Fl.
Ob.
Cl.
Hn.
C Tpt.
Tbn.
Perc.
Pno.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.
str. mute
str. mute
open
open
arco
pizz.
like aeolian sounds on the flute
S.P. flaut.
arco norm.
extr. flaut.


134
Fl.
Ob.
Cl.
Hn.
C Tpt.
Tbn.
Perc.
Pno.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.
slap
loco
arco
pizz.
extr. flaut.
arco norm.
flaut.
rep. the music in the box till the end of the arrow.

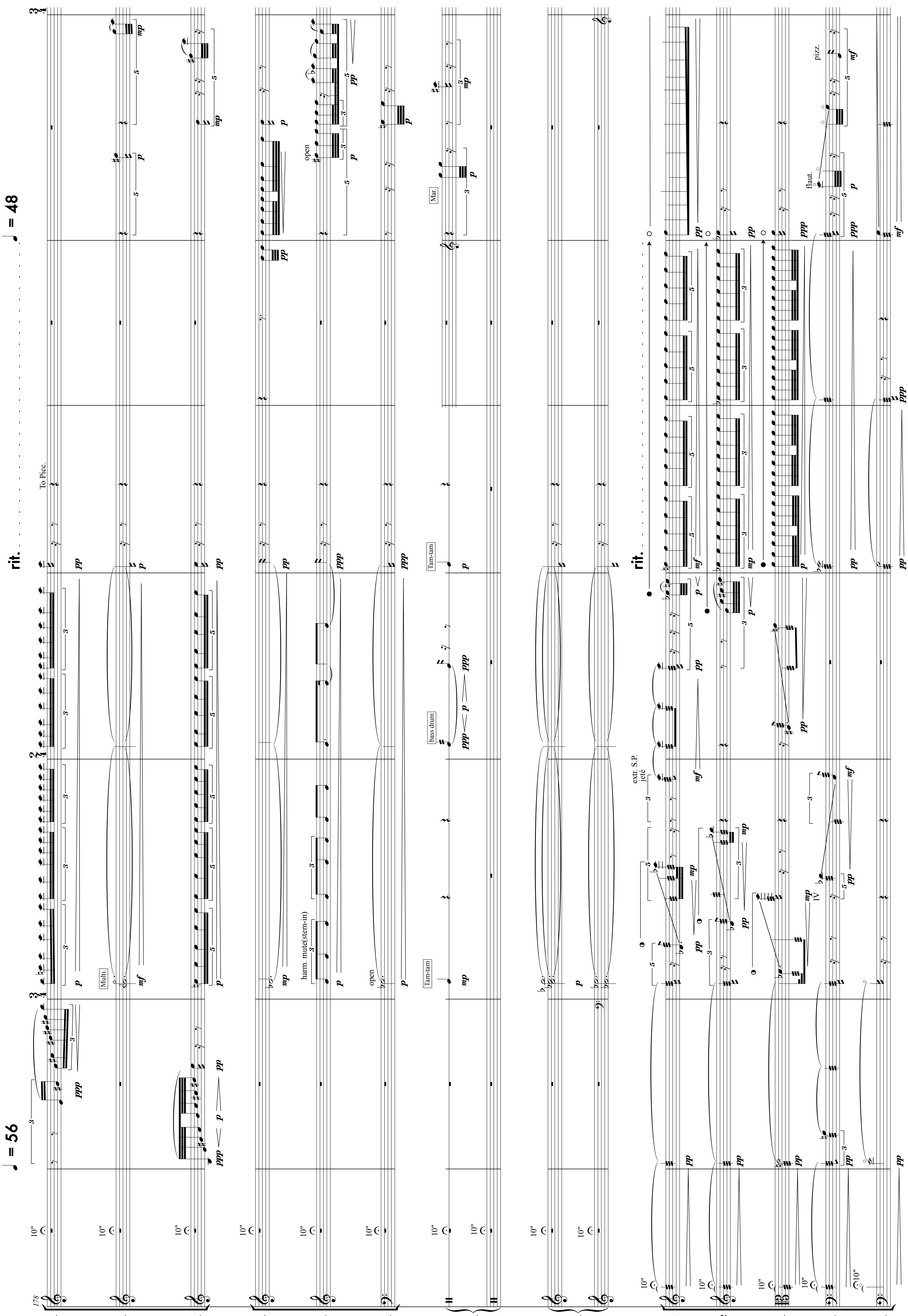

142
Fl.
Ob.
Cl.
Hn.
C Tpt.
Tbn.
Perc.
Pno.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.
slap
str. mute
Ped. 1/4
pizz.
arco
arco norm.
extr. flaut.


149
Fl.
Ob.
Cl.
Hn.
C Tpt.
Tbn.
Perc.
Pno.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.
str. mute
open
arco
cresc.
più mp
IV

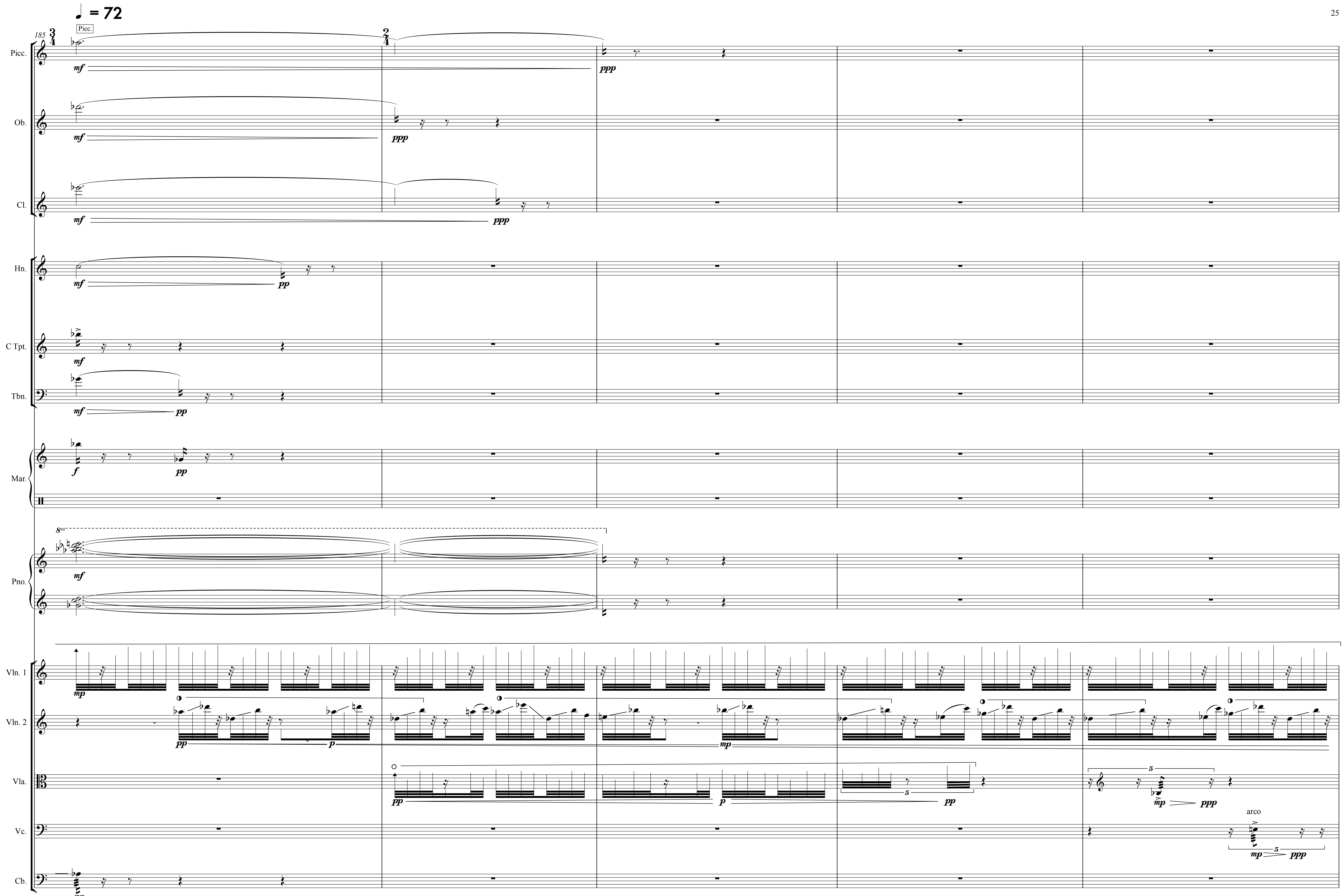

rit.
♩ = 54
molto accel.
156
Fl.
Ob.
Cl.
Hn.
C Tpt.
Tbn.
B. D.
Pno.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.
air sounds, more air thaan flute sound.
half air and half flute sound.
half air and half oboe sound.
air sounds, more air thaan clarinet sound.
bass drum
wood blocks
flaut.
sim.

