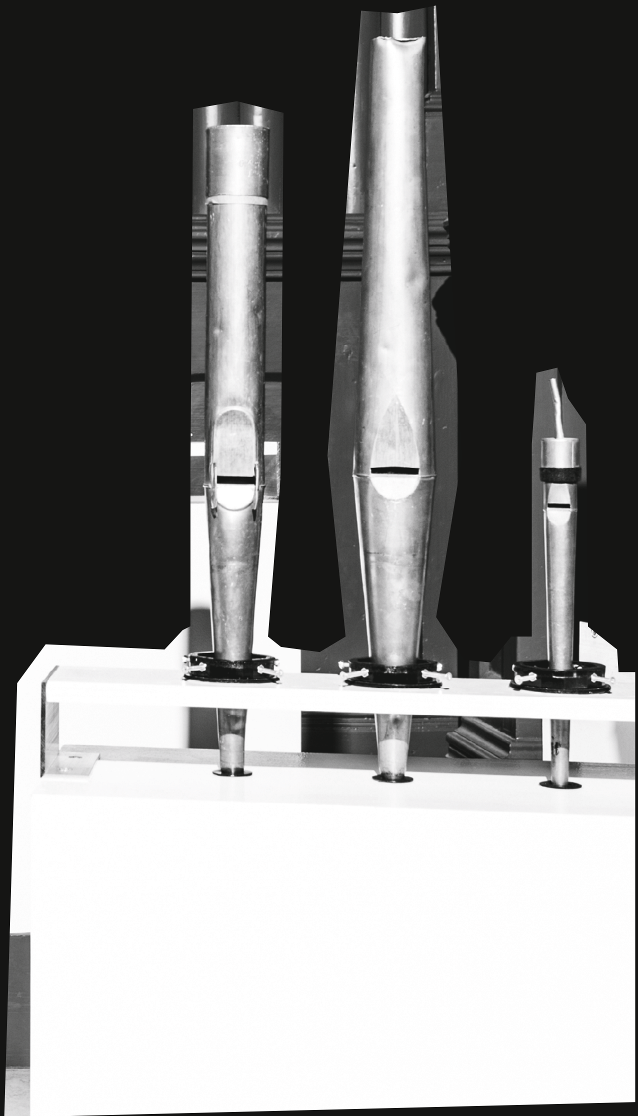
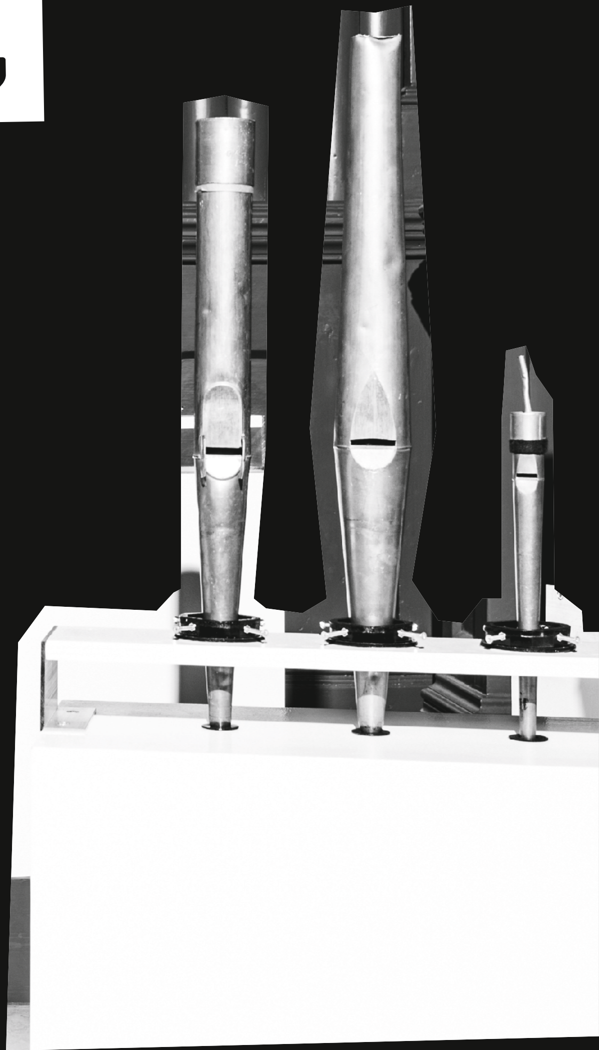
SIZZLING, HISSY, ERRATIC, AND BEATING.





BACHELOR'S THESIS
BY OSCAR PETERS,
INSTITUTE OF SONOLOGY
THE HAGUE, 2022

Acknowledgement

I would like to express my sincere gratitude to my mentor Gabriel Paiuk for advising on my thesis, encouragement, and guidance throughout this year. In addition, I would like to thank all my teachers for sharing their inexhaustible knowledge during the past years, and for their many inspirational lessons, and my fellow students and friends, for creating a memorable study environment. I sincerely thank Hans Kulk, who introduced me to the *Willem Twee Analog Studios*, where he inspired, taught and encouraged me during the years prior to my current education. And last, I would like to thank Stanny for all the support, love, and help with this thesis, and my family for the unconditional support that they have always offered.

Contents

Introduction

During the summer of 2016, I started experimenting with electronic music in the Willem Twee Analog Studios in ’s-Hertogenbosch. Within weeks, I was caught and obsessed by the big, old oscillators and filters that they have, and the *play* that instantly occurs within such a studio environment. The surgical precision and simplicity that every piece of equipment offered, combined with a sonic domain that was yet unfamiliar to me, radically shifted my attitude towards sound as a compositional parameter, the organisation of space, dynamics, and pitches. Besides that, this experience expanded my definition of music. During this period, I mainly investigated *Musique Concrète*, as I was very interested in these musical ideas. During that period I made several etudes, which were characterised by the use of sound-transformations in the analog studio domain. These transformations were made with e.g. tape recorders, bandpass filters and ring-modulators.

When I was introduced to a small pipe organ at the same venue a year later, I was struck by the variety of sounds that was produced by the instrument. Whilst having Pierre Schaeffer’s music-making aesthetics in mind, it was *play* that led me to explore the sonic potential of the organ, without having any cultural, historical or theoretical baggage that refrained me from carrying out these experiments. Whilst I am unable to play the organ in the conventional way, I mainly used beer coaters or tape, in order to sustain a selection of keys, which formed consonant harmonies, or large magnitude clusters. Hereafter, I would vary the *wind pressure*, in order to create dense—unstable—sound textures that I had never heard before. The compositional strategies that I had learned before in the analog studio, could be copied directly onto the organ. These include gestural or form related strategies picked up from Musique Concrète, or the translation from additive and subtractive-synthesis to *wind pressure* alternations.

> **Schaeffer had developed an aesthetic that was centred upon the use of sound as a primary compositional resource. The aesthetic also emphasised the importance of play (jeu) in the practice of sound based composition.**[1]

The richness of sustained clusters have the potential to fill up an entire acoustic space, and by introducing variable *wind pressure* (WP), you can make the—always majestically sounding organ—sound broken, but alive at the same time.

> **Some of the registers did not work at all, but it so happened that all the registers that did work, were the kind of registers that I loved, and they gave beats and combinations that were beautifully poetic, which I did not play.**

1 Dack, “Technology and the Instrument,” 39.

My favourite is when there are sonorities that I let continuum together, and they play themselves, and you think you hear them as arpeggios and enormous amounts of fluctuations that I am not doing at all. The sound is doing it with themselves.[2]

While my experiments in the analog studio endured, the organ seemed to be a complex, but spectrally rich sound source to use for sound manipulations within the analog studio domain. When processing pre-recorded sound clusters from the organ with filters, ring-modulation and tape recorders running on variable speed, I uncovered countless new sonic potential, and just like a child in a candy-store; I wanted it all.

Audio Example 1 *Bloom*. A composition that resulted from various processed audio recordings that were taken from the organ. *Bloom* was recorded in the *Willem Twee Analog Studios.*
www.oscar-peters.com/AE_01/

This fascination and joy caused by sound, composition and experiment, led me to enrol to The Institute of Sonology—a faculty within the Royal Conservatory of The Hague— in 2019. During the first year, I mainly expanded my knowledge within the analog studio, which resulted in several multichannel fixed-media works. However, during the second academic year that I spend at the Institute of Sonology, I made two new works, which both orbited around the organ. Hereafter, the organ—and its sonic potential within the context of contemporary electronic music—would continue to play an important role in my artistic output. For example, this continuing and growing fascination for the contemporary organ led me to built six experimental organs in 2021.

The aim of this paper, is to investigate the musical and cultural context that led to a *New Organ Music*. This term describes a movement that originated during the 1950s. The term is used to describe organ music that was conceived within a modernistic perspective, and is associated with composers such as György Ligeti, Bengt Hambraeus and Mauricio Kagel. I will closely examine the cultural role that the contemporary organ played within avant-garde music, and see what parallels we can discover with electronic music, which was also being developed during the 1950s. The organ—more often than not—has its roots in the sacred space, but for this thesis, I will solely look at non-liturgical organ music that was conceived in a modernistic perspective, and which focused on the exploration of new sound colours, rather than melody and harmony.

Later in this thesis, I will introduce and analyse my self-designed instruments, and explain how they relate to the musical aesthetics that will be presented within the first chapter. During this part of the thesis,

2 Palestine, interview.

I will also make a parallel between my work, and some monumental organ works such as György Ligeti's *Volumina*. However, before I arrive there, I will give several examples on the topic of instruments design, and discuss the dialogue—or the lack of dialogue—between the composer-performer and inventor.

During the first chapter—***In search of new [organ] music***—I will research the historical context in which ***New Organ Music*** originated, and will precisely analyse and define the methodology and sound properties that were unveiled. In order to get a better understanding of this context, we will look at e.g. the relation between the Darmstadt summer course lectures, and influences from Gottfried Michael König during György Ligeti's time in the WDR studios in Cologne.

The extensive amount of documentation that is available on Ligeti's *Volumina* makes it useful to analyse this work in depth, and will function as an example throughout the first chapter of this thesis. Apart from written descriptions of the methods that are presented in e.g. *Volumina*, an extensive spectral analysis is presented, in order to give a better understanding of the behaviour that characterises *New Organ Music*.

The second part of this thesis—***The composer-performer, and Inventor***—evolves around the dialogue between composer-performer and the inventor. Along these lines, I'll look at some exemplary organ designs, their inventors, and examine to what extend these inventions have been affected by compositional or performative aspects. In addition to that, I will introduce my self-designed organs and motivate how they relate to the *New Organ Music* aesthetics that are described within the first chapter. I will present an extensive technical overview, and discuss several considerations that were made during the process. Furthermore, I will present a spectrum analysis—similar to the analysis presented in chapter 1.4—that was taken from a single flue pipe which was activated by one of my instruments. Through this analysis, I will make a comparison between my instruments and the contemporary organ.

The third, and last chapter—***From the instrument to the musical domain***—an analysis of recent works—provides two analysis's of recent artistic works: *Staande Golf* and *Breath*. *Staande Golf*—a sound installation that was exhibited in *Museum Het Valkhof* (July, 2021)—explored a strategy of stochastic algorithmic processes, and spatial distribution that implicated the acoustics of the exhibition space. *Breath* is a 44 minutes long composition—which was live performed during *November Music* (November, 2021)—that combines twenty-five computer controlled organ pipes with live electronics and a small contemporary organ. I will provide an overview of several strategies that were used throughout the compositional processes, and investigate how they correlate with the musical aesthetics that are presented within the first chapter of this thesis.