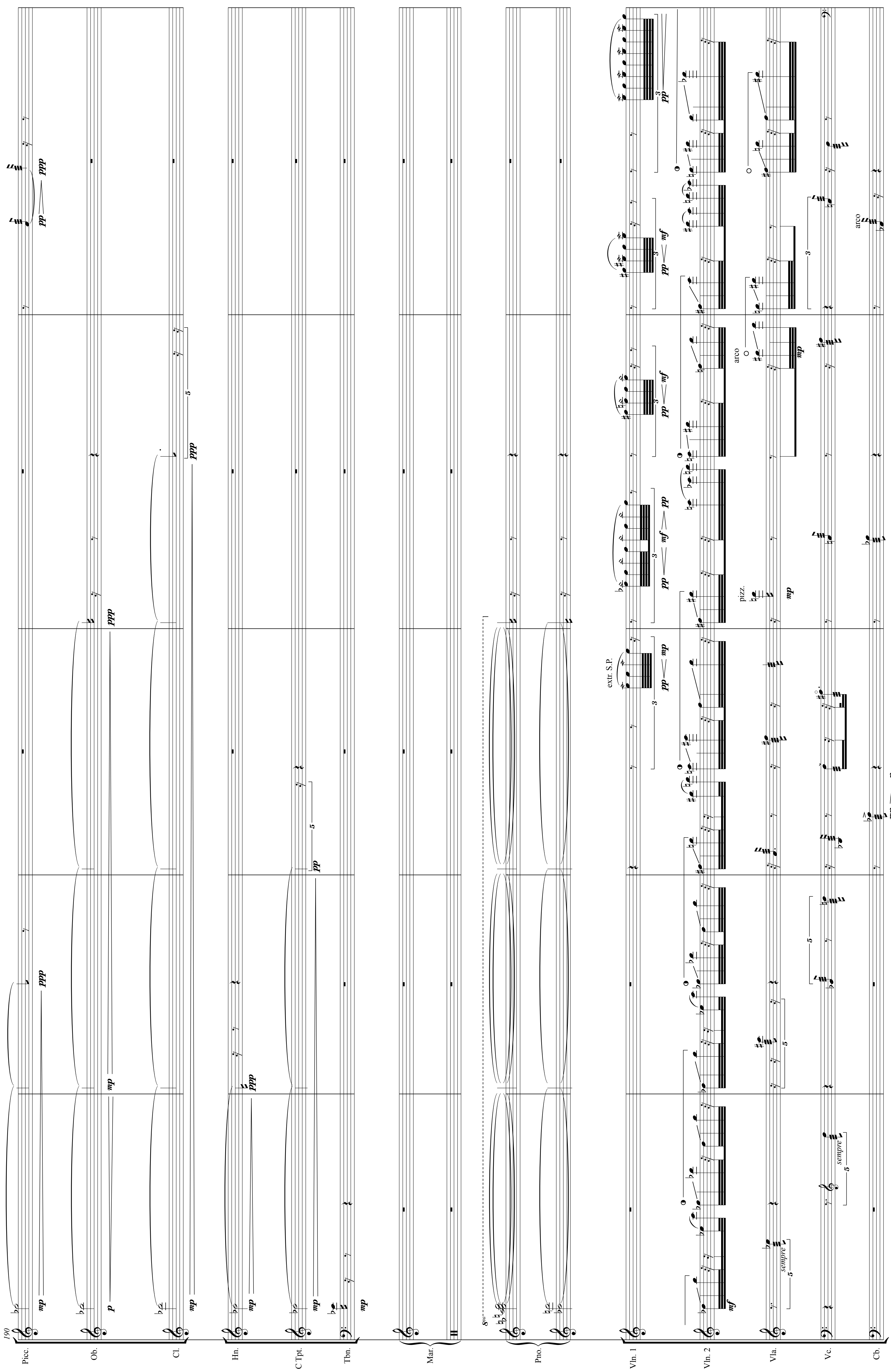

22
♩=64
162
Fl.
Ob.
Cl.
Hn.
C Tpt.
Tbn.
Perc.
Pno.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.
play E slightly sharp
open
harm. mute
ord.
trem.

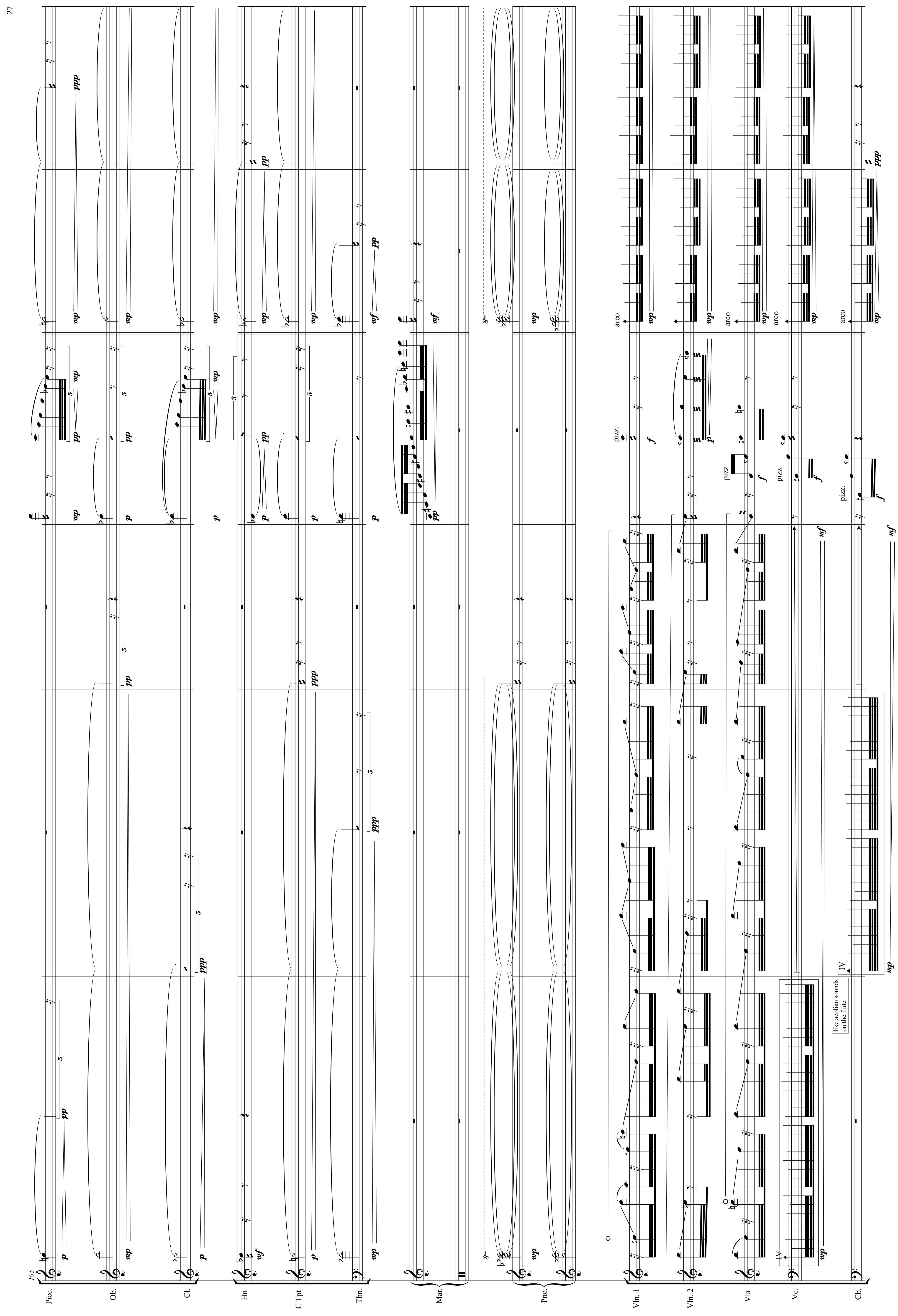

170
Fl.
Ob.
Cl.
Hn.
C Tpt.
Tbn.
Perc.
Pno.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.
harm. mute
D slightly flat
open
Tam-tam
wood block
pizz.
arco
II