1 | In search of *New Organ Music*

1.1. 1950s—From Darmstadt to Bremen

In contrast to composers who would later define the avant-garde music, almost all composers who wrote for solo organ during the first part of the twentieth-century, did not abandon the musical aesthetics of the nineteenth-century. They were left untouched by progressive and neo-classical tendencies, and many composers of that orientation have fallen into oblivion.[3] In the European context, Olivier Messiaen (1908-1992), could be seen as a key figure amongst other major composers who attempted to write modernistic music for solo organ.[4]

During the 1950s, Olivier Messiaen—who had been teaching at the 1949 *Darmstadt ferienkurse*—had been occupied with serial procedures and Webern's employment of twelve-tone music.[5] While he—and his environment—had been occupied with serial procedures that organised musical parameters such as pitch and rhythm, Messiaen—also known for his extensive analysis's—had developed a new rhythmical language based on analysis's that he derived from Stravinsky's music. In addition, he had been influenced by Greek and Hindu rhythms. This—combined with his studies on serial procedures—resulted in two works for solo organ in 1950 (*Messe de la Pentecôte*) and 1951 (*Livre d'Orgue*). Even-though these modernist organ works composed by Messiaen were not very popular or often played by organists at the time, they were unique in the use of rhythm and unorthodox registers combinations. These unorthodox register combinations resulted in sound colours that were not common at the time and clearly contradicted with earlier—nineteenth-century—aesthetics in organ music.[6]

Even-though Messiaen's *Messe de la Pentecôte* (1950) and *Livre d'Orgue* (1951) do not present the same sound material as e.g. Ligeti's *Volumina*, the works by Olivier Messiaen can be seen as critical influences for the works that would later be produced by Bengt Hambraeus. Hambraeus—who would later inspire Ligeti for his monumental work *Volumina*—decided to study at the *Darmstadt ferienkurse* in 1951, to learn about developments in contemporary music. A year later—during the same summer course—he would meet Olivier Messiaen, which led him to study twelve-tone music. His introduction to twelve-tone music would drastically influence his compositional style.

Hambraeus's renewed compositional approach could later be heard in *Permutations and Hymn* (1953). This work for solo organ, combined twelve-tone music—that he had learned from Messiaen in Darmstadt—with several unconventional organ register combinations. The latter displayed his interest in sound colour, and—for that time—unorthodox register combinations.[7] These mixtures—called *Spaltklang*—relied on large gaps within the used registers, such as 16'+ 2', 16' + 1' or 32' + 2'. The last register

3 Busch and Herchenröder, "The German Speaking Lands," 1.

4 Gjerde, " The Forbidden Organ Concert," 3.

5 Delaere, "Olivier Messiaen's Analysis Seminar and the Development of Post-War Serial Music," 35.

6 Gjerde, " The Forbidden Organ Concert," 3.

7 Herchenröder, "From Darmstadt to Stockholm," 309.

combination, combines a *thirty-two* foot register with a *two* foot register, which adds up to a difference of four octaves. Inspirations for these combinations can be found in Messiaen's organ cycles (early 1950s).[8]

Six years after Hambraeus's *Permutations and Hymn* (1953), he conceived a new composition, called *Constellations 1.* This work had a clear focus on the development of the sound material—through the use of sound clusters—rather than twelve-tone music, and was *"sometimes almost sounding like electronic music."* [9] Apart from experimenting with clusters, Hambraeus had included rhythmical notations that specified additions and subtractions of certain register stops. Besides that, he specified organ stops that were only partially pulled. The latter results in sound colours that were—for that time—uncommon to the instrument,[10] but would have a great impact.

Later that year, Bo Wallner—a Swedish musicologist—presented *Constellations 1* during a special *Swedish evening* at the Darmstadt *ferienkurse*. During this event, a tape-recording of Hambraeus's *Constellations 1*, reached the ears of György Ligeti. Soon after, Ligeti established close contacts with the Swedish avant-garde, amongst whom was Bengt Hambraeus. When in 1961, both composers were commissioned by Hans Otte—head of the contemporary music department of Radio Bremen—to contribute new organ works for a concert series called *Pro Musica Nova*, Ligeti and Hambraeus came together and discussed new possibilities for solo organ compositions.[11]

1.2. 1962—The Forbidden Concert

Before 1961, organ music had progressed within the shadows of contemporary, avant-garde music. Composers like Luciano Berio, Pierre Boulez, John Cage, Luigi Nono, and Karlheinz Stockhausen had not written for solo organ.[12] Arnold Schönberg—who had been working on avant-garde music in the post-war era—had declared the organ to be outdated as early as 1906, and in 1949 he would write that the contemporary organ simply doesn't fit his musical aesthetics, because the instrument lacks dynamic expression.[13] Even-though they would later abandon the instrument, many composers who would define the avant-garde, studied organ music before. For example, Stockhausen conducted his first music studies with protestant organist Josef Kloth. However, the relationship between church and avant-garde composers—and other artists that identified themselves with these renewed, avant-garde aesthetics—was in decay. As the avant-garde attempted to make new art through free experimentation, they cut their ties to previous artistic and cultural traditions. This included the conservative—mostly catholic—church.

---

8 Herchenröder, "From Darmstadt to Stockholm," 310.

9 Idem, 311.

10 Gjerde, " The Forbidden Organ Concert," 8.

11 Herchenröder, "From Darmstadt to Stockholm," 312.

12 Herchenröder, György Ligetis Orgelwerke: Struktur und Assoziation, 129.

13 Eidenbenz, Glaus and Kraut, *Fresh Wind*, 91.

Another reason for the absence of the instrument's presence within avant-garde music, could be that most organ music around that period was still perceived within a liturgical context. Obviously, the fact that the organ was almost always located within the sacred space, contributed to this—lack of—development.

However, the attitude towards the instrument radically changed on May 4, 1962, during a concert that was part of the *Pro Music Nova* concert series. Concert director Hans Otte commissioned three composers to conceive modernistic compositions for solo organ, which were initially set to be performed during a concert in the Bremen cathedral. But as the suggested program was found to be too radical by the church council, the concert was cancelled. However, it was not because of the radical nature of the organ compositions that the event was cancelled. Hans Otte's *Alpha-Omega*—which was also part of the program—included a choreography, which was found to be—as decided by the church council—inappropriate to perform in a sacred space. As a result of this, the concert concluded in a concert hall within the Radio Bremen building, with tape-recordings of the commissioned organ works.[14]

> **The church authorities in the Bremen cathedral vetoed the concert in the last minute. ...Because I—Hambraeus—was at that time working at the Swedish Broadcasting Corporation, it was possible to arrange, with very short notice, a recording of the three organ work in Sweden. As the most suitable equivalent to the Bremen cathedral organ, we decided to use the Gothenburg Concert Hall. ... But as soon as Welin started to play the eruptive beginning of Ligeti's work, some vital fuses blew, with resulting short-circuit in the electric transmission system. Within a couple of hours, a contingency plan had to be organised, with the result that we could have immediate access to two different churches in Stockholm (450 kilometers from Gothenburg!) And as quickly as possible move the organist, his assistants and recording technicians to the other city. The two organs were chosen because they together could provide approximately the same sound as we would have in Bremen or Gothenburg. ... Welin recorded all three works twice on the respective organs in the St. John and Gustav Wasa churches in Stockholm, after which the technician synchronised the takes, featuring certain sonorities from respective instruments. The result: a hybrid organ emerged under desperate and bizarre conditions.** [15]

The fact that the—forbidden—concert concluded in this particular format, raises many questions on my end. While I assume that these choices were made out of absolute necessity, we can still speculate about the sonorous, and psychological effects this had on the listener—as the concert setting shows interesting similarities with *Acousmatic music*. The latter is a form of electroacoustic music that was

14 Gjerde, " The Forbidden Organ Concert," 8.

15 Hambraeus, *Aspects of Twentieth-Century Performance Practise*, 129-130.

developed during the late 1940s, within the compositional tradition of Pierre Schaeffer's *Musique Concrète*. Through this listening method, the source—cause relationship is decoupled, allowing people to listen—without any predetermined expectations caused by cultural or historical connotations—solely to the sound that emerges from the loudspeaker. In addition, *Acousmatic music* tends to prioritise the development of sound-colour and spectrum, rather than the traditional western musical pillars—which are harmony, melody, rhythm. The resemblance between these specific musical aesthetics and the form in which the compositions were presented in the Radio Bremen concert hall, is striking. However, as I said earlier, we can only speculate about possible intentions, effects, and affects, since there are no writings on this particular topic.

> **The word—Acousmatic—was taken up again by Pierre Schaeffer and Jérôme Peignot to describe an experience which is very common today but whose consequences are more or less unrecognised, consisting of hearing sounds which no visible cause on the radio, records, telephone, tape recorder etc.Acousmatic listening is the opposite of direct listening, which is the "natural" situation where sound sources are present and visible. The acousmatic situation changes the way we hear. By isolating the sound from the "audiovisual complex" to which it initially belonged, it created favourable conditions for reduced listening which concentrates on the sound for its own sake, as sound object, independently of its causes or its meaning.** [16]

Shortly after the Radio Bremen concert, Swedish organist Karl-Erik Welin successfully premiered *Volumina*, in the Westerkerk, Amsterdam. By this time, news of the short circuit had given the work an infamous association with danger and scandal.[17]

The Radio Bremen event marked a shift in attention towards the instrument. Other composers—that did not show any interest for the instrument before, suddenly wanted to write for solo organ. They became interested in the organ *"as they became interested…in the treble recorder, the harpsichord, the accordion, or electronic music"*. [18] The latter is an interesting paradigm shift, as the majority of composers around that time, strictly composed for instruments that had a history within an orchestral or classical music context. The listed instruments—including the organ—do not have such a history, and have different cultural connotations. For example, even-though the accordion has a rich history within folk tradition, the instrument had always existed outside the scope of orchestral, classical, or avant-garde music. But if we look at electronic music—or the treble recorder—we cannot identify such musical traditions whatsoever. However—in retrospect—the 1950s marked the beginning of such a rich musical tradition.

---

16 Kane, *Sound Unseen*, 4.

17 Levy, *Metamorphosis In Music*, 136.

18 Herchenröder, "From Darmstadt to Stockholm," 314.

Radio Bremen Concert, 4 May 1962; left to right, Hans Otte, Mauricio Kagel, György Ligeti, Bengt Hambraeus (composers); Karl-Erik Welin (organist), Bo Nilsson, Giuseppe G. Englert (assistants). (Herchenröder, “From Darmstadt to Stockholm,” 304.)

During the *Pro Musica Nova* concert, three momentous compositions for contemporary organ were premiered: György Ligeti’s *Volumina*, Mauricio Kagel’s *Improvisation ajoutée*, and Bengt Hambraeus’s *Interferenzen*. These three compositions can be seen as landmarks within the establishment of *New Organ Music*—also referred to as spectral organ music.[19] Although most writings on this topic refer to this specific movement as *New Organ Music*, I prefer the term *Spectral Organ Music*. The latter emphasises the most significant characteristic of this music, which is the development of unusual sound colours that contrasted with earlier organ music traditions. In addition to that, I find the use of *Spectral Organ Music* more relevant if we speak about recently conceived organ music. For example, I would define my recent work *Breath*, as a spectral organ piece. The latter will be presented in Chapter 3.2.

Where past compositions written for solo organ focussed on the development of melody and harmony, the three earlier mentioned composers explored the nature of the instrument, as they searched for new dynamic, timbral, tonal, and non-harmonic musical parameters. These works explored sounds that had always been part of the contemporary organ, but were seen as mechanical, undesired noises. For example, the use of *half-pulled register stops* in order to create gradually changing sound colours, uncovered a new sound potential, that had previously always been seen as an undesirable side effect of mechanical parts.

19 Busch and Herchenröder, “The German Speaking Lands,” 60.

Similar *extended*-technique strategies had been executed before in instrumental music by the earlier mentioned post-war avant-garde composers, but had never occurred in organ music. Wolf-Eberhard von Lewinski, a German music critic who had witnessed the event would later write, *“Really new, much more revolutionary than anything Messiaen has attempted in this field.”* [20]

1.3. New Materials

If we listen to *Volumina*, *Interferenzen* and *Improvisation ajoutée*, we hear that all three works explore the use of non-melodic and non-harmonic sound structures in order to develop new sound colours. The use of tone clusters or sound-masses—as Ligeti referred to these sound materials—was critical in order to avoid tonal and harmonic relationships, and create abstract—seemingly electronic sounding—complex sound colours.

> **“Tone clusters, a theoretical conception of sound founded by Henry Cowell in the early 1910’s,”** [21] **could be seen as a turning point in Avantgarde music. “Tone clusters marked a turning point in music history: they make up chords which are characterised by noisiness in opposite to tonal-ness”.** [22]

Even-though composers like Iannis Xenakis (*Metastasis*, 1955) and Krzysztof Penderecki (*Threnody to the Victims of Hiroshima*, 1959), are known for their adaptation of tone clusters in instrumental music, the use of these techniques remained mostly unprecedented within scope of organ music. Since the 1950s, Bengt Hambraeus—who can be seen as one of the most significant figures of Nordic avant-garde—had been experimenting with tone clusters on organs. His first experiments can be heard in his innovative Constellations 1 (1958), which functioned as the departure for his work *Interferenzen*. Besides that, *Constellations 1* can also be seen as the main inspiration for Ligeti’s *Volumina*.[23]

However, Ligeti’s inspiration for *Volumina*, could also be traced back to the electronic music studio at the *Westdeutscher Rundfunk* in Cologne. During his period at the WDR studio, he worked closely together with Gottfried Michael Koenig and Karlheinz Stockhausen—who were the most decisive influences on Ligeti’s electronic work.[24] Ligeti studied electronic music composition in the WDR studios from 1957-1958, and during that period, he realised three works. Two of these works—*Glissandi* (1957) and *Artikulation* (1958)—are

20 von Lewinski, “Die Orgel als Elefant oder Königin,” 20.

21 Ong and Kopiez, *The Perceptual Similarity of Tone Clusters*, 1.

22 Idem, 1.

23 Busch and Herchenröder, “The German Speaking Lands,” 61.

24 Iverson, “Historical Memory and György Ligeti’s Sound-Mass Music,” 88.

well-known. But a third work, *Pièce électronique Nr. 3* (1957), remained unfinished.[25] However, this piece—which was initially titled *Atmosphères*—could be seen as an important step, that lead Ligeti to transfer ideas from the electronic domain into the acoustic domain.[26] Even-though *Pièce électronique Nr. 3* utilises additive-synthesis for the majority of the piece,[27] it can be seen as an important step for later acoustic sound-mass works such as *Atmosphères* and *Volumina*.[28]

Compared to the instruments that were used within *Atmosphères*, the organ is fairly unique when it is used in combination with sustained tone clusters. Because of its 'mechanical lungs', the organ is capable of sustaining notes indefinitely, whereas for example, a string instrument can only be excited for a limited amount of time. Because of this mechanical property, I would suggest a certain similarity to the electronic domain, where a similar sound cluster could be constructed by using additive-synthesis. An example of such—electronically constructed clusters—can be heard in Ligeti's *Pièce électronique Nr. 3.* However, these similarities only apply within the boundaries of spectral characteristics. If we look at the micro-temporal capabilities of the organ, we must conclude that it is not as flexible as many electronic devices, which are generally capable of achieving radical micro-temporal changes through modulation, or hand-performed interventions. Whereas the contemporary organ was initially designed to perform binary *on* or *off* key-actions.

If we look at the instructions[29] that are provided for *Volumina*, we see that Ligeti has given us a very detailed overview, from which we can learn, and understand how he translated his visually drawn sound-masses onto the organ manual. These instructions are not only essential in order to obtain a better understanding of *Volumina*, they also provide a blueprint of the *extended*-techniques that appear and coexist in Mauricio Kagel's *Improvisation ajoutée*, and Bengt Hambraeus's *Interferenzen*.

To perform the clusters in *Volumina*, the interpreter can be supported by one or two assistants. As the interpreter is physically unable to cover the complete magnitude of the largest clusters—which are spread-out over multiple manuals—the assistant(s) can help to cover some of the unattended areas. However—as Ligeti specifies in the instructions—the interpreter is able to perform *Volumina* without using an assistant, but with help of *bleigewichte*. These are lead weights that are used to sustain a selection of keys on the organ manual. The amount of weights can vary, depending on the number of assistants and manuals.[30]

---

25 *Pièce électronique Nr. 3* was completed in 1996, by Kees Tazelaar and Johan van Kreij at the Institute of Sonology, The Royal Conservatory of The Hague.

26 Iverson, "Historical Memory and György Ligeti's Sound-Mass Music," 90.

27 Idem, 95.

28 Idem, 91.

29 Ligeti, *Volumina Für Orgel,* Spielanweisungen.

30 Idem.

> **Depending on the width of the cluster, fingers, palms, or the edges of the hands and forearms are used.** [31]

About the earlier mentioned *bleigewichte*, no substantial documentation could be found. However, as they seemed highly functional, I wanted to investigate this particular playing-method, and see how this would effect my experiments. So far I had been using e.g. tape, in order to sustain clusters, but that did not allow for much flexibility or rapid changes. After several experiments, I developed twenty-four 3D-printed enclosures which were filled with lead hail (Figure 1.1). The measurements were defined by both the volume of hail that provided sufficient weight, and the size of the keys. These weights had a great impact on the manner in which I interacted with the contemporary organ. The use of these 'simple' weights enable me to make quicker changes, and proved to be very helpful during live performances.

Figure 1.1. Lead weights sustaining several keys on the organ manual.

If we look at *Volumina's* instructions, we see that Ligeti provided a thorough overview of the different types of clusters that are use throughout the work. These clusters each differ in their harmonic configuration, magnitude or dynamic behaviour. While the presented illustrations are specific to Ligeti's *Volumina*, the methods that were used are not.

Figure 1.2, shows three cluster types which are defining the opening and ending parts of *Volumina*. These clusters are static, and each have a different harmonic configuration. Each cluster has a certain range (e.g., C1—C3), which is specified within the score.

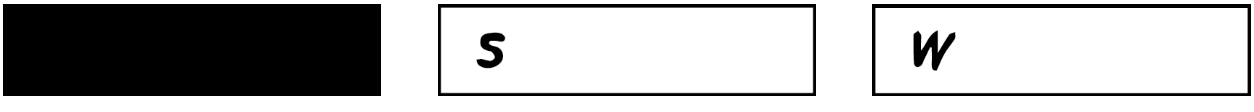


Figure 1.2. Left to right: Chromatischer Cluster, Diationischer Cluster, Pentatonischer Cluster (Ligeti, *Volumina Für Orge*l, Spielanweisungen.)

31 Ligeti, *Volumina Für Orgel*, Spielanweisungen.

In the *chromatic* cluster, all successive keys are sustained simultaneously (e.g., C1, C#, D, D#, E, F, F#, G, G#, A, A#, B, C2). Within the second cluster type, which is *diatonic*, all white keys—*untertasten*—are being sustained (e.g., C1, D, E, F, G, A, B, C2). The last cluster has a *pentatonic* configuration, in which all black keys—*obertasten*—within a specified range are utilised (e.g., Gb1–Ab–Bb–Db–Eb–Gb2). The harmonic contents and dynamic behaviour of these clusters are static, but they can be gradually built-up or phased out. Figure 1.3, displays a movement, that starts with a static chromatic cluster, but gradually transforms into a diatonic cluster. In order to achieve this gradual change, all black keys should be released as evenly as possible, starting at the lowest note.

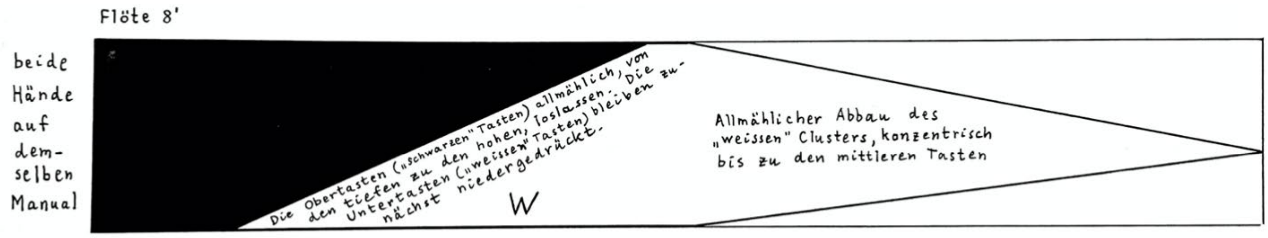


Figure 1.3. A chromatic cluster that gradually shifts into a diatonic cluster. (Ligeti, *Volumina Für Orgel*, 5.)

> **To gradually break down the very broad initial cluster. In [3], the left elbow first, then the left arm, left hand, right hand, right arm and right elbow in turn gradually slide from the position of "upper keys lower keys together" to the position of "lower keys only," so that the upper keys are released one after the other as evenly as possible.** [32]

In addition to the earlier described stationary clusters, Ligeti used clusters that are defined by their movement. Within these moving clusters, we can distinguish two separate entities: clusters with *moving contours*, or *internal movements*. The cluster with moving contours (Figure 1.4) has a *chromatic* harmonic configuration, but the interpreter should prioritise the overall curves of the cluster. Therefore—as noted by Ligeti—the player is allowed to miss several keys within the specified chromatic range. Performing this specific cluster also introduces a certain *limited* amount of improvisation.

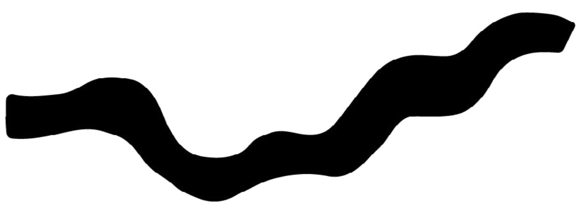


Figure 1.4. Cluster with moving contours. (Ligeti, *Volumina Für Orgel*, Spielanweisungen.)

Figure 1.5. Cluster with internal movements. (Ligeti, *Volumina Für Orgel,* Spielanweisungen.)

32 Ligeti, *Volumina Für Orgel*, Spielanweisungen.

The last cluster type that Ligeti introduces in *Volumina*, is defined by *internal*—fluid—*movements* (Figure 1.5). Within these specific clusters, both white and black keys are used, and therefore, there is a strong sense of *chromaticism*. Similar to the cluster with moving contours, improvisation within the given limits is possible. This same cluster, is also introduced in a different configuration throughout *Volumina*. Within this different appearance, the interpreter should play the internal movements in staccato notes. The introduction of staccato notes creates an interesting contrast throughout the piece, as the majority of *Volumina*, orbits around a gradual flow, rather than quick movements.

1.4. Fresh Wind

From 1956 to 1957, Ligeti had worked and studied electronic music in the WDR studios, and it was not until then, that Ligeti came into touch with compositional strategies that were connected to electronic music. In most cases, these strategies were specifically designed with the aim to gain compositional control over the electronically produced sound colours.[33] These strategies include procedures such as additive-synthesis, filtering, and *Bewegungsfarbe*. During the two years that Ligeti worked in the WDR studios, he worked closely together with Gottfried Michael Koenig. This eventually lead him to assist Koenig on the realisation of Essay in 1957, which allowed him to analyse and study Koenig's concept of *Bewegungsfarbe*.[34] Ligeti's understanding of the "*perceptual blurring phenomenon of Bewegungsfarbe seemingly offers a methodology for melding discrete articulations into a continuous sound in micro polyphonic passages*." [35]

> **About Essay, Ligeti wrote: "Koenig's Essay includes successions of sinusoids forming at certain moments melodic lines that one can follow, but that at other moments appear as strange agglutinations created by the briefness of the sounds and the rapidity of their succession."** [36] **And also: "To the ear, the impression given by these sound constructions is strange—we did not have before any aural experience of entangled sounds. [...] When we fall into the domain of time values whose shortness brings us to the threshold of fusion [that is, according to Ligeti, of successions of sounds shorter than around 50 milliseconds], we obtain not only the illusion of a simultaneity of attacks that, in fact, are successive, but also a new sound quality that Koenig names "timbre of movement" (Bewegungsfarbe)."** [37]

33 Iverson, "The Emergence of Timbre," 85.

34 Koenig, "*Process and Form: Selected Writings on Music,*" 16.

35 Iverson, "The Emergence of Timbre," 86.

36 Ligeti, *Neuf Essais sur la Musique*, 181. As quoted in Koenig, "*Process and Form: Selected Writings on Music*," 16.

37 Ligeti, *Neuf Essais sur la Musique*, 187. As quoted in Koenig, "*Process and Form: Selected Writings on Music*," 16.

Ligeti utilised Koenig's compositional method of *Bewegungsfarbe*—also referred to as moving sound colours—in *Pièce électronique Nr. 3*, which is built up from a similar sine wave structures.[38] Later—while further exploring the concept of *Bewegungsfarbe*—Ligeti would develop his own adaption of this concept, which he would map onto the acoustic realm. Even-though Ligeti's interpretation of *Bewegungsfarbe* does not entirely meet Koenig's description, the compositional approach that was designed in order to gain control over the moving, changing sound colours is similar. Apart from that, Koenig's concept of *Bewegungsfarbe* was specifically designed to be used within the electronic studio domain, and thus I believe that it is unavoidable to leave some aspects open to interpretation whenever such strategies are adapted within other musical contexts. Ligeti's adaptation of this concept can be heard, in *Apparitions* (1960), *Atmosphères* (1961), and *Volumina* (1692).[39]

If we look at *Atmosphères*, we see that superimposed individual instruments were subject to micro polyphonic passages, in order to develop sound colour. However, in *Volumina*, Ligeti uses a combination of sound clusters and micro polyphonic passages, as a result of WP (*wind pressure*) alternations. While making use of the organ's capability of sustaining notes indefinitely, Ligeti explores gradual change of colour by varying the WP. This combination allowed Ligeti to gain compositional control over the resulting sound colours.