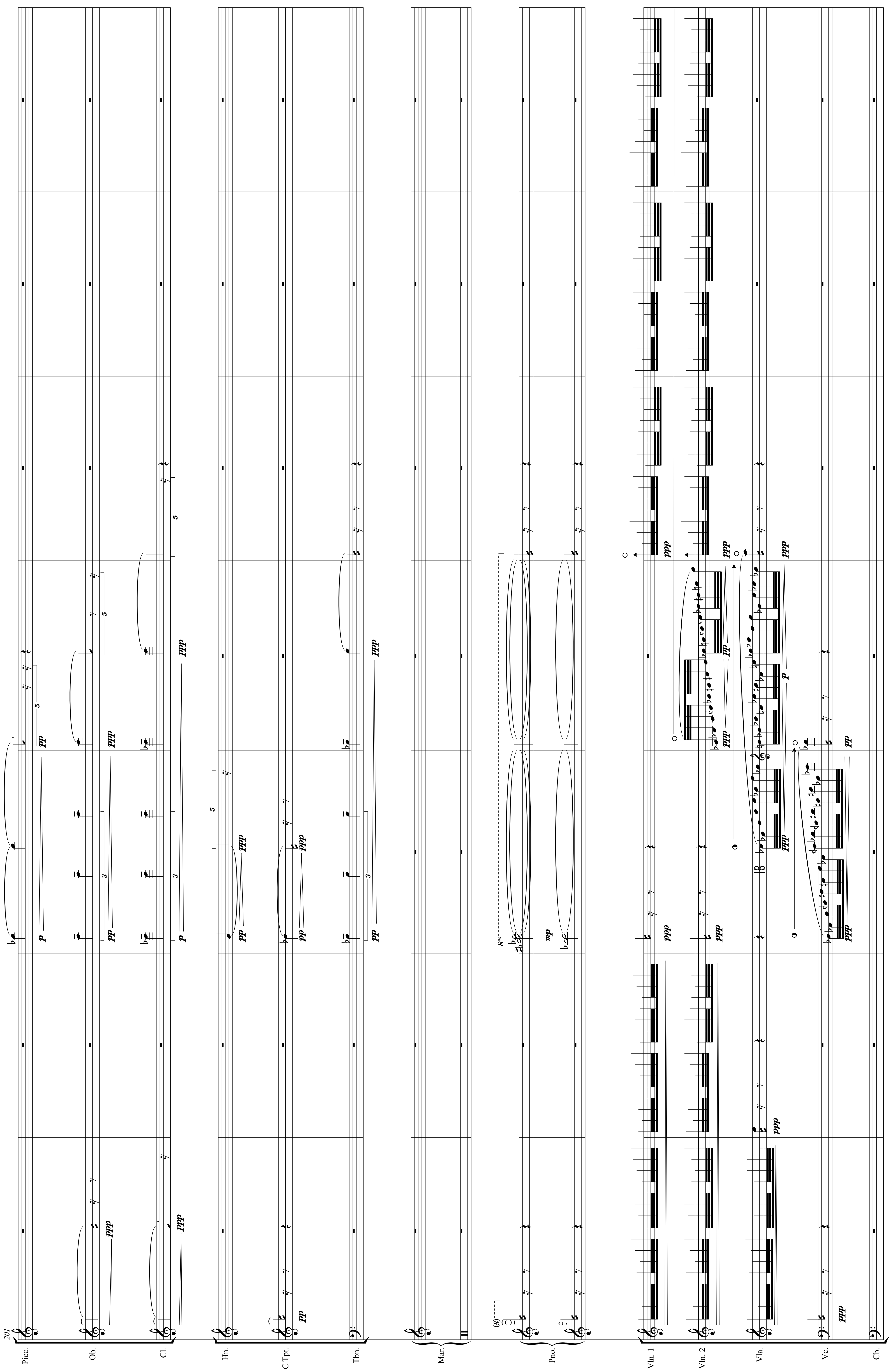


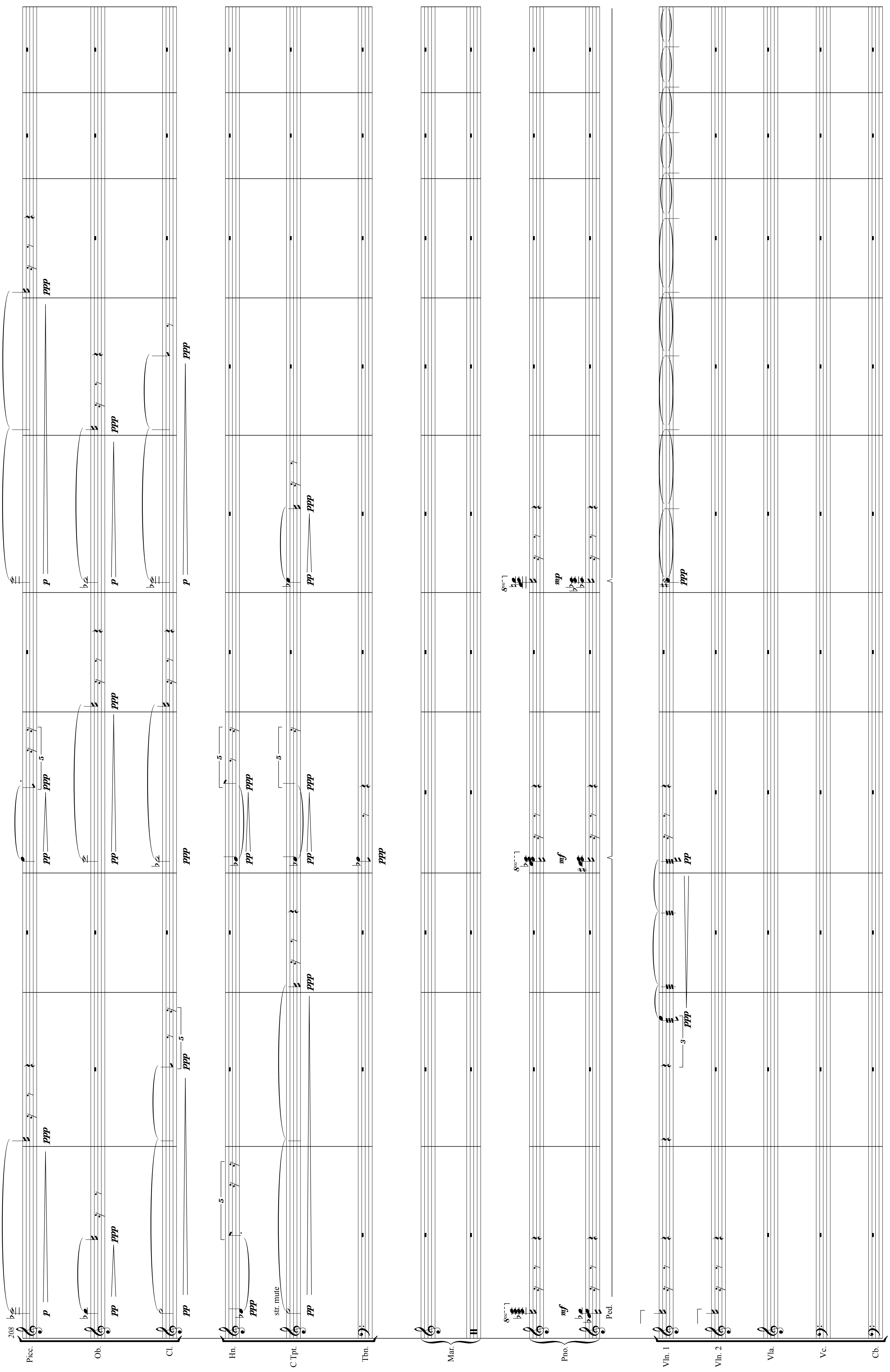
♩ = 56
rit.
♩ = 48
178
Fl.
Ob.
Cl.
Hn.
C Tpt.
Tbn.
T.-t.
Pno.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.
10"
To Picc.
Multi.
harm. mute(stem-in)
open
Tam-tam
bass drum
Mar.
extr. S.P.
jeté
IV
flaut.
pizz.

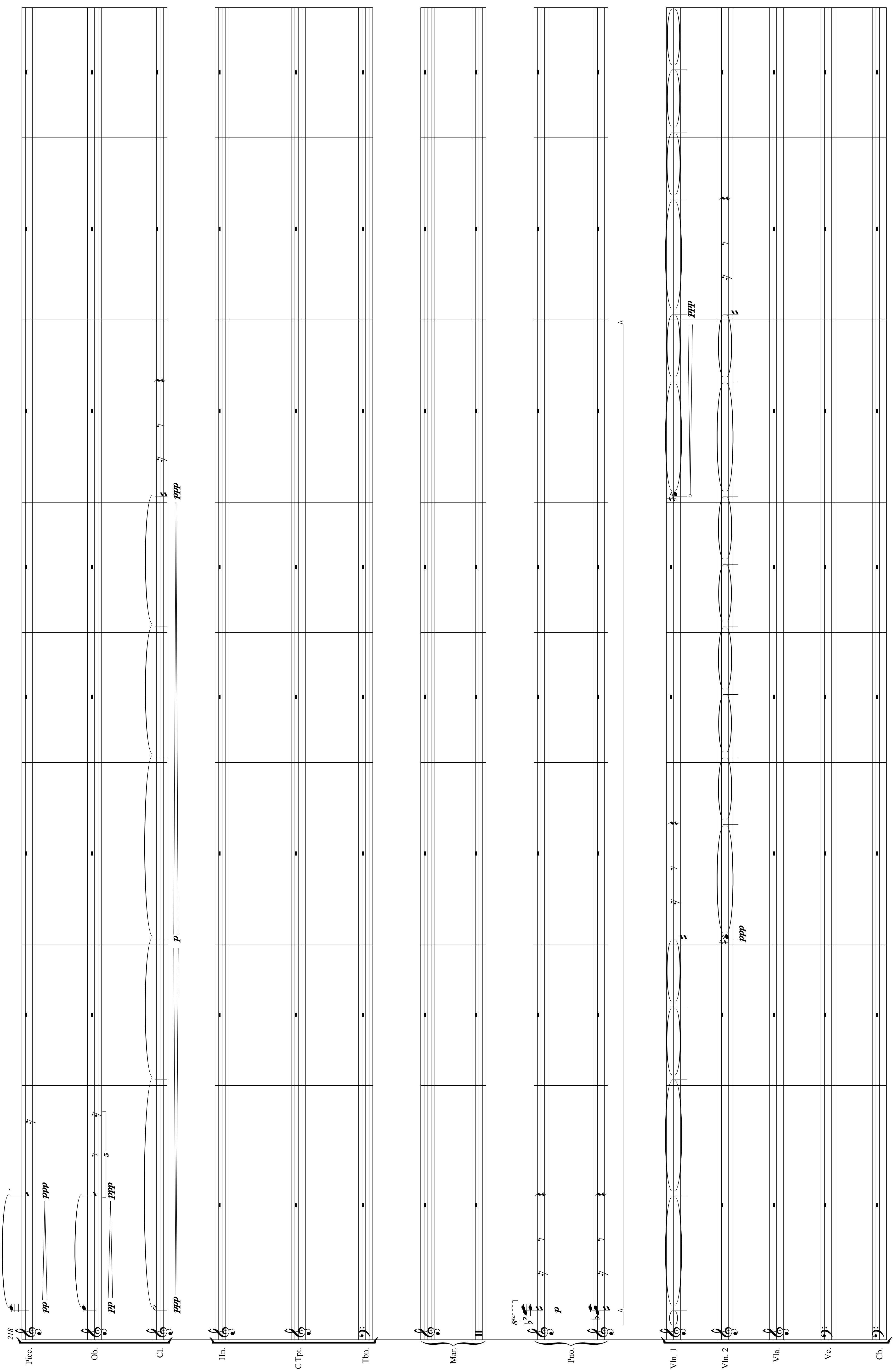

♩ = 72
185
Picc.
Picc.
Ob.
Cl.
Hn.
C Tpt.
Tbn.
Mar.
Pno.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.
arco

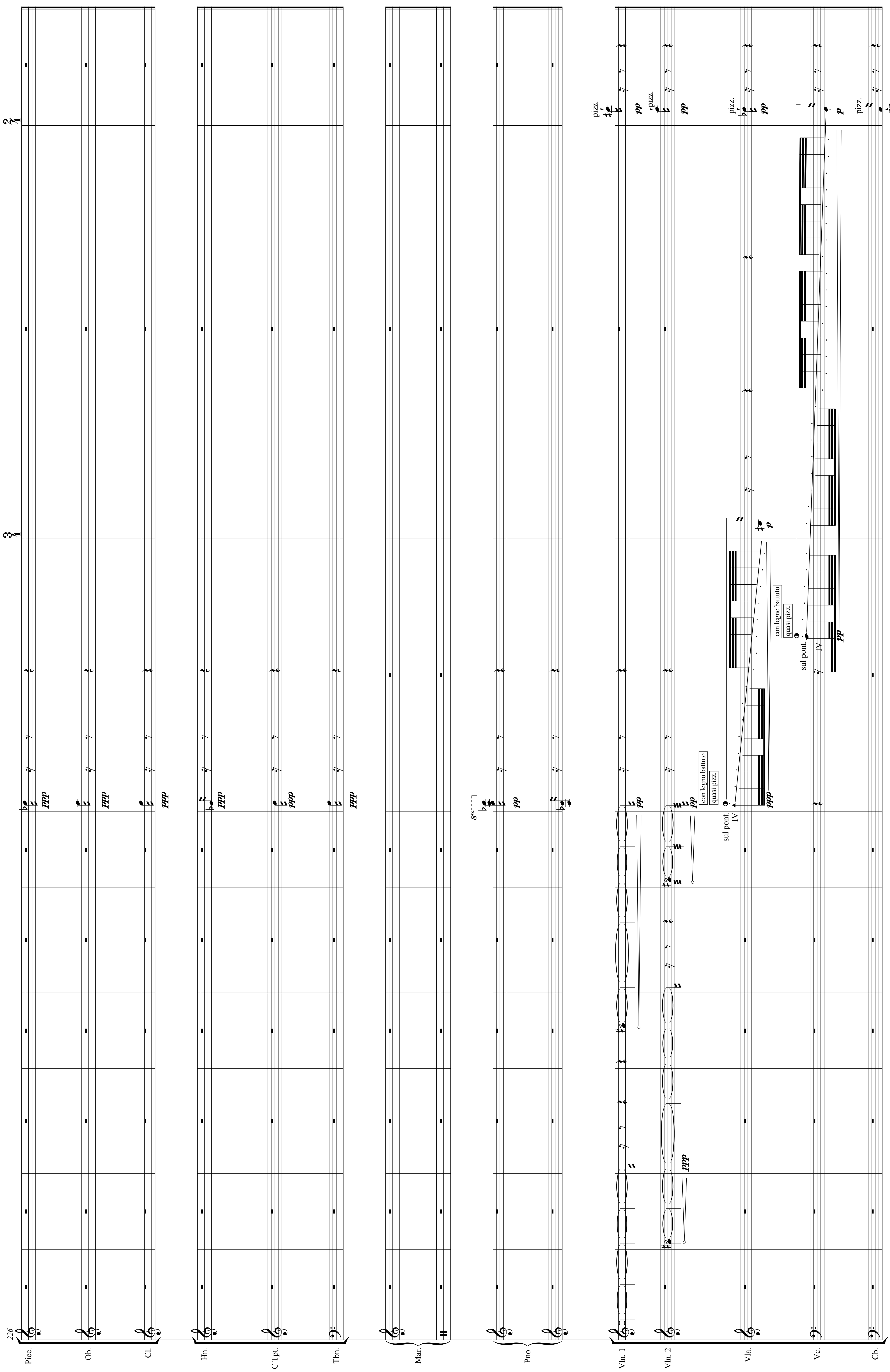

190
Picc.
Ob.
Cl.
Hn.
C Tpt.
Tbn.
Mar.
Pno.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.
extr. S.P.
pizz.
arco
sempre


195
Picc.
Ob.
Cl.
Hn.
C Tpt.
Tbn.
Mar.
Pno.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.
like aeolian sounds on the flute
IV
pizz.
arco


201
Picc.
Ob.
Cl.
Hn.
C Tpt.
Tbn.
Mar.
Pno.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.

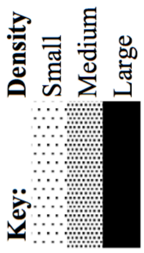

208
Picc.
Ob.
Cl.
Hn.
str. mute
C Tpt.
Tbn.
Mar.
Pno.
Ped.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.

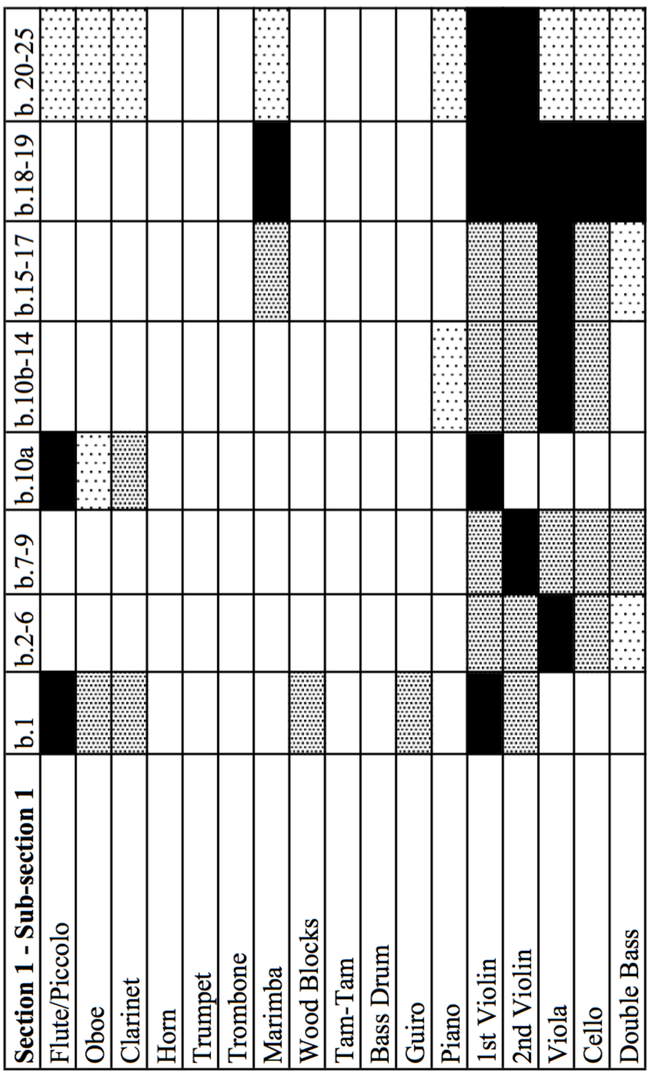

218
Picc.
Ob.
Cl.
Hn.
C Tpt.
Tbn.
Mar.
Pno.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.
pp
ppp
5
p
8va


226
Picc.
Ob.
Cl.
Hn.
C Tpt.
Tbn.
Mar.
Pno.
Vln. 1
Vln. 2
Vla.
Vc.
Cb.
ppp
pp
p
pizz.
sul pont.
IV
con legno battuto
quasi pizz.

Appendix C – Orchestration Map (for *Bells Die Out* (2013) – Khumalo)

The orchestration map presents a average of the density of each instrument for the specified range of bars. For example, if an instrument plays for 80% of the range of bars, this will result in large density. Around 50% is medium density, and less than 50% is small density. This gives an idea of how much each instrument is used throughout the piece.





Section 1 – Sub-section 2	b.26-36	b.37-40	b. 41-42	b. 43-44	b. 45-49	b.50-53	b.54-56	b.57-63	b.64-68	b.69-74	b.75-79	b.80-85	b.86-89
Flute/Piccolo													
Oboe													
Clarinet													
Horn													
Trumpet													
Trombone													
Marimba													
Wood Blocks													
Tam-Tam													
Bass Drum													
Guiro													
Piano													
1st Violin													
2nd Violin													
Viola													
Cello													
Double Bass													

Section 1 - Sub-Section 3	b.90-93	b.94	b.95	b.96	b.97-99	b.100-102	b.103	b.104-107	b.109-112	b.113-117	b.118-124
Flute/Piccolo											
Oboe											
Clarinet											
Horn											
Trumpet											
Trombone											
Marimba											
Wood Blocks											
Tam-Tam											
Bass Drum											
Guiro											
Piano											
1st Violin											
2nd Violin											
Viola											
Cello											
Double Bass											

Section 2 - Sub-section 1	b.125-128	b.129-132	b.133-135	b.136-140	b.141-144
Flute/Piccolo					
Oboe					
Clarinet					
Horn					
Trumpet					
Trombone					
Marimba					
Wood Blocks					
Tam-Tam					
Bass Drum					
Guiro					
Piano					
1st Violin					
2nd Violin					
Viola					
Cello					
Double Bass					

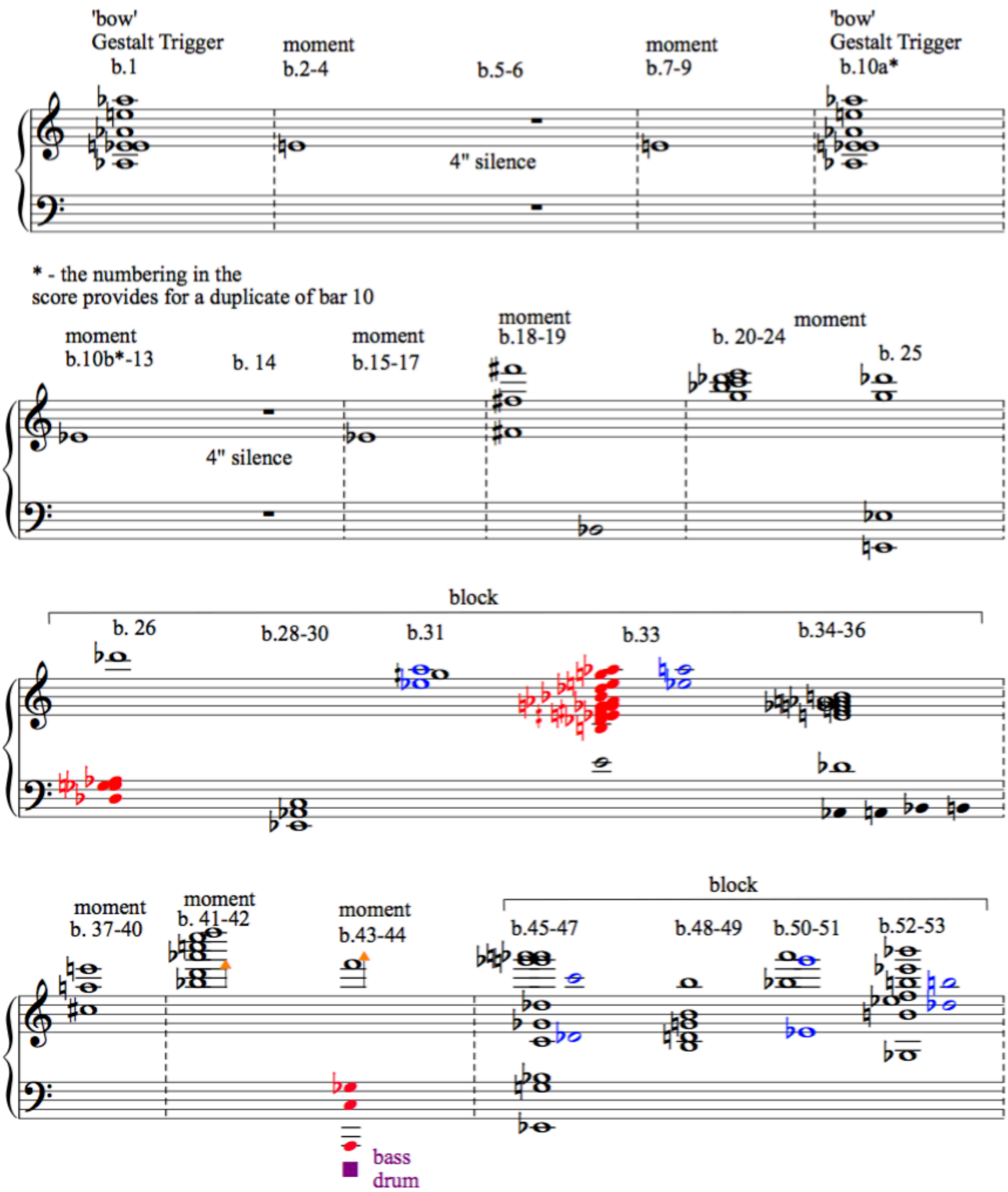
Section 2 - Sub-section 2	b.145-147	b.148-149	b.150-153	b.154-157	b.158-162	b.163-167	b.168	b.169-174	b.175-178
Flute/Piccolo									
Oboe									
Clarinet									
Horn									
Trumpet									
Trombone									
Marimba									
Wood Blocks									
Tam-Tam									
Bass Drum									
Guiro									
Piano									
1st Violin									
2nd Violin									
Viola									
Cello									
Double Bass									