> **In organs with a mechanical stop, the register buttons can be pulled out or pushed back gradually ad libitum, even in places where this is not specifically noted in the musical text: it is important to use the possibilities of the mechanical organ to produce "intermediate sounds" with fluctuations in intonation, as far as possible to use in many ways. Since the cluster technique creates complex swellings and non-harmonic sound components anyway and the sound of the entire piece is therefore neither harmonic nor tempered, the additional "impurities" created by playing possibilities are welcome for the character of this music.** [40]

If we look at WP variations, there are two methods that can be used. The most common method uses the register stops in order to gain control over the amount of wind that reaches the pipes. This method can be executed fairly precise, especially if we compare this to the second method. Apart from controlling the register stops, the interpreter—or assistant—can turn *on* or *off* the wind motor, whilst sustaining a certain cluster. The latter is rather binary, and does not allow for much control. However, if we look at *Volumina*, we see that Ligeti utilises this method during the beginning and ending of the work.

38 Koenig, "*Process and Form: Selected Writings on Music*," 17.

39 Herchenröder, *György Ligeti's Orgelwerke*: *Struktur und Assoziation*, 45.

40 Ligeti, *Volumina Für Orge*l, Spielanweisungen.

If we look outside the scope of *New Organ Music*, register stops were used in a rather binary fashion. A register was either fully enabled [1]—sounding ever so majestically—or disabled [0], and thus not sounding at all. But by introducing *half-pulled register stops*, the interpreter—or assistant—gained control over the amount of wind that reaches the organ pipes within a chosen register. Organ pipes are intonated according to the amount of 'fixed' WP that is produced by the wind motor, and are not intended to be used with a fluctuating WP. Therefore, the speech of an entire register is altered whenever the amount of provided WP is less than expected.

If we listen to the sonic effects that are caused by this procedure, we hear a correlation between WP, and parameters such as dynamic behaviour, sound colour and pitch. The dynamic response to an increase or decrease in WP, results in an almost linear relationship between WP and amplitude. This gave Ligeti the possibility to make dynamic changes throughout *Volumina*, to which he refers as *Register-diminuendo, Register-crescendo*. This discovery was significant, especially since composers such as Arnold Schönberg had declared the organ to be irrelevant due to the lack of dynamic expression.

Audio Example 2 A recording of a cluster (Figure 1.1) that is affected by an increasing WP.
www.oscar-peters.com/AE_02/

If we look at the correlation between WP and sound colour, we discover that the sonic behaviour of a flue pipe is quite divers. If the amount of WP is being slowly increased, we can roughly describe two stages of behaviour. During the first stage, no fundamental frequency can be perceived, and this behaviour can best be characterised as *unstable* and *erratic*. The audible results can be described as *noisy*, and *sizzling*. If the WP now slightly increases, the fundamental frequency becomes audible, but without producing any additional harmonics. Therefore the waveform is sine wave-like, and sounds radically different that a flue pipes *intended* sound colour. From this moment forth, any increase in WP will result in additional harmonics. The correlation that is described here, can be compared to additive-synthesis or—in its reversed capacity—subtractive synthesis. These are two procedures that Ligeti had studied and used during his period at the WDR studios in Cologne.

Apart from the changes that occur within the dynamic behaviour and sound spectrum, we can discover a third—and last—correlation. If we look at the pitch, we see that a flue pipe roughly modulates a semitone down, accordingly to the provided WP. This means that a flue pipe (C3) will speak properly tuned whenever the register stop is fully pulled, but will decrease in pitch (towards B2) if the WP starts to decrease.

Now, having explained the effects on each individual parameter (*volume, sound colour, pitch)*, we should understand that these three phenomena always appear simultaneously. In addition to that, these procedures effect an entire register at once, and do not give the interpreter control over each individual flue pipe. This means, that a decreasing WP will result in a simultaneous loss of volume and pitch, and will show a gradual decay of the harmonic spectrum.

Slow diminuendo, which occurs by itself when the wind pressure decreases. [41]

1.5. Spectrum Analysis

Besides presenting a written description of the audible effects that are caused by WP fluctuations, a spectrum analysis will be presented as well. The recording that was used during this analysis, was made on a small organ, which is located within the *Willem Twee Toonzaal*. During the recording, the organ's four foot *Prinzipal* register was used. The recording was made with an A-B microphone setup, while using two Neumann KM184 cardioid condenser-microphones. These microphones were routed to Ableton, through a simple audio interface. Between both microphones, a 17 centimetres spacing was introduced, and the A-B setup was placed on a 150 centimetres distance from the flue pipe. In order to filter out rumble, frequencies below 200 Hz were cut out, in order to get a better spectral representation of the flue pipe.

Audio Example 3 The recording that was used for this analysis.
www.oscar-peters.com/AE_03/

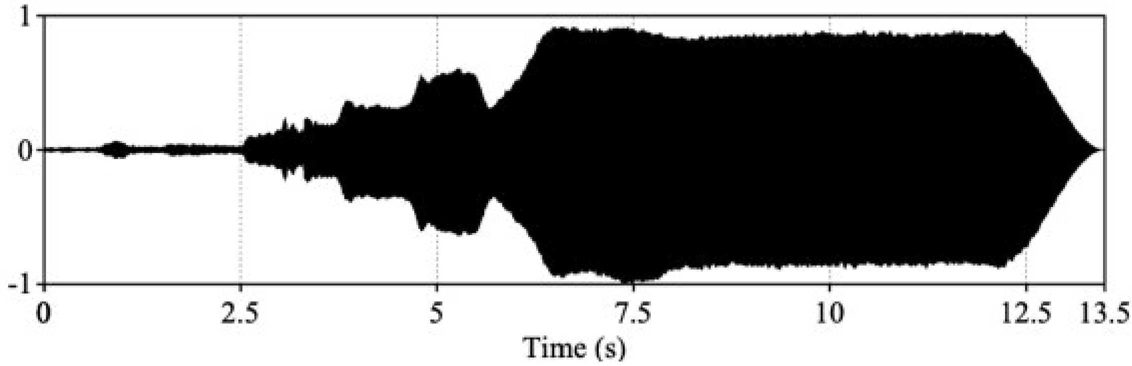
The analysis (Figure 1.6) shows a recording of a flue pipe [note D, 585 Hz] which is modulated with an increasing WP that ranges from 0 to 100% within a timeframe of 13,5 seconds. As mentioned earlier, we can describe two stages when we increase the WP from 0 to 100%. The first stage [0-3 seconds] is characterised by highly unstable behaviour, and the sounding effects can be described as noisy and unpredictable. The jet-stream that is needed in order to produce a fundamental pitch is not present, and during this stage, the turbulent wind creates resonances around the opening of the organ pipe. The corresponding spectrograph (Figure 1.7) shows an irregular spectrum, in which we cannot identify any fundamental pitch. This is being confirmed by the pitch analysis (Figure 1.8), which shows an indeterministic curve for this first stage.

The second stage is characterised by—what Ligeti refers to as—'intermediate sounds'. During this stage, the harmonic spectrum unfolds, and both volume and pitch increase. When we look at the beginning of the second stage [3 seconds], we see that the irregularity—which characterised the first stage—disappears, and that we can visually extract a fundamental frequency. This is proven by the corresponding spectrograph (Figure 1.9), that shows us the fundamental frequency, without any additional harmonics. Due to the absence of additional harmonics, this results in a waveform which is sine-wave-like. The first fundamental [at 3 seconds] has a pitch of approximately 560 Hz—which is 6 Hz higher than a C#.

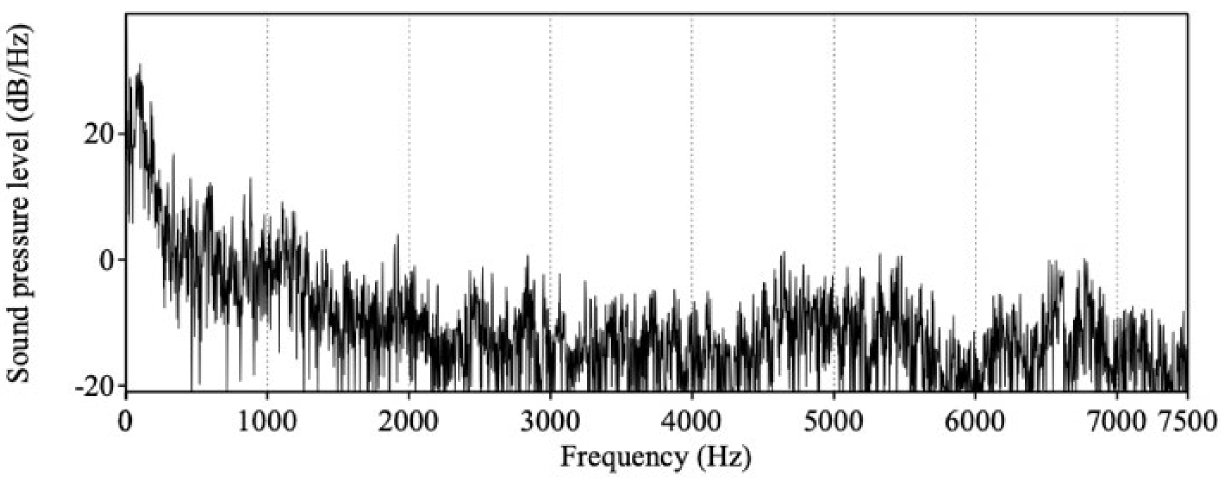
If we look at the last seconds of the recording—where the WP is increased until 100%—we find yet another important difference. Were the previous example only contained the fundamental frequency, we

41 Ligeti, *Volumina Für Orgel*, 22.

now find a spectrum that contains all harmonics (Figure 1.10). As the flue pipe is intonated according to this WP, the speech of the flue pipe is now as it was intended for. Therefore there are no more *anomalies*, or *intermediate* sounds present. In addition, we see (Figure 1.4) an increasing amplitude, a relationship that is inherent to the increasing WP.



| *Figure 1.6*. Waveform of the recording.



| *Figure 1.7.* Spectrograph. 0-3 seconds.

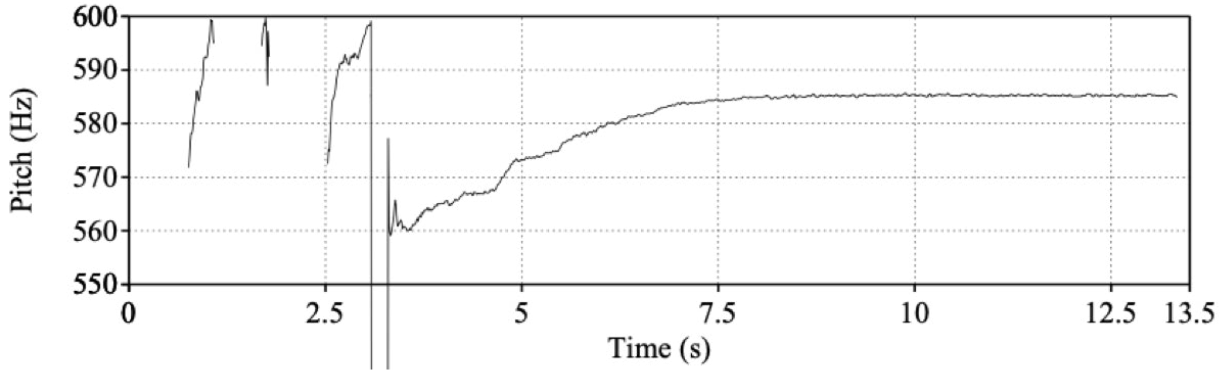


Figure 1.8. Pitch analysis.