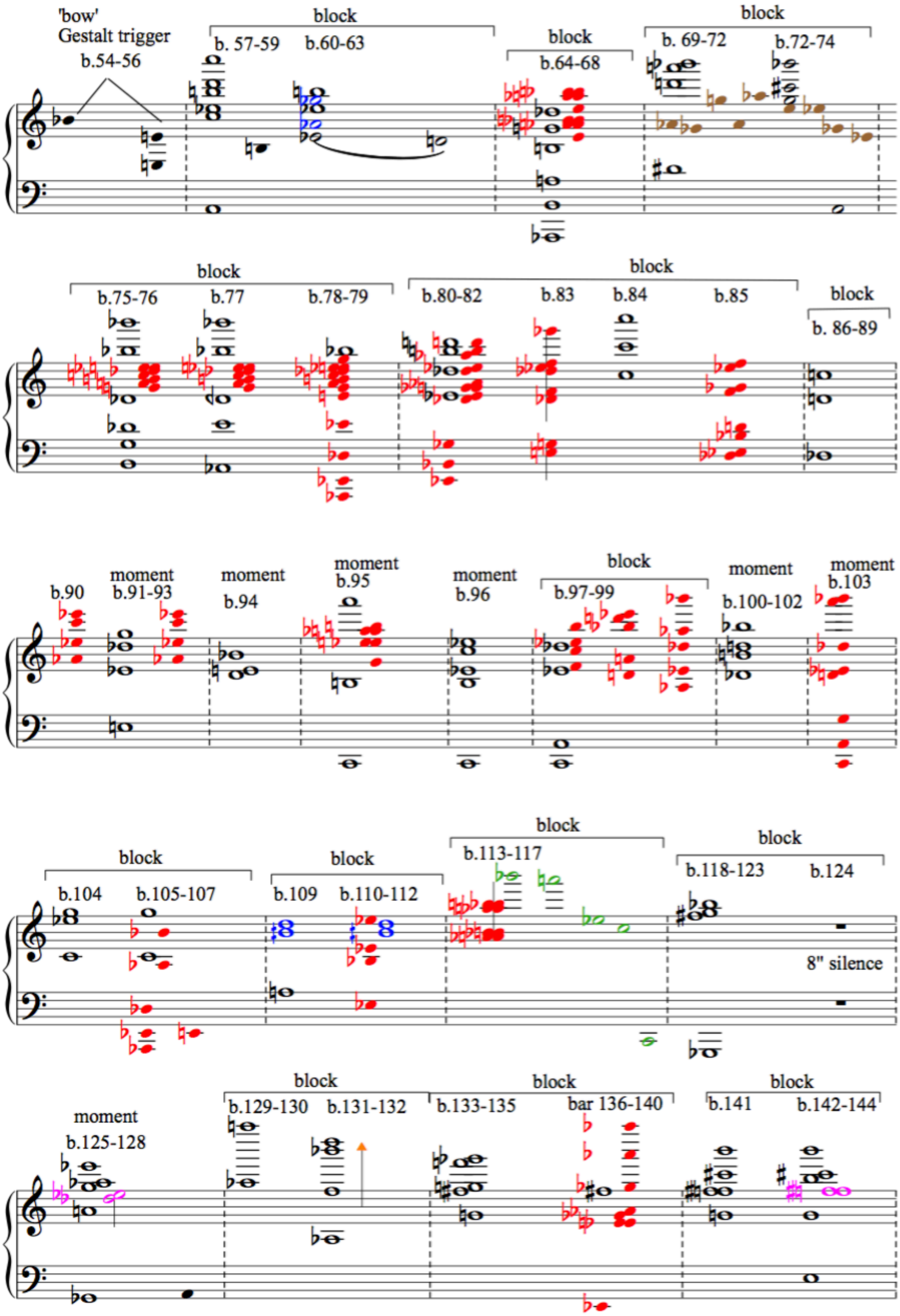
Section 2 - Sub-section 3	b.179-181	b.182-184	b.185-189	b.190-194	b.195-197	b.198	b.199-202	b.203-204	b.205-207	b.208-210	b.211-212	b.213-217	b.218-222	b.223-231	b.232-234
Flute/Piccolo															
Oboe															
Clarinet															
Horn															
Trumpet															
Trombone															
Marimba															
Wood Blocks															
Tam-Tam															
Bass Drum															
Guiro															
Piano															
1st Violin															
2nd Violin															
Viola															
Cello															
Double Bass															

Appendix D – Harmonic Reduction (for *Bells Die Out* (2013) – Khumalo)

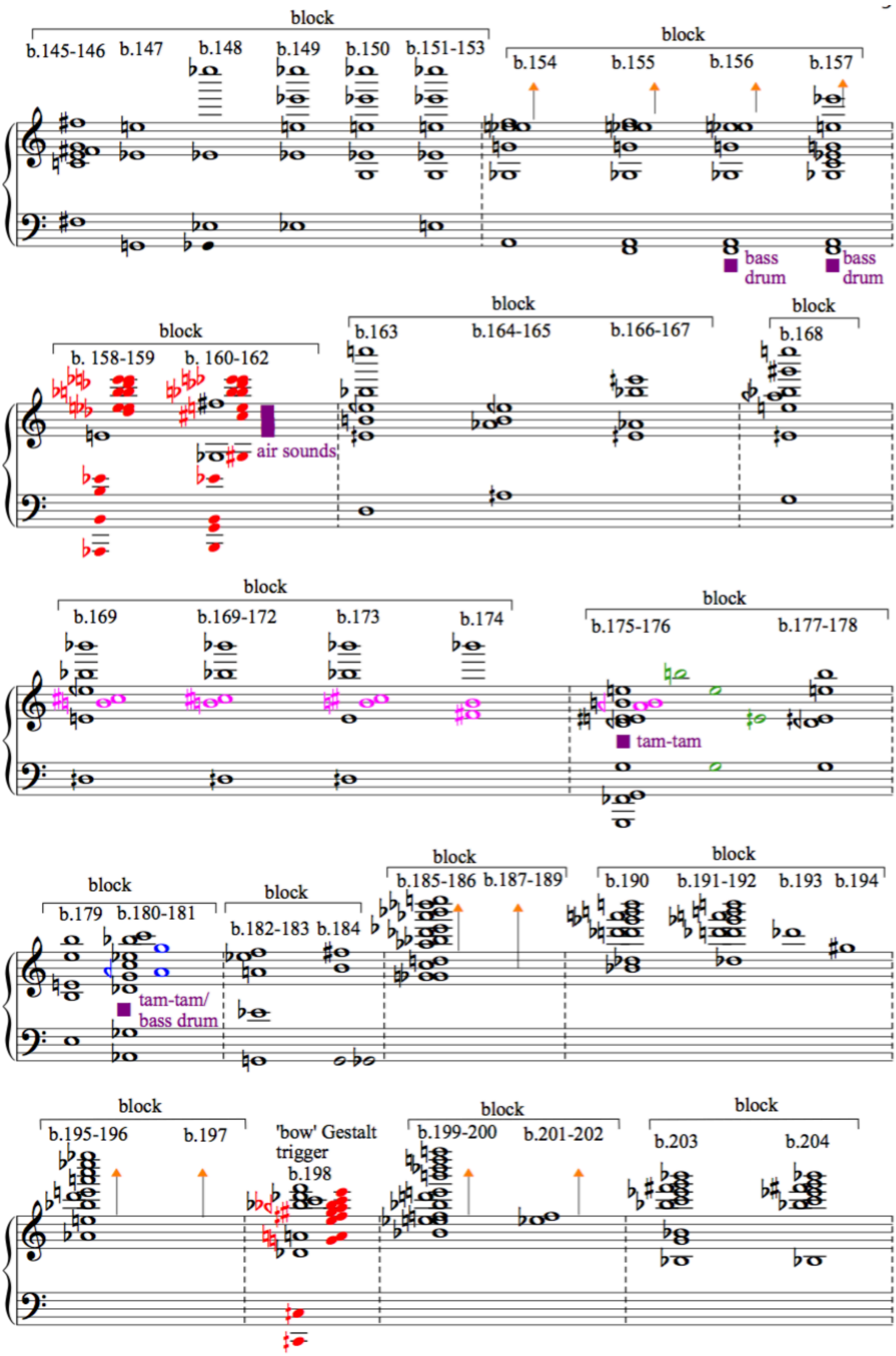
The harmonic reduction was compiled by the author.