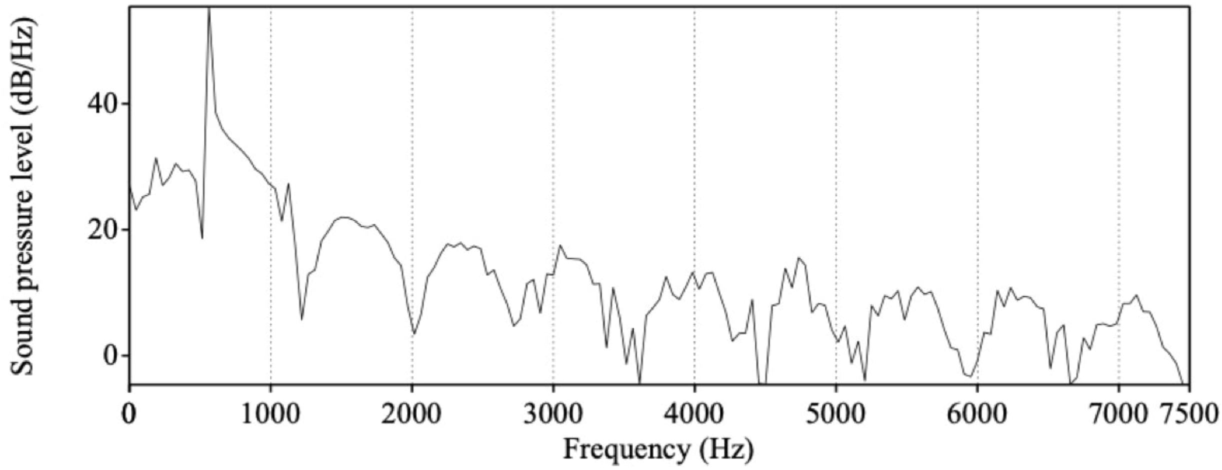


Figure 1.9. Spectrograph. At three seconds.

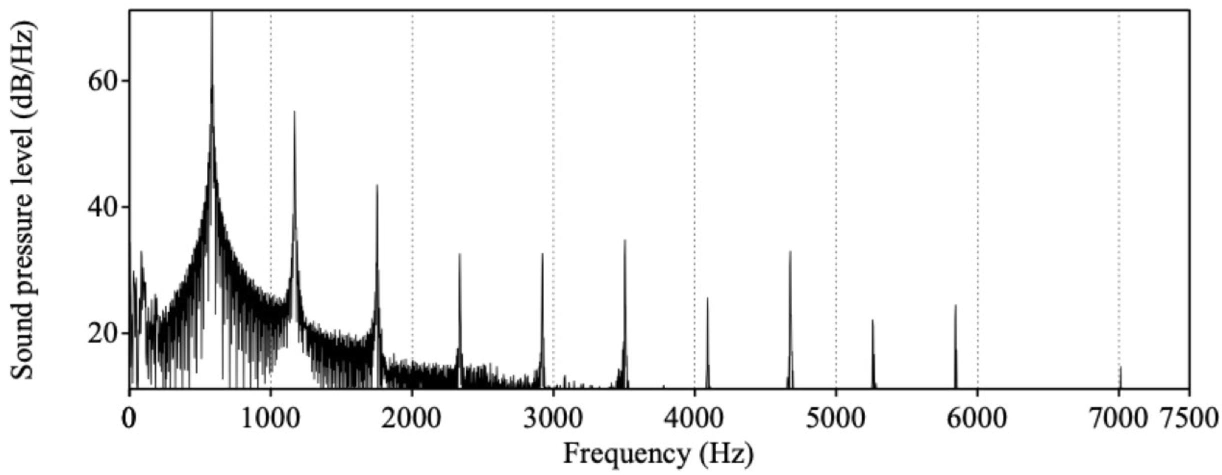


Figure 1.10. Spectrograph. Full spectrum.

2

The *composer-performer*, **and** *inventor*

2.1. Dialogue between *composer-performer* and *inventor*

The dialogue between performer-composer, and inventor has always been a vital part of the development of instruments. New music styles—more often than not introduced by composers—have often resulted in new innovations within instrument design—including the organ. As an example, two cases will be discussed, that each demonstrate the dialogue—or the lack of dialogue—between composer-performer and inventor. First, I will discuss the work by Aristide Cavaillé-Coll, who can be seen as someone that flourished by the relationship that he had as an inventor with composers and performers. To counter this, we will take a look at the—less celebrated—thirty-one-tone organ produced by Adriaan Fokker. As Fokker's origin lies within mathematics, we could argue that he lacked the dialogue between composer-performer and inventor, that Cavaillé-Coll has obviously profited from. And last, I will present the instruments that I have built myself, and explain how they connect to my earlier experience on the contemporary organ and the *New Organ Music* aesthetics. Besides that, I will discuss the continuous feedback-loop between my role as a composer-performer and inventor.

Aristide Cavaillé-Coll (1811-1899) is famous for the numerous innovations and the impressive number of organs that he has produced. As he was both a composer-performer and an inventor, his work cannot be missed when we talk about the occurring dialog between composers and inventors.

During the eighteenth-century—which was characterised by drastic changes and industrialisation—a new, *romantic*, perspective on music, art and literature took shape in France. These new art aesthetics —that were characterised by the expression of emotional freedom—led to a new musical period. Composers such as Frédéric Chopin (1810-1849) and Franz Liszt (1811-1886)—who can be seen as the personification of the new Romantic style—preferred to use the piano as their musical vehicle, as it had much more flexible dynamics compared to the previously favoured *Baroque Organ*. As the organ had fallen out of style after the 1970s, it became a victim of the revolution. The instrument became a symbol of political power, and more and more organs met the fate of destruction by the revolutionaries.[42]

While the organ blossomed during the earlier Baroque period, it was not until the second half of the nineteenth-century, that its place within contemporary music was restored. This was largely due to the efforts of César Franck (1822-1890) and Aristide Cavaillé-Coll. Cavaillé-Coll had developed a new organ aesthetic, that combined classical structures with Romantic expression. During the 1840s, Cavaillé-Coll brought the sound of Romanticism's much used *Symphonic Orchestra* to the *Symphonic organ* by introducing some radical inventions.[43] The innovations that made Cavaillé-Coll's Symphonic organs so utterly different from its predecessors, can be divided into three groups. These are: mechanical assists, new types of

---

42 Sung, "The Cavaillé-Coll Organ and César Franck's Six Pièces," 1.

43 Idem, 2.

tone colour, and expansion of the pedal division.[44] Apart from these technical innovations that defined the *Symphonic Organ,* an interesting cultural-historical shift took place. As the organ was previously placed within a liturgical cultural context, the *Symphonic organ* now became part of a different musical tradition, that represented different cultural values and musical aesthetics. Beside that, the '*Symphony*' as a musical entity, implicates different acoustic spaces than churches. However, as most *Symphonic organs* were still located within church, and interesting paradigm shift occurred, which introduced *Symphonic music* to the sacred-space.

The innovations that Cavaillé-Coll introduced, were a direct consequence of the dialogue between him, and a vast group of performer-composers with whom he maintained a close relationship during the early nineteenth-century. He worked closely with composers such as Jacques-Nicolas Lemmens (1823-1881), César Franck (1822-1890), and Charles-Marie Widor (1844-1937).[45] Apart from providing the *Symphonic* organ with specific technological advances that met the requirements that were set by the *Romantic* style, the *Symphonic* organ was so radically different from its predecessor—the baroque organ—that it became hardly impossible to perform baroque music on the *Symphonic* organ, and vice versa.

For a more recent, but less celebrated instrument design, we look at the *Fokker organ*. The Fokker Organ, was initially installed (1950) in the Teyler's Museum (Haarlem), after the project was initiated by Adriaan Daniël Fokker (1887-1972). The organ was relocated to Muziekgebouw aan 't IJ in 2009 after a thorough renovation by the firm Pels and Van Leeuwen.

Fokker—who was a professor of physics at the University of Leiden—took interest in music theory while Dutch universities were closed during the Second World War.[46] In 1940, the twentieth volume of the *Oeuvres complètes*—written by seventeenth century Dutch physicist Christiaan Huygens (1629-1692)—was published. These writing contained Huygen's mathematical foundations of his thirty-one-tone equal temperament. The latter was a tuning system that had a major influence on Fokker's later work.

> **Huygens's thirty-one-tone system maps the octave into thirty-one notes, with near pure intervals such as the octave, 5ths, 3rds, and 7ths. Even-though these intervals are not perfectly pure, the acoustics properties of the system made them indistinguishable from pure with interference beats occurring once every five to seven-seconds. Huygens's work was largely forgotten and rarely ever put into practise.**[47]

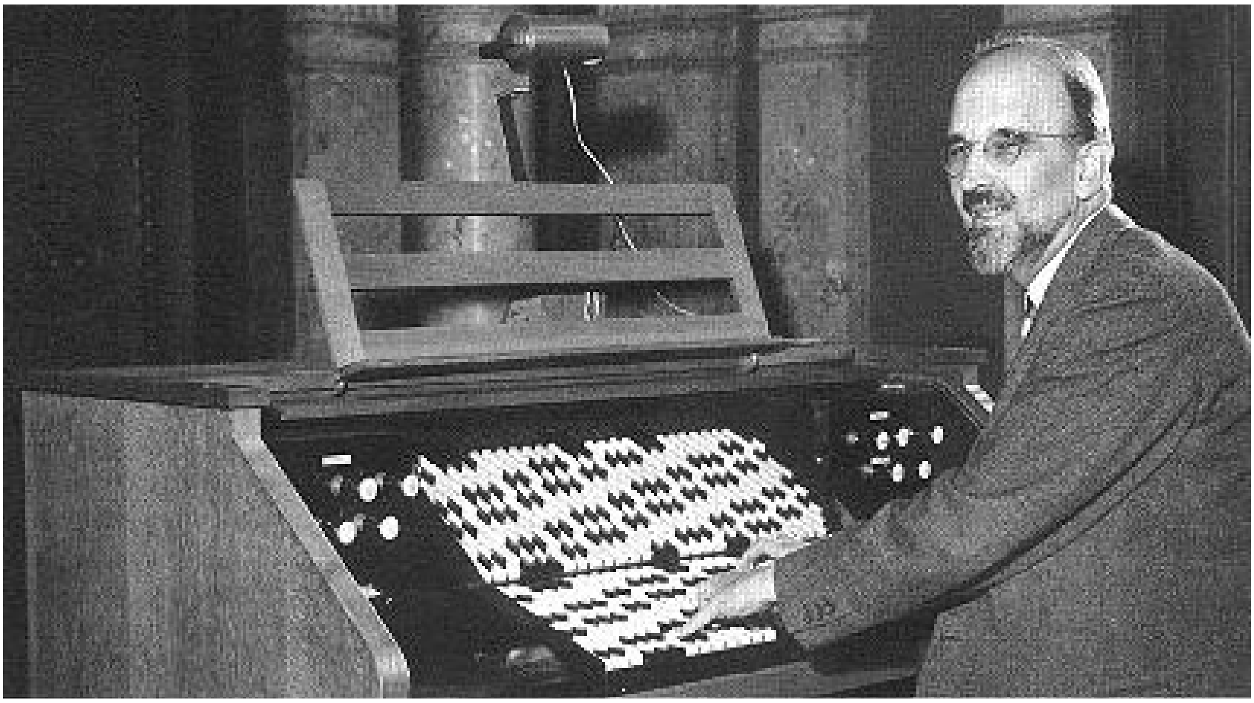
44 Sung, "The Cavaillé-Coll Organ and César Franck's Six Pièces," 4

45 Idem, 3.

46 "Adriaan Daniël Fokker," Huygens-Fokker Foundation Centre for Microtonal Research, accessed March 9, 2022, https://huygens-fokker.org/whoswho/fokker.html.

47 "Fokker Organ," Huygens-Fokker Foundation Centre for Microtonal Research, accessed March 9, 2022, https://huygens-fokker.org/instruments/fokkerorgan.html.

In order to investigate Huygens's tuning theories, Fokker built a small organ in 1943, that allowed him to explore the *Euler-Fokker genera*. The music-theoretical research Fokker had conducted during the war, resulted in the book *Rekenkundige bespiegeling der muziek—Arithmetical reflection on music*—and was published in 1945.[48] After 1945, he continued his activities in music theory, musical composition, and tuning theory. These activities eventually led him to design and realise a full scale organ, that was built in 1950 and was based on Huygens's thirty-one-tone system. The main console has two thirty-one-tone manuals, that each range from C to G''' and contain 143 notes, spread out over 319 keys.



Adriaan Daniël Fokker playing the main console of his thirty-one-tone organ.[49]

After the initial installation of the organ at the Teyler's museum in 1950, concerts were frequently organised during the period 1951-1955. The majority of the musics were re-arranged microtonal compositions, that were originally intended for other microtonal instruments, or had historical similarities in term of tuning. Besides that, several composers were commissioned to produce works for Fokker's thirty-one-tone organ. The first organist to play the instrument, was Paul Christiaan van Westering, and some composers that were involved include Henk Badings, Anton de Beer, and Jan Pieterszoon Sweelinck.[50] After 1955, the—previously frequently organised—concert series turned into a monthly event, and in 2000, the instrument was dismantled and put into storage, making its future uncertain.

---

48 "Fokker Organ," Huygens-Fokker Foundation Centre for Microtonal Research, accessed March 9, 2022, https://huygens-fokker.org/instruments/fokkerorgan.html.

49 Idem.

50 Idem

Even-though the Fokker organ showed great potential to realise musics of the late renaissance and early baroque—due to similar theoretical ideas—Fokker strongly believed that the instrument could accommodate the exploration of other culture's musics, as well as the sound of the natural world. But more importantly, due to its thirty-one-tone equal temperament, according to Fokker, the instrument would open doors for musics of the future. However, in general, most composers did not seem to be interested in this particular tuning system, and the majority of composers never abandoned the twelve-note tunings.[51]

In 2009, the Fokker organ was installed in Muziekgebouw aan 't IJ, after it was fully renovated. Additionally, the organ was updated with technological advances, such as a full MIDI implementation, and a new console that allowed the performers to save patches. After re-installing the organ, the Huygens-Fokker Foundation initiated an annual six-concert series.[52]

Even-though an impressive repertoire of written works for the instrument has been expanding since the 1950s, the concept of a such a microtonal organ never caught on. As impressive as the Fokker organ is, it still—72 years after its initial installation—remains the only thirty-one-tone octave organ in the world. As a result of this, the majority of the repertoire remains unknown, and we could only speculate about the uncertain future for both the organ and its repertoire.[53]

Other than the organs that were built by Aristide Cavaillé-Coll, the Fokker organ was built within a scientific context and had different musical motivations. Besides that, the organ did not originate out of new musical aesthetics that were initiated by composer-performers. Whereas Cavaillé-Coll used a vast group of composer-performers to gain feedback about his inventions, Fokker did no such thing. It is only after the completion of his organ, that composer-performers were asked to compose and perform on the instrument. In my opinion, this was the most significant reason why the concept of a thirty-one-tone organ never expanded.

When we look at the contemporary organ, the instrument has been modified several times as musical styles progressed. As mentioned before, examples of such modifications can be traced back to organ builder Aristide Cavaillé-Coll, who added various features to the *baroque organ*. Similarly to this example, my instruments were specifically designed to accomplish and further explore techniques than the contemporary organ would allow me. Prior to the experiments that I have conducted on the contemporary organ, instrument building had never been part of my artistic practise. But due to the limits that were imposed by the contemporary organ, I could not—without the intervention of electronic sound manipulation—develop the musics that I had in mind. The latter motivated me to engage in instrument design.

51 Harlow, "Recent Organ Design Innovations and the 21st-century 'Hyperorgan'," 8.

52 Idem, 9.

53 Idem, 10.

2.2. *Totem*

In 2020—after having researched the sonic possibilities of the contemporary organ between 2016 and 2020—I stumbled onto a Marktplaats advertisement, that sold an octave of organ pipes. During that academic year, I was partaking in Justin Bennet's *Sound Installations class*, and within that context, I immediately started developing some basic ideas for a sound-installation that utilised these organ pipes. As more and more ideas started to flood my mind, I slowly started collecting organ pipes.

While I collected organ pipes of all kinds, I started experimenting with different methods in order to excite them. Intuitively, I started blowing the organ pipes, and quickly realised that there were countless sonorities, that I did not discover before through the use of the contemporary organ. For example, by blowing an organ pipe, there is much more precise control over the provided WP (*wind pressure*) than you can achieve through *half-pulled register stops*. It allowed for micro-temporal variations in WP, which made the sounds incredibly organic and full of expression. The latter brings an interesting contrast to the early 1900s, were—as mentioned earlier—Arnold Schönberg demoted the instrument due to the lack of expression capabilities.

However, even-though this alternative way of excitation proved to be very powerful—and provided me with many insights—under no circumstance they can be seen as a substitute for the contemporary organ. Perhaps the most appealing feature of the contemporary organ—to me personally—can be traced back to its *mechanical* lungs, that have the power to sustain notes indefinitely. This feature contrasts to my experiments, as the human body is physically incapable of providing a vast amount of wind for an indefinite period of time. During my experiments, sound-structures had always appeared within a small *cell* that lasted roughly three to six-seconds. The behaviour of such a cell, was being determined by the wind that was provided by my *exhalation*. Therefore, we can conclude that each cell started with a relatively high WP, which decreased over time—as I ran out of *breath*.

In addition to these experiments, the possibility to over-blow an organ pipe—like most wind-instruments can be over-blown—revealed sound colours that could not be manifested on a contemporary organ. Even-though I intended to utilise the organ pipes in a sound-installation—rather than a fixed-media composition—I caught several of these experiments in a recording. These recordings were eventually developed into my fixed-media composition *Holocene* (2020).

Audio Example 4 *Holocene* (2020).
www.oscar-peters.com/AE_04/

While my experiments continued, a strategy for a sound-installation began to take shape. I decided to emulate my previous experiments on the contemporary organ, and thus create a sound cluster, that would be subject to a fluctuation WP (*wind pressure*). The latter could be seen as a reference to the techniques that were used throughout Ligeti's *Volumina*. As this idea seemed worthwhile to investigate, several different types of fans and blowers were tested—in order to find a wind motor that could provide sufficient WP. While the majority of these wind-generating-devices were incapable of doing so, I stumbled across a centrifugal-blower, that provided enough WP. After doing some very basic experiments, I made a final technical sketch (Figure 2.1) of the proposed sound-installation, and started assembling.

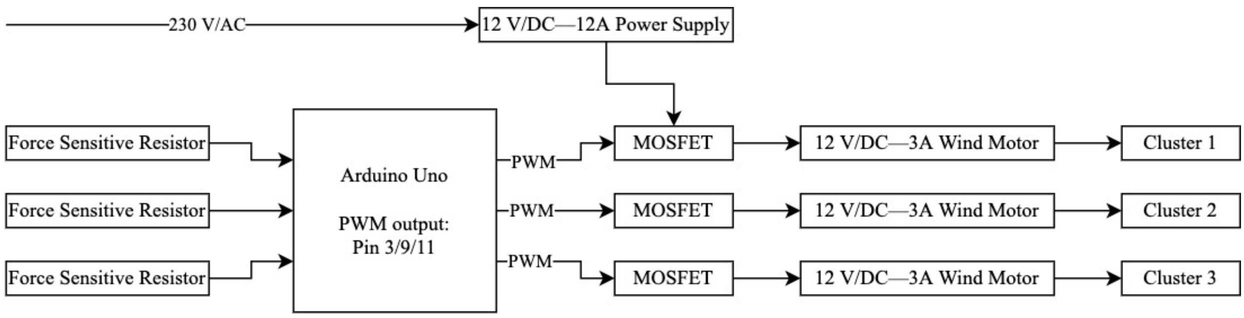


Figure 2.1. Schematic overview of *Totem*.

The result of this project—a sound-installation called *Totem*—was presented in art gallery *West* (The Hague, 2020), as part of an end-of-term exhibition from Justin Bennett's *Sound Installations class*. Even-though the sonic result was not perfect, it still transcended my expectations. But even more importantly, it instantaneously led to new research questions and possible artistic works. My next challenges were to develop a system that would enable me to control the WP through a computer. Or even better, a system that would provide this level of control for each individual flue pipe—opposed to controlling a sound cluster all at once. What started as a basic idea for a sound-installation, quickly transformed into speculative thoughts that were centred around instrument design. These thoughts, orbited around ideas that could possibly eliminate several problems that I had experienced whilst using the contemporary organ.

2.3. *Reface*

Reface was a project that was a direct continuation of *Totem*. But opposite to *Totem*, *Reface* was a research project, which was centred around the speculative thoughts on instruments design, that I had developed before. The aim of this project was to develop instruments, that would allow me to further explore and investigate the sonic behaviour of the organ pipes. This project was financially supported by the municipality of 's-Hertogenbosch.

The reasons that led me to build my instruments (Figure 2.2) are twofold. First of all, they are of practical nature. For example, it is not easy to gain access to an organ within an organisation such as a church. Especially when you are experimenting with unorthodox methods, that make the organ sound in such a way that not everyone can appreciate it. Besides that, most contemporary organs contain over 2000 pipes. Therefore, it takes months to install and intonate all the organ pipes according to the acoustic properties of their surrounding. For that reason, we cannot relocate an organ, as easy as we relocate a drum-kit or a guitar for every other concert.

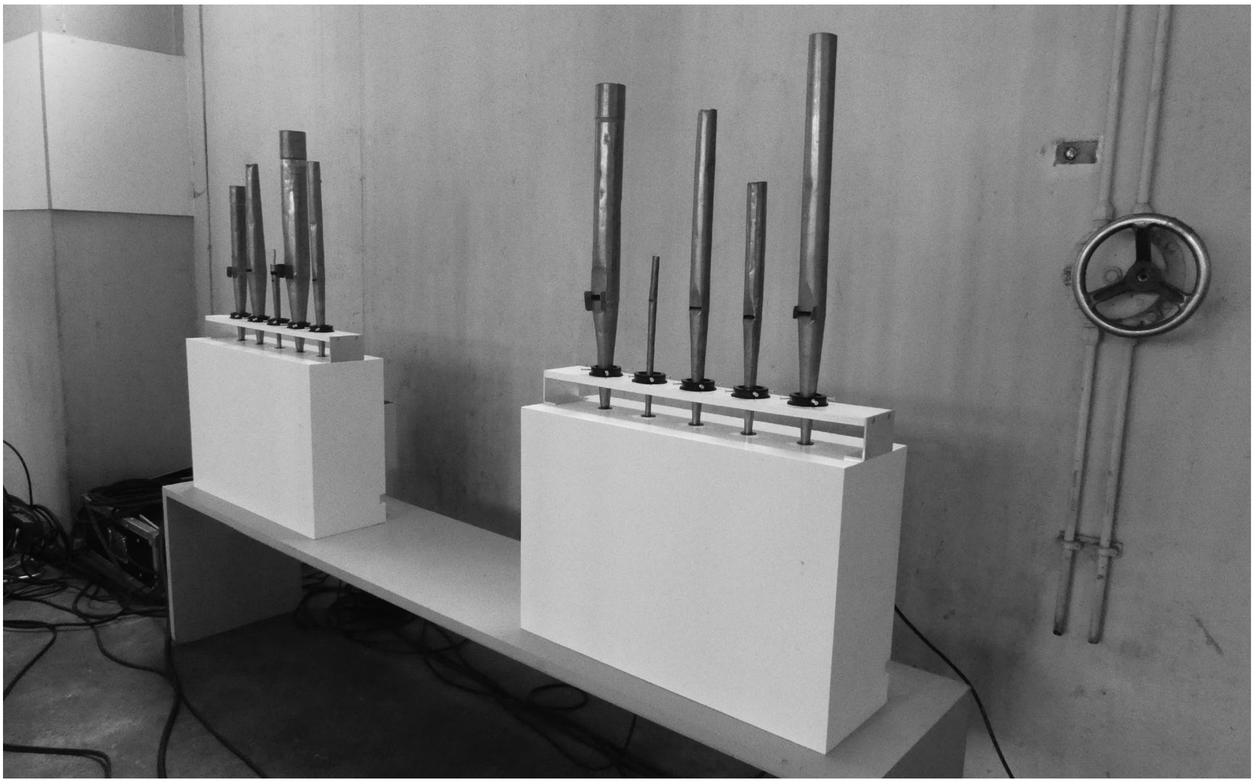


Figure 2.2. Two of my instruments. Photo taken during a Sonology Concert at Het Hem, Zaandam.

As we can think of many more practical issues that are inherited with the instrument, the most important reason that motivated me to engage in instruments design, was due to the lack of control that was offered by the contemporary organ. As I explained before, the techniques that I had used during my experiments on the contemporary organ, were not that different from the techniques that were used by György Ligeti, Bengt Hambraeus and Mauricio Kagel. Due to my inability to play the organ manual in a conventional manner, I sustained notes by using beer coasters or tape. Hereafter, I would develop the sound clusters by altering the WP, in order to discover a wide variety of emerging sound colours. However, in spite of the powerful sonic results, the control parameters that can be used for these *extended*-techniques, are limited.

The register stop—which is the most commonly used parameter in order to alternate the WP—was designed to be either *on* or *off*. However, the register stops are acting as a valve, whenever they are partially pulled. This means, that whenever a register stop is pulled out at 30%—the organ pipes speak accordingly.