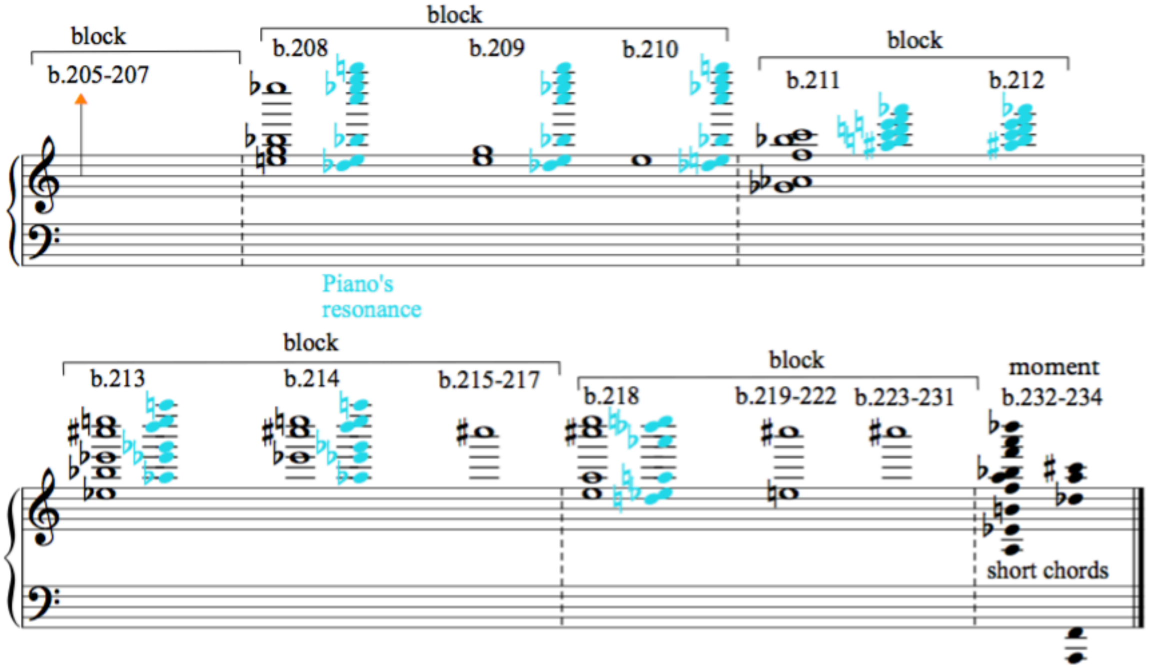
Notes in red - short pitches used for energetic texture
Notes in pink - pitches used for the oscillating second
Notes in blue - the pitches notated for multiphonics
Notes in green - staggered entries
Notes in brown - melodic line
Upward pointing arrow in orange - indefinite high pitches
Square block in purple - indefinite pitch from percussion
Notes in turquoise - pitches ringing in the piano's resonance chamber





'bow'
Gestalt trigger
b.54-56
block
b. 57-59
b.60-63
block
b.64-68
block
b. 69-72
b.72-74
block
b.75-76
b.77
b.78-79
block
b.80-82
b.83
b.84
b.85
block
b. 86-89
b.90
moment
b.91-93
moment
b.94
moment
b.95
moment
b.96
block
b.97-99
moment
b.100-102
moment
b.103
block
b.104
b.105-107
block
b.109
b.110-112
block
b.113-117
block
b.118-123
b.124
8" silence
moment
b.125-128
block
b.129-130
b.131-132
block
b.133-135
bar 136-140
block
b.141
b.142-144


block
b.145-146 b.147 b.148 b.149 b.150 b.151-153
block
b.154 b.155 b.156 b.157
bass drum
bass drum
block
b. 158-159 b. 160-162
air sounds
block
b.163 b.164-165 b.166-167
block
b.168
block
b.169 b.169-172 b.173 b.174
block
b.175-176 b.177-178
tam-tam
block
b.179 b.180-181
tam-tam/ bass drum
block
b.182-183 b.184
block
b.185-186 b.187-189
block
b.190 b.191-192 b.193 b.194
block
b.195-196 b.197
'bow' Gestalt trigger
b.198
block
b.199-200 b.201-202
block
b.203 b.204


block
b.205-207
block
b.208
b.209
b.210
block
b.211
b.212
Piano's resonance
block
b.213
b.214
b.215-217
block
b.218
b.219-222
b.223-231
moment
b.232-234
short chords

Appendix E – Interviews with Miles Warrington

Interview with composer Miles Warrington on the 4th of June 2015 at the South African College of Music, Cape Town.

RvT: Are you quite well read on spectralism?

MW: Yes, fairly, I wouldn't say that I am an expert, but it is a form of musical language I am interested in, from a compositional point of view, using spectralism as a parameter in composition, it gives you the tools to explore harmony that is not really available to you by single notes in acoustic instruments, I find that with electroacoustic music gives you a lot of scope for a musical language that is difficult via pure acoustic instruments.

RvT: So it gives you the tools to work harmony but also with texture.

MW: Yes, with texture and timbre… I made notes about it…

RvT: So have you been mostly working with electroacoustic music?

MW: Yes, well… I used spectralism in my major orchestral work for my degree.

RvT: Lets chat about spectralism, as it is quite a broad genre.

MW: Yes.

RvT: The spectralists don't want to be called a school, or labelled, as it is diverse, and they explain their various approaches, Murail speaks of the attitude about sound and composition approach.

MW: I am interested in sound and gesture. So limiting yourself to one kind of style, whether you invent a variation on the style or not, to express yourself, is to not put yourself in a box of one type of style or thinking, but to be able to think outside of those parameters is what I am interested. Just to say here, the compositional techniques regarding spectralism, I made some notes: Harmony based on timbre a note on an acoustic instrument in connection with spectral components, like sine tones/pure tones, a chord is a collection of partials and can thus be seen as a timbre. So spectral analysis allows the composer to create the spectral components of the note, that the composer can create harmonic relationships across notes do not exist with acoustic with instruments, sound analysis can create harmony. And that is what I did in part of my main composition that supported my thesis and we can have a look at that if you want.

RvT: I would love to.

MW: Some background on the piece itself. It is for violin and electronics which uses a gesture heuristic, usually technology is used to act as a solution to a problem, because it acts as a solution in the gesture domain, it is referred to as a gesture heuristic. And what this allowed me to do was: I created an action tracker which uses a camera system I developed and PureData to track the fingertips of the violinist. I used existing technology to create a finger tracking solution by training a classifier. Like the famous classifier that detects facial recognition. I used that same method to train the classifier to detect fingertips, and then used an existing set of binaries for PureData externals, to plug that classifier into the PureData external and then to use PureData as the interface between the musical stuff and the stuff happening in real life, the movement. Which then allows you to create patches that detect timing between events, and therefore to manipulate audio in live, real time. So you have procedural audio manipulation, and data driven audio manipulation.

RvT: So the procedural data manipulation would happen through the live movement of the fingers…

MW: Correct.

RvT: And the data manipulation is something that is pre…

MW: Yes something that is set, so you could trigger a data driven event by creating a part of a patch that just looks for that moment and just stream something off the hard drive without taking into context the timing of events that have happened before, so a one to one correspondence, whereas a procedural event, would start timing the event when it detects something, and then time between the next point and based on the timing between those events the violin has taken in that part of the score, would then process live pre-recorded audio or create synthesis or whatever it is, and apply that to the audio in live time.

RvT: I don't understand exactly how it was done, but I get the general idea…

MW: Yes, getting the idea. That was the rationale behind the piece called *In-Gest* (*2013) for violin and electronics*, with a 'G', not the joke jest, although I suppose that could be a funny take on it. Ingest to take in, and gestural, mixing the two ideas. So that was the idea behind the piece, so what I did was, the piece is structured from gestural sheets, each sheet has an implied human gesture, a movement, an idea, walking. So here [points to section in score], I recorded myself walking on gravel, and extracted partials from walking on gravel, and built chords from those partials, and used those chords to create the violin's scenes. So the system detects the violinist at detection one, data driven, and times from there to there, and when the violin reaches the open string, it then knows how to process this. Based on the timing of the events it randomly generates footsteps based on the partial's extraction, and you then hear the partials being made into chords with the sound of the footsteps, heel toe, under the violin, and the violin accompanies the footsteps with *col legno* double stops.

RvT: So then the violin's timbre adds a new timbre to the actual footstep partials, merging a new timbre.

MW: Exactly because they are sonically linked, pitch linked, partially linked, harmonically linked. This is an example of spectralism, because the partials, individual sine tones, have been turned into chords, and layered with the acoustic score, so there is spectralism.

RvT: Definitely, yes. Also when you hear a timbre you don't hear all the different partials, but when you focus your attention on trying to pick out the partials, then your perception changes so that you can track the root. So without consciously doing that, you hearing a timbre, and so by going into the details, you bring out… what you presenting is then timbre, as you have brought out a new timbre that can be perceived as one timbred tone, and not a group of partials.

MW: It is like reverse engineering the sound of footsteps in a way. One cannot have all the partials because then you will get the footsteps. You don't want that. I have taken, extracted, some that are fitting with the acoustic score and then just aligned them so that you have these chords that are playable over each other in any way and they fit with each other, whichever way they are played randomly, it is not *alleatoric*, or how can I describe it, it is serial in a way, but not completely serial because you have very specific tones…

RvT: Yes, you have worked it out, it is slightly *alleatoric*, it is *controlled alleatorism*. You have also taken an artist's touch with the data, recreating the data exactly would be, you might as well just record the footsteps and play it back…

MW: Although it's interesting… the idea that one can create any sound in the universe artificially from those basic elements in sine tones… fascinating…

RvT: I agree…

MW: Some aspects of composing in this way is sound design, because you are manipulating pre-recorded material to create your own sonic environment or soundscape, and that is sound design, a form of sound design, without trying to replicate existing sounds artificially.

RvT: I need to have a look into sound design, by sound design are you referring to *musique concrete*?

MW: No, sound design, you could do it artificially where you learn the physical properties of a specific sound and with mathematical principles you would replicate that sound artificially, that would be designing sound, and then you could tweak specific parameters, you can use FM synthesis to artificially create the sound of a helicopter, like Andy Farnell did with his book *Designing Sound*.

RvT: I haven't heard of that…

MW: I think you should have a look at that… Ok, anything else from here [looks through score of In-Gest] well in this score you have micro tonality in the violin, and that is played over large vertical chords made up of specific frequencies, which have been tailored from recordings of violin sounds, all the sounds in this piece have been recorded in the studio from violin extended techniques to generate effective material for the work. Each of them depending on their context have been manipulated accordingly. So here is also an example of spectralism, because you have specific frequencies isolated, which are partials, layered on top of each other to create specific chords in the acoustic score and are then are processed depending on procedural events.