Although this seems like an effective, and intuitive control parameter, such an organ stop was never intended for this specific use. The range of motion that is set for this parameter, is typically two to three-centimetres, and because of the many mechanical parts that are set into motion by the organ stop, it is incredibly difficult to create fluent motions. Besides that, a register stop, controls the WP for all pipes within the same register simultaneously. Therefore, it is impossible to have individual control over each flue pipe's speech. These two separate issues were given a major priority during the development of my instruments.

2.4. *Reface*—a technical overview

The instruments that I intended on building, needed to comply with a list of technical advances that originated either from my experiments on the contemporary organ, or the development of *Totem*.
These priorities are listed below:

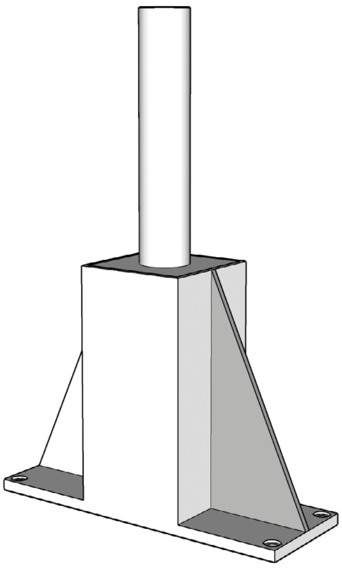
1. Every organ pipe should be controlled individually, opposed to the contemporary organ, where a single parameter controls an entire register at once.
2. Every organ pipe should be controllable by a computer, in order to gain control over precise motions.
3. Instead of building a single organ that accommodates many pipes, six smaller modules should be produced, which should each accommodate five organ pipes.

Implementing individual control over each organ pipe's WP, seemed to be the biggest challenge. In order to accomplish this, I investigated two different approaches. As earlier explained, the organ stop can be seen as a mechanical valve, that lets proportions of wind reach the organ pipes. With this in mind, I looked into the possibility of using—similar to the contemporary organ—a single wind motor, in combination with electronically controllable proportional valves. Even-though the idea seemed promising, I never tested it, due to the high costs of the proportional valves.

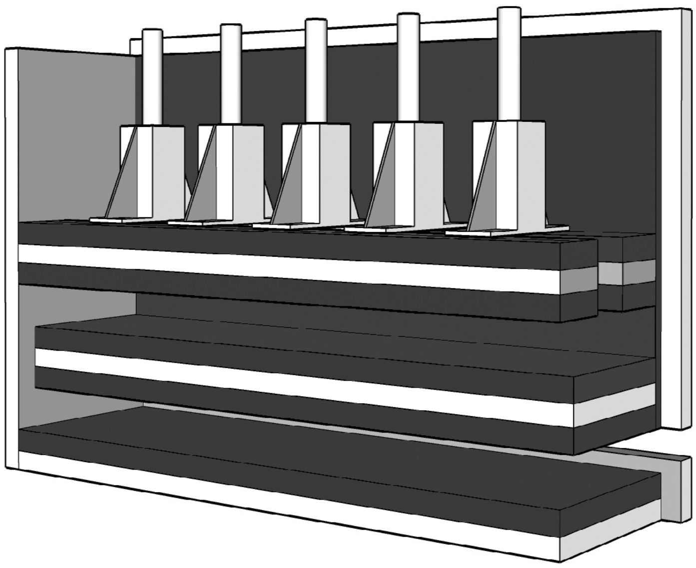
The second—and final—solution would utilise individual wind motors for each organ pipe. This seemed very straightforward, but finding a wind motor that was small, not too expensive and capable of delivering a high static pressure—was not as easy as I had hoped for. However, after tying-out various wind motors—which were each designed for different applications—I found a match, which proved to be capable of delivering sufficient WP. In addition, this motor—Sanyo Denki, San Ace 36—featured a designated *Pulse Width Modulation* inlet, that allowed for immediate connection to a microprocessor such as an *Arduino Uno*.

The next phase of the project, focussed on designing a setup that would allow the wind to run smoothly into the organ pipes. As the coupling between the wind and organ pipes turned out to be crucial, I conducted various experiments, which eventually led to a successful setup. The main challenge, was to converge the wind at the outlet of the motor, into a low turbulence jet stream. In order to resolve this issue, I 3D-printed several wind-reservoirs, that each had different dimensions. Within the final model (Figure 2.3), the wind motor blows directly into the reservoir, in which static pressure is being built up. Connected to the reservoir, is a seven centimetres tall tube, on which the organ pipes are being placed.

Although the wind motors proved to be capable of providing plenty of WP—and were relatively quiet—they needed acoustic damping, to prevent them from interfering with the sounds that would be produced by the organ pipes. The motors produce—at their inlet—67 dB(A) SPL of noise, when operating at their maximum RPM. Implementing acoustic damping did not cause any difficulties, but ended up shaping the exterior dimensions of the instruments. Before air reaches the inlet of the motor, it is being channeled through a narrow passage, which is covered with *Polypress* acoustic foam (Figure 2.4).



| *Figure 2.3.* Air reservoir.



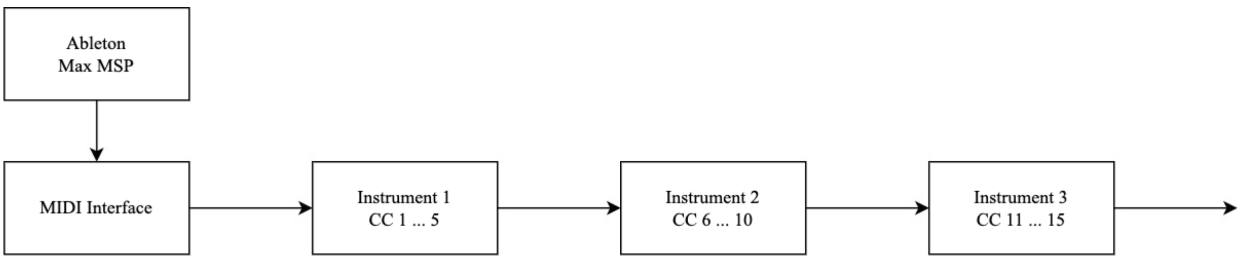
| *Figure 2.4.* Layout enclosure. In dark grey: Polypress foam.

In addition to the acoustic noise that was produced by the motors, I had found out that—if directly connected to a wooded surface—strong resonant sounds were being amplified. The frequency of the audible resonances were linked directly to the motor's RPM, and therefore had no correlation with any fundamental frequency that would be produced by an organ pipe—thus resulting in dissonances.
By decoupling the wind-reservoirs from wooden parts that were connected to the rest of the enclosure, this issue was overcome. The wind-reservoirs were now glued directly onto the firm *Polypress* material, which absorbed all vibrations.

2.5. Interfacing

With the aim of developing an electronics scheme that would allow for digital communication between the instruments and a computer, I considered two options. The first strategy utilised a *Teensy 3.5*, that translated *OSC* data into *PWM* signals. As the Teensy offers a *32-bit* resolution, I assumed that this combination would present a rich parameter space. However, as several experiments proved, the difference with an *8-bit Arduino Uno*—that converted *MIDI data* into a PWM signal—remained inaudible. Due to certain time constraints on this project—and previous knowledge of both the MIDI protocol and the Arduino coding language—I decided to use an Arduino Uno, rather than executing the earlier described strategy. Other than using the *Note-on, Note-off* protocol, I had been using *Control Change Messages* (*CC*), in order to alternate each individual wind motor's RPM. Therefore, these CC values (0-127) directly correlated with the WP that was provided by each motor. Hereafter, each wind motor was given its own address (CC 1 ... 30), which allowed me to control each individual organ pipe carefully.

Inspired by many keyboard-synthesisers, I equipped each instrument with a *MIDI-input* and *MIDI-through* circuit. The MIDI-input circuitry is used to interface between the Arduino microprocessors, and software such as Ableton, or Max MSP. Implementing the MIDI-through circuits, allowed me to cascade the instruments, meaning that a string of MIDI data is passed on from one instrument, to the other (Figure 2.5). This approach, would prevent me from using lengthy cables that would exceed the maximum cable length that is set for the MIDI protocol. In theory, the maximum length under which the MIDI-protocol can operate, is set on 50 feet (approximately 15 metres). However, in practise, exceeding a cable length of six to nine metres can result in signal loss.



| *Figure 2.5.* Signal routing.

2.6. Sonic inheritances of mechanical qualities

The design choices that I had made while building the instruments, proposed severe consequences for certain properties that define the contemporary organ. Whereas my instruments present individual wind motors for each organ pipe, the contemporary organ utilises a single wind motor that builds up WP in a bellow and wind-chest. Hereafter, wind reaches the organ pipes through key-actions, that can be performed in a rapid manner. The latter results in transient sounds. If we compare the attacks that are created by the contemporary organ to the instruments that I designed, we see an interesting difference.

Although the circuitry that was used to interface between a computer and the instruments, is able to process rapid changes, the wind motors are not. Due to several mechanical parts, a short timeframe —typically two to three-seconds—is required in order to reach the desired RPM. This results in a slope, that causes several audible artefacts, which are characteristic for my instruments. The slope affects sound colour, dynamic behaviour, and pitch, and occurs whenever the motor is accelerating or decelerating. This particular artefact can be compared to a technique that is commonly used on synthesisers, and which is called *portamento*. Portamento is an effect that causes successive notes to slide towards each other, rather than performing abrupt changes in pitch. This particular behaviour can be seen as the most deterministic feature of my instruments.

Although this *slope-behaviour* is characteristic for my instruments, we can discover a similar behaviour on the contemporary organ, whenever we turn *on* or *off* the wind motor. This is a technique that was described earlier (Chapter 1.4), and explored by Ligeti in *Volumina*.

2.7. Spectrum Analysis

During this part of the thesis, I will present a spectrum analysis that is similar to the earlier presented analysis (Chapter 1.5). This analysis, will focus on a single flue pipe (*E, 659 Hz*) that was excited by one of my instruments. The aim of this analysis is to give a better understanding of the sonic behaviour that is characteristic to my instruments.

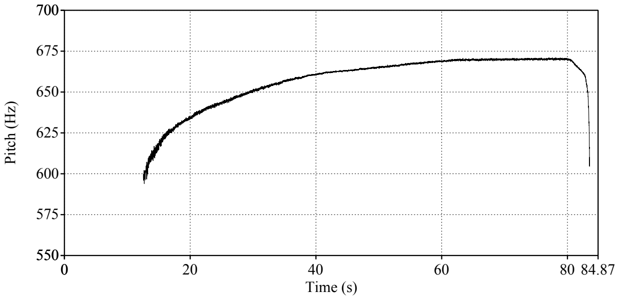
Audio Example 5 The recording that was used for this analysis.
www.oscar-peters.com/AE_05/

Even-though a similar increasing WP sweep is presented in this analysis, there is a major difference. My organs are capable of following a linearly increasing line that is programmed within a computer. The contemporary organ lacks such precise control over the amount of WP that is increased or decreased, and therefore the analysis of my organs is slightly more accurate. Besides presenting a WP sweep that ranges from 0 to 100%, ten individual recordings were made—starting at 10% WP—with increasing intervals of 10% (Figure 2.6).

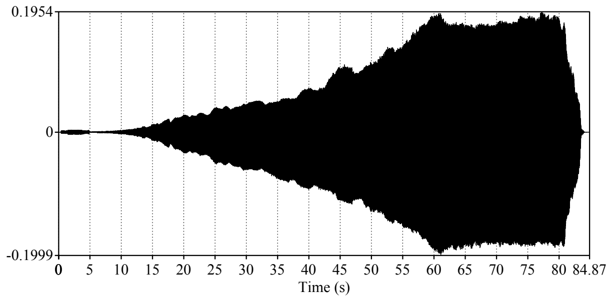
If we look at the first 10% increase in WP, we can identify a fundamental frequency, but similarly to the analysis that was made from the contemporary organ, the spectrum shows much irregularity, and the audible result can best be described as noisy. However, if we continue, and increase the WP another

10%, the noise-like character disappears, and a harmonic series starts to unfold. Besides that, the fundamental frequency increases. This behaviour is proven in Figure 2.7, which shows a pitch-analysis that was derived from the recorded sweep.

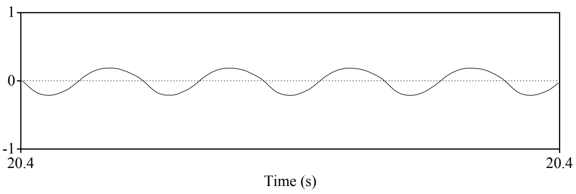
If we continue to increase the WP, we notice that additional harmonics appear, and their corresponding amplitude increase. Besides that, we see that the second harmonic eventually becomes louder than the fundamental frequency. Up until a 60% increase in WP, the first harmonic remains the loudest. Therefore, this frequency dominates the waveform (Figure 2.9), as well as the audible frequency. However, between 70 and 100% increase in WP, the second harmonic becomes louder than the initial fundamental frequency. Therefore, the waveform is now dominated by the second partial, and lost its sine wave-like character (Figure 2.10). This specific behaviour cannot be traced back to the contemporary organ, and therefore it is an important compositional parameter within my artistic works. Whenever the second harmonic becomes louder that the first harmonic, the audible frequency shifts an octave upwards. Therefore, we can use the same flue pipe to reach two frequencies rather than one—the fundamental frequency, and the adherent octave. Similar behaviours exist on wind instruments (e.g., a saxophone), where over-blowing is used as an extended technique.



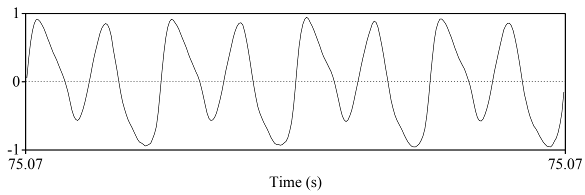
| *Figure 2.7.* Pitch Analysis.



| *Figure 2.8.* Wave-file recorded sweep.



| *Figure 2.9.* Sine wave-like waveform.



| *Figure 2.10.* Waveform. Dominated by the second harmonic.

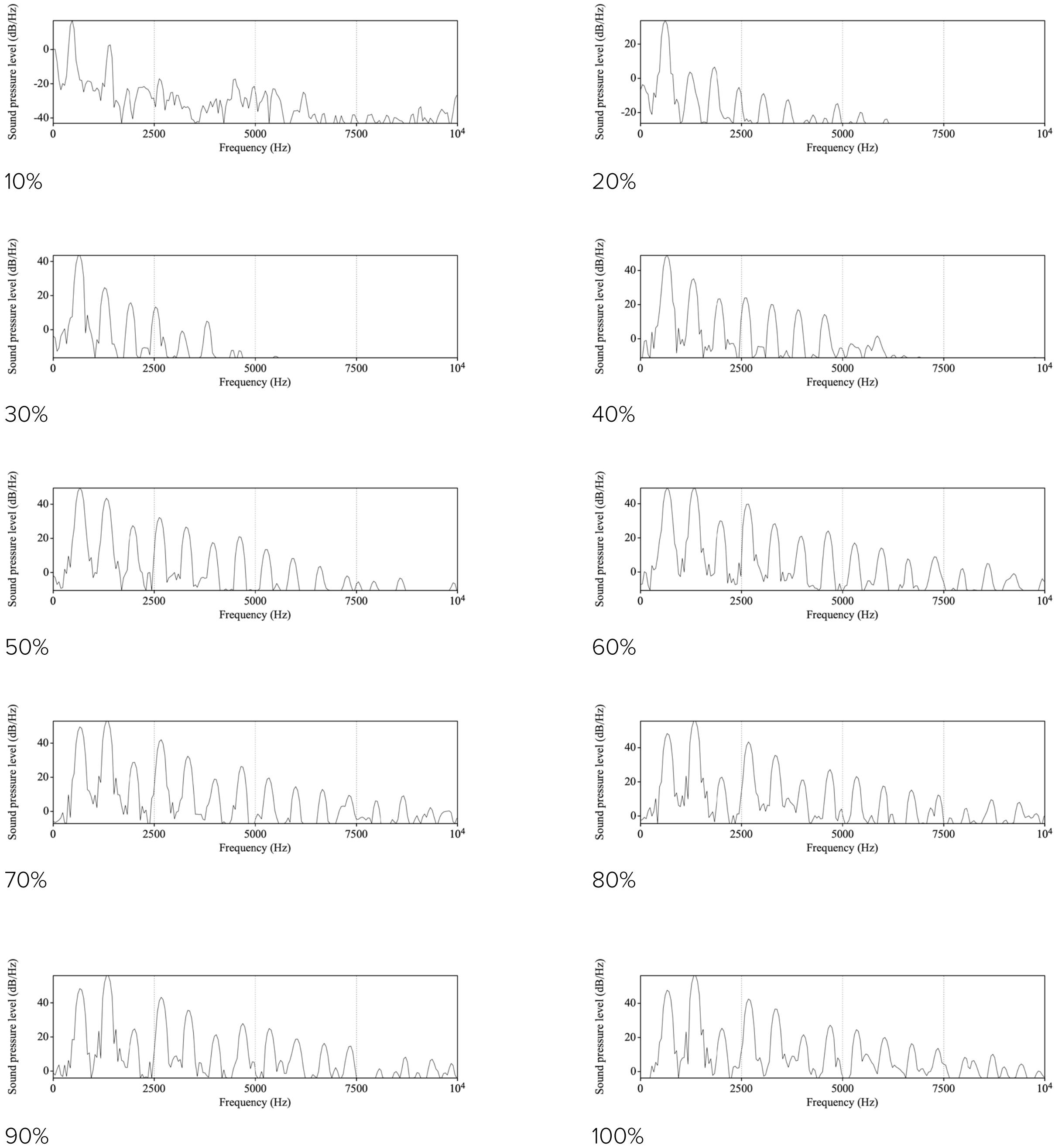


Figure 2.6. 10 spectrographs. Each spectrum represents a 10% increase in WP.

2.8. Comparisons

If we look at the spectra that are presented in *Chapter 1.5* and the spectra presented in *Chapter 2.8*, we find interesting differences. These differences define both instrument's spectral characteristics, and will be compared with each other based on their analysis's.

The most outstanding dissimilarity between my instruments and the contemporary organ can be traced back to the manner in which the WP can be altered. If we look at the contemporary organ, we see that a register stop has a total length of roughly 3.5 centimetres (Figure 2.11). These register stops —as described in *Chapter 1.4*—are used in order to alter the WP. However, the WP only starts to increase when we *pull-out* the register stop 1.75 centimetres. Meaning, that the full range of motion between 0 and 100% WP only covers the remaining 1.75 centimetres. This results in a 10% increase in WP for every 0.175 centimetres, that the register stop is being *pulled-out*. Just by looking at these numbers, we can already conclude that the contemporary organ simply lacks precise control over this action. This is confirmed when we start to compare some of the analysis's that were earlier presented.

For instance, if we compare the pitch-response that was taken from both instruments, my instruments (Figure 2.7) show a much more defined and stable curve than we measured before with the contemporary organ (Figure 1.8). This can be explained with two simple reasons. The irregularities that the pitch curve taken from the contemporary organ shows, can be a result of the lack of precise control, combined with human interaction. The absence of the latter, implicates a high degree of control within my instruments, and also allows for precise reproduction. In addition to that, due to the 8-bit MIDI resolution, every percent of increase or decrease can be accurately automated.

If we look at the same pitch-curves again, we notice that my instruments are capable of creating a much wider pitch range than the contemporary organ—which is being confirmed by the spectral analysis's presented in chapter 1.4 and chapter 3.5. As seen in the spectra that were taken from my instruments, we see that a second harmonic becomes louder than the initial fundamental frequency. Whenever the WP reaches a certain amount—between 70 and 100% (fig 2.6.3)—the flue pipe is over-blown, resulting in radical shift in timbre and pitch. This phenomena remains absent whenever we look at the contemporary organ's spectra and pitch curve. This is a result of the amount of WP that both instruments can produce. As the flue pipes on the contemporary organ are intonated whenever the register-stops are fully pulled, the WP is lower than the amount of WP that my instruments are capable of producing when the wind motors are running at their maximum capacity. Therefore the dynamic and pitch range on my instruments is wider than the majority of contemporary organs. As a result of that, the sonic behaviour of the organ pipes can be further investigated then the contemporary organ would allow me.

Figure 2.11. Register stop that covers a 3.5 centimetres reach.

3

From the instrument, to the musical domain —*an analysis of recent works*

3.1. *Staande Golf*

After having finished the instruments, two presentation moments were scheduled. The first one—an exhibition in *Museum Het Valkhof*—was planned in July 2021, and the second—a live performance—was set during the *November Music* festival in ’s-Hertogenbosch (November, 2021). As both presentation moments were very different, I had the opportunity to develop two different approaches in order to engage with the instrument. *‘Staande Golf’*—which means ‘*Standing Wave*’—is a sound-installation, which was commissioned by the *Valkhof Festival*, and was placed within the entrance hall of *Museum Het Valkhof*, Nijmegen, The Netherlands.

The initial design—implemented in both the electronics scheme and the presumed interaction with a computer—was focused on live performance, not per se on creating a sound-installation that would run for countless hours without me being present. While this new situation introduced many difficulties, I quickly developed a new strategy, in which the computer would be absent, and the Arduino’s would play a different role. The Arduino’s—normally used to translate MIDI data into PWM signals in order to control the wind motors—would now each execute a code, that would enable or disable certain pipes—according to an algorithmic process written directly onto each individual microprocessor (Figure 3.1).

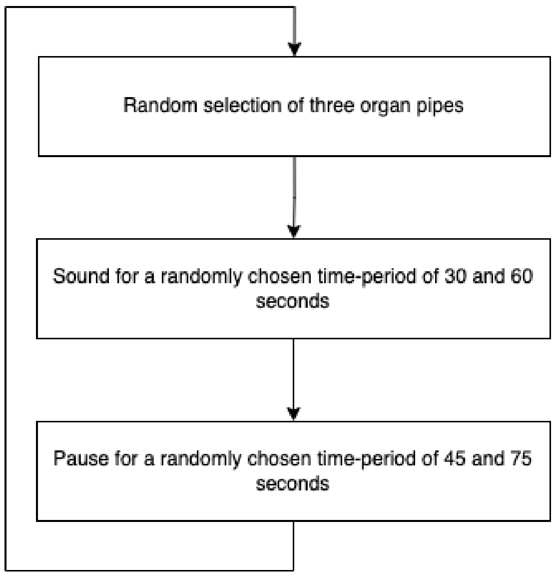


Figure 3.1. Algorithmic process.

The Arduino code was quite straightforward, but in combination with the chosen organ pipes, it turned out to be effective. I chose to use—similar to the diatonic cluster, as used in *Volumina*—only *white key* notes, which would turn on and off according to a semi-random patch that I wrote for each microprocessor. I had chosen these particular pipes because of two simple reasons. Limiting the selection to a diatonic scale, created a balance in the—randomly chosen—sounding result. These results either depended on consonant intervals, or clustered sound that exemplified acoustic phenomena, such as beating patterns. The consonant intervals created a notion of tonality, but at the same created a certain ambiguity. Due to the random distribution that is part of the algorithmic process, no functional harmonies are present—only stochastic relationships.

Decided by the algorithmic process that was embedded within the Arduino's, each instrument selected three random pipes—which then sounded for a certain period. This interval is randomly chosen between a minimum of thirty-seconds, and a maximum of sixty-seconds. Hereafter, the same rules are repeated for a pause, only this timeframe can vary between a minimum of forty-five-seconds, and a maximum of seventy-five-seconds. Due to this randomisation of pauses and active periods, there is no synchronisation between the instruments.

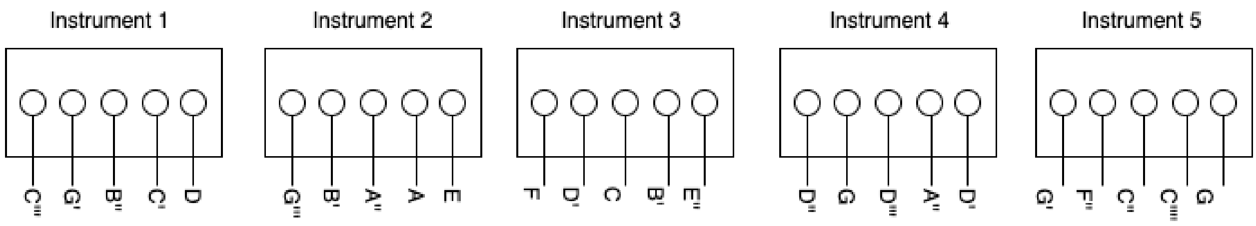
In practise, an average of two to three instruments were sounding