RvT: Interesting, so what you have done is, I think, at the moment at the front, or at the top of what is happening in the world, when spectralism started it was instrumental and half of the technology had not been discovered yet, and these tools that you use, are at the front of what is happening with development, and I am sure there is a lot more I don't know about…

MW: …And me too… we are always learning. Certainly one should think of the work that people like Meyer Eppler and Stockhausen did with generation of sine tones, one cannot ignore that they were on to spectralism already, there's no two ways about it, and in fact I would say that is probably when it started, when was Grisey's *Partiels* written?

RvT: 1970-1971 I think, which is just after Penderecki's decade. I just wrote about him being a proto-spectralist, because he worked in the studio and with oscillators generated different sound worlds, by combining different oscillators of different frequencies and combining different sound sources to create a global sound, and tried to imitate that instrumentally. So that makes him proto-spectral, he didn't necessarily have the exact data and orchestrate partials, but had technology in his mind, and combined many different sound sources of extended techniques in the orchestra to create a global timbre, which is where I think spectralism is different to any other form of creating a new sound world, where you think of the details that form a timbre and orchestrate a new timbre.

MW: What's fascinating for me is that, there are composers like Helmut Lachenmann, I love his music. He is writing, he is scoring acoustically *musique concrete*, acousmatic… because if you listen to his music it sounds like recordings of every day sounds, like the door squeaking, or door slamming, footsteps on a solid floor, banging sounds, metal, metallic sounds of metal on metal, if you listen to *Gran Torso*, string quartet… what I am hearing is an acoustic narrative, not hearing normal acoustic music. So he is doing the opposite of what electroacoustic music is doing, he writes electroacoustic music, I feel that his acoustic music makes use of highly extended techniques to generate sounds, that mimic acousmatic sounds, sounds that are not necessarily musical. One could then analyse those sounds that are created by the acoustic instruments and look at their spectrums and compare them to sounds that are supported naturally narratively by analogues in the real world that are not generated by instruments, like the footsteps or for slamming, glass breaking, and you will be surprised by how close they are.

RvT: Does he at all, think of the psychoacoustic aspect do you think?

MW: I would imagine he does.

RvT: Perception of hearing the footsteps, or someone crying and the feeling that generates.

MW: Very interesting, I don't know if you have heard of Leigh Landy?

RvT: No, I haven't.

MW: He is professor of electroacoustic music at one of the universities in the UK, and he ran a very important project called the intention and reception project, which was a study of how electroacoustic music has meaning for people, and they exposed people from the street, and young people, and exposed them to experimental electroacoustic music… art music… and asked them a series of questions, how does it make you feel, what sort of images does it evoke, what does it mean to you. And one of the discoveries was the importance in electroacoustic music to have what's called the "Something to hold on to factor". Prof. Landy coined that term, and is a direct reference to some kind of naturally occurring sound without its transformation, for example a bird…

RvT: Something you recognize…

MW: Something you recognize, thank you, and perhaps the idea with Lachenmann, is to mimic that acoustically as closely as possible and therefore create an automatic association with a real occurring sound. You can construct very complex, abstract narratives from that, and that's how I see his music.

RvT: Have you done any research into psychoacoustics?

MW: I have done a little bit, I discussed psychoacoustics from the point of view of the techniques, let me read a little bit for you.

RvT: Did you write about the "something to hold on to factor"?

MW: Yes, I did.

RvT: I think composing with the listener in mind is definitely something that shouldn't be ignored.

MW: My biggest thing was with musical gesture, the image in a composer's mind of a sound, what kind of image does that sound have? So a phrase, a musical phrase, what kind of image does it have, what kind of ontological movement does it have, or shape, whether it is fleeting, up or down, slow long, stretched, sparse, whatever that image is these are what are called sonic forms, or musical gestures.

[Reads from his DMus thesis] "sonic forms" are the formal structures of music, which in themselves do not contain meaning, but when articulated in a musical setting reveal "corporeal signification" and are therefore significant in providing semantics. The discovery of the body acting as mediator of cognitive information, especially in music, has necessitated the need to develop what are termed "mediation technologies" where sonic forms are combined with technology. The idea is that these technologies assist in bridging the gap between "mind and matter".

So the whole exploration of creating this technology to facilitate two scores, one acoustic and one electronic is to bridge that gap between mind and matter.

RvT: So the technology was used to bridge the gap between electroacoustic and acoustic music?

MW: And in that process you have a psychoacoustic, cognitive phenomenon taking place which I made a part of the compositional process.

RvT: So the listener is aware of this?

MW: Well, hopefully, yes.

RvT: It would have an effect on how they perceive the sound?

MW: Hopefully, what happens is the gestures are strong enough to evoke some kind of an analogue with the pictures that I had in mind, they have similar kind of… because when Ralf Inge Godøy, one of the leading musicologists in the study of musical gesture at the moment, coined the term "sound tracing" where you hear a sound, and then you trace its movement. They did large studies with groups of people, control groups and so on… and played these people musical phrases and then they would trace on drawings what kind of shape it would have and the similarities from person to person was unbelievable. I mean how close everyone is to the same shape when you hear the sound.

RvT: Which means it is a language that is being communicated…

MW: Well, I am not sure of it being a language…

RvT: That speaks to your sub-conscious…

MW: Maybe.

RvT: Then again, it depends on your cultural background…

MW: Referential background… It's a huge thing…

RvT: We don't have to go into that…

MW: No. That is a huge topic…

RvT: So basically, the listener is then aware of these gestures, and they get that image, and can trace those gestures in their own mind, and you were aware of that when putting the gestures together.

MW: Right the idea is that you have musical phrases that imply some kind of musical gesture and then with the instrumental gesture heuristic, the action tracker takes the instrumental gesture, which is a different form of gesture, sound producing gestures for example, that are concomitant to making the phrase happen they are intrinsic to one another, you have to move your fingers like this to create that pattern…

RvT: Sorry to interrupt you… So what you have done, you jump into the music world… So, in reality you have the walking gesture, and now we recreating that walking gesture with instruments, so now we moving into a musical space and creating a musical gesture, derived from walking, and now with technology, you are getting the intrinsic part of that musical gesture and creating something new…

MW: And that's done through what I came up with through putting the research together to create two models of what I call "gesture signification model", so for example in the first model [points to diagram in thesis] you have the ontological process where the composer imagines the musical phrase, that's part of compositional ideation. Then you come up with the elemental phrase, and that leads to musical gesture. Which then creates instrumental gesture, which leads to the sound. Then there is the other way round [refers to another diagram in thesis] musical gesture signification model B, ontological process where the composer imagines the sound, and then through the process of sound tracing you create an elemental phrase from the musical gesture. So they can go in either direction.

RvT: As you were saying earlier, you don't want to limit yourself to a style, or put yourself in a box, and I haven't heard of any composers who compose in the same way as this. And this is related to spectralism, using psychoacoustics, and delving into the process of sound and diving into everything that has to do with sound and how it is perceived.

MW: But I just want to make it clear, you say the word style. Although it is obvious that this is falling into the art music aesthetic…

RvT: Definitely…

MW: And the reason I have chosen the electroacoustic art music aesthetic, is because it allows you that scope to experiment and to give you the freedom for these compositional parameters and work with them. Whereas if you were doing it in jazz it would be a very free form of jazz and like the really crazy *alleatoric* jazz by Sun Ra. You wouldn't be able to do it in a popular music aesthetic; in a way the idea is determining the style.

RvT: And the idea is to create a new style?

MW: Well I don't think it is a new style, I think I would be very hesitant about that. I'm not really one for creating new styles. I think the thing about composition today is that it is a syncresis, ideas merging together, which gives us the opportunity to come up with something very interesting. Coming up with a new style like the new complexity movement for example, it is just tangential movement of making music so complex so that there are possibilities for the performers to make mistakes which are added as compositional parameters, because it is impossible to play the music perfectly, so the mistakes are written in, if you think of composers like Michael Finnissy and Brian Ferneyhough, for example, although I find their music interesting, it is beyond saying anything meaningful other than contributing to the aesthetic by making the performer make mistakes.

RvT: That's the only new thing…

MW: That's the only new thing, and maybe the scores in themselves are like a work of art, but I think you could write some of that stuff differently without letting the performer make mistakes.

RvT: Yes, definitely.

MW: The beauty of spectralism is that it is complexity from simplicity.

RvT: Complexity is just a combination of simple things. I think there is so much music that has been written, and so much that has been innovated, and it is like different seeds that have been planted and grow, develop and connect with different styles. New things build on what has already been done by bringing your own creative energy, and the fact that you mentioned the art music genre, where you create a work of art that is substantial and has a lot of thought put into it, that can then become something that lives in its own right, an autonomous art work.

MW: Yes, I say somewhere here [points to thesis] without the cultural context… I'll just read you the paragraph, if I can find it… I just want to talk a little about aesthetics.

RvT: Do you use FFT? And what software for spectral analysis do you use?

MW: I use Michael Klingbeil's software SPEAR.

RvT: Oh great, that's exactly what I use.

MW: And there is also a cool little programme called Spek and Sonic Visualizer.

RvT: Is that what you use to get those images that are in the score?

MW: Yes, here is quite an important paragraph:
[reads from thesis] – The aesthetic intention of each sheet by exploring the bounds of timbral limitations of the violin through extension by the mediation technology, is to concern itself with what is referred to as the "something to hold on to factor". Since each sheet is interested in providing a gestural affordance – a semantic image of movements in the outside world - the electroacoustic work *In-Gest* is certainly the result of interest by the composer in "discovering meaning in electroacoustic compositions". Consequently, the choice to explore this communication of meaning through the means of the electroacoustic art music aesthetic is supported, since

according to the definition as supplied, the medium mixes the disciplines of *musique concrète* and electronic music where the possibilities for exploring musical communication are boundless. Boundless in the sense that harmonic, rhythmic and other micro-structural elements are not limited by the constraints of the language that is defined by its cultural context. Where it fits though, is certainly into the well-established cultural landscape of electroacoustic art music by making reference to established compositional techniques and methods, a cultural discourse that is clearly concerned with sound and gesture.

RvT: Let me have a look again, you were reading here? [points to paragraph and reads] micro-structural elements are not limited by the language that is defined by its cultural context. What did you mean there?

MW: Well, they talk about cultural context in the sense that, for example, new tonality, a context of music that is western European, but its specific focus, and language, communicative thing it is talking about is bound by that cultural context, and this is unbounded by that because electroacoustic music as we see is from all parts of the world much like sounds of nature occur everywhere - South American, African electroacoustic music, North American, European, Japanese… Whereas, western classical music is really sort of mostly associated with European culture.

RvT: Does it also have to do with the meaning then? So the meaning is not bound by cultural context and anybody from any culture would be able to understand the gestures?

MW: Yes.

RvT: Visualize those gestures as you have…

MW: That is a very interesting point, I didn't think of it that way, but you are right I am sure.

RvT: Did you read that book, that is owned by the SACM library, but I have it now on interlibrary loan, called *Spectral World Musics: Proceedings from the Istanbul Spectral Music Conference* where there are a number of articles written.

MW: Send me the details, I would like to read that.

RvT: The one article, *Implicit Timbre Perception – Cornelia Fales* is very interesting, all about how we perceive timbre and the European perception of timbre. The beginning of how timbre was defined goes back to the 18th century when Rameau started his theories. It all had to do with him listening to sound and trying to hear overtones and pick them out. It is quite in depth, but it goes to show that the concept of timbre was a very new thing, and has taken a long time for us to understand it, and she explains the psychology behind it, with the Gestalt… how the perception of what you focus on, with the two candle holders and the face, where you can't see both at the same time, but only what you focus on… you can either only hear the timbre implicitly, hear the timbre tone, or can consciously try to hear out the overtones all the parts of the chord. She is also an ethnomusicologist, and has spent a lot of time in Burundi, and researches how the Barundi people hear timbre, or understand the concept of timbre, and they don't describe any of the musical parameters as it is an oral tradition, there was never a need to notate, and with notation you need the different parameters. But because it is an oral tradition, they would just say you should play faster or slower, or that is an ugly sound, here is a prettier sound, etc. And so she looks at their perception of timbre…

MW: It is contextual…

RvT: Exactly, and noise and sound, and how the western culture has from developed a difference between noise and sound. Whereas the Burundi music incorporates white noise as a musical element. And then she speaks about a very interesting Burundi music called *Whispered Inanga*. The *Inanga* is a type of zither, and the Burundi language is a tonal language, so the melodic contour of speaking has meaning. So with *Whispered Inanga* they communicate by whispering, but because whisper doesn't have a specific pitch, it is a white noise structure, so the tonal inflections are played on the zither, and the listener… sorry forgot to mention that when they make music they have the listener in mind, and so there is the performer communicating with the listener, and so because they are from the same culture they can communicate and have this musical language that they can communicate with gestures, and so the listener completely understands. And, is similar with bow music, where the mother would play the music to soothe the daughter, having the listener in mind, wanting the listener to feel soothed. And so with the *Whispered Inanga* they want the audience to understand what they are whispering and so they communicate, and the listener hears the combined timbre of the zither's overtones meshing with the white noise structure of the whispering, and so they hear that together.

MW: That is fascinating, for me, equal temperament ruined harmony, it really has in so many ways. It is one small part music.

RvT: It is such a civilized thing.

MW: Where the universe is not like that at all, much richer and much more imagination than we could possibly imagine.

RvT: So with my research I'm not sure if I want to go into the political context, but I want to find out if anybody has approached spectralism in an African way… like with the African idiom, how the whisper meshes with the zither, and meaning that is created, with soothing, knowledge of psychoacoustics, to combine all of these ways of technology that we have with an African idiom. And I know there are musicologists who are specific on what a South African approach is and how traditional music can be appropriated, but I don't want to get into the complicated nature of that. I just rather want to see if spectralists have approached music in an African way.

MW: Well, one of the other reasons why I said the elements are not limited by the constraints of a language defined by its cultural context, is music is acultural if you think of it as sound and gesture, it crosses those boundaries, for so long music has been as two debates, music is evolutionary phenomenon and the other is that music is a cultural phenomenon, and that is why we have the different musics, and I don't see it like that at all because we are dealing with physics, and if you are in the universe you are bound by physics.

RvT: Sorry to interrupt you, and that is true because of our psychology, what we hear is not reality, because the Gestalt our brain makes sense of frequencies that enter our ear.

MW: We are very visually based, which is a problem, that our auditory perception only adds to visual information, and that is why blind people see the world completely differently, you know… completely, just as a composer imagines movement its quite different from usually how someone who doesn't understand the context of the music perceives movement… but the interesting thing of the sound tracing is that it reveals that there are universal understandings of the shape of sound, and that is the physical phenomenon that is with us.

RvT: So you haven't composed with African music?

MW: No, but I am very interested in it. I am planning a project in August where we are going to use my heuristic to interface with the African instruments, and then do an electroacoustic piece, video gesture recognition piece with African instruments how mixed performance aspects of that is different from Western instruments, there is a research article waiting to be published on that.

RvT: And you are going to write that?

MW: Well certainly look at doing one. We have to write the pieces, change the heuristic to fit that instrumental context, do a performance, learn what the performance practice is of that mixed media environment and then write about that process and how it contributes to our understanding of these things. Certainly on the cards.

RvT: And you are going to use spectralism with that?

MW: I'd love to, I mean what could be, if you think of the sound of the piece of metal of the Kalimba makes, how many partials that is made up of, timbrally it is a unique sound, and how they tune?

RvT: How they tune, exactly, you could look at the data of how they tune, and retune the western instruments, it's not new to do that, Volans did that, but interesting and a great thing that he did.

MW: Yes, look composers are always indicating *scordatura* for strings when playing with traditional instruments, or to create a sound that fits with that context.

RvT: Because it is the reality, and might as well go with it. Thank you very much.

Interview with composer Miles Warrington held over Skype on the 15th of March 2016

RvT: When did you start working with technology?

MW: In the late 90s when I was studying with Jürgen Bräuninger, I did the electroacoustic course there and got my own computer and started working with sequencers and things. That was my first introduction to music tech and we did work in the old electronic music studio at the University of KwaZulu Natal.

RvT: So you say working with sequencers?

MW: Yes, sequencing with a DAW like Cakewalk, Digidesign which was the frontrunner to Protools.

RvT: So did you work with taking recordings and manipulating the recordings in the DAW or working with synthesized sounds?

MW: Yes, both, we experimented with granular synthesis with virtual synthesizers and then we made various electronic tracks by manipulating recorded material and using MIDI.

RvT: When did you start using PureData?

MW: Only at the beginning of my doctorate.

RvT: Was the first time you used spectralism, or taking spectral analysis and then writing the pitches for acoustic with *In-Gest?*

MW: Yes, and little bit in *Umsipha (2015) for orchestra*.

RvT: We discussed the spectral work found in *In-Gest* before, where would can one find spectral writing in *Umsipha?*

MW: Well if you have a look at the chord. Do you know what the piece is about?

RvT: No.

MW: The word *Umsipha* occurs in both isiXhosa and isiZulu. It means two different things in the different languages even though it is the same word. In isiXhosa it means a chord, as in a musical chord, and in isiZulu it means muscle. So the piece is a chord that flexes its muscle in a metaphorical way throughout the piece. The opening chord is the main chord and on page 27-28 [composition portfolio] where it starts with these high artificial and natural harmonics of the strings and the microtones in the oboes, the chords begin to meld in to further use of quarter tones and *glissandi* and representing the flexing of the muscle. The changing chord is based on spectral information gathered from the MIDI chord in Sonic Visualizer.

RvT: So you took a MIDI recording of the opening chord to spectrally analyse the content?

MW: Yes, well, I couldn't really use anything else. The chord builds up and is a spectral form of the chord.

RvT: A zoomed in form?

MW: Yes. It is not an absolutely pure spectral representation. There is spectral information there.

RvT: So did you take the original chord, zoom in and stretch the time out? A longer deeper version of it.

MW: Yes, in a way it is a longer version of it to make it different.

RvT: Generally, throughout the piece you have these parts where it is a sound-mass texture.

MW: There is no pure consonant chord throughout the work until the last chord which is a D-Major chord. On the last page is a massive version of the original chord before the resolution.

RvT: How did you work with Sonic Visualizer for *emanation-re-imagined-emanation (2015) for orchestra*?

MW: So the original recording was processed into Sonic Visualizer and a melodic range layer added to the spectrum in order to see the specific frequency and pitch. So by hovering the mouse over the sonogram one can see the precise frequency and get an idea of the dynamic intensity (amplitude). By doing so I worked very carefully and with some artistic licence of course.

RvT: How large is the snapshot in time?

MW: About 20 seconds. I worked in 20 second snapshots throughout the piece.

Appendix F – List of Audio Recordings

The recording of *Bells Die Out* (2013) performed by the Wet Ink Ensemble in .mp3 format

Letter of Permission from the composer Andile Khumalo

I, **Andile Khumalo**, composer of the work *Bells Die Out (2013) for ensemble*, hereby grant permission to Harm Roché van Tiddens to include the score for *Bells Die Out* as an Appendix to his Masters of Music in Composition thesis in fulfilment of the requirements for the degree of Master of of Music and to be completed in the year 2016, at Stellenbosch University. I confirm that the .wav recording of the performance in New York by the Wet Ink Ensemble may be included in the aforementioned thesis and that I have the necessary permission from the Wet Ink Ensemble to agree to this inclusion. Furthermore, I agree that the documents may be uploaded onto SunScholar, the open access digital research archive of the University.

Signed Date: 1/06/2016

Letter of Permission from the representative for the Wet Ink Ensemble, Alex Mincek

I, **Alex Mincek**, a representative for The Wet Ink Ensemble, performers of the work *Bells Die Out (2013) for ensemble* in New York City hereby grant permission to Harm Roché van Tiddens to include the .wav recording for *Bells Die Out* as an Appendix to his Masters of Music in Composition thesis in fulfilment of the requirements for the degree of Master of of Music and to be completed in the year 2016, at Stellenbosch University I agree that the documents may be uploaded onto SunScholar, the open access digital research archive of the University.

Signed Date: 1/06/2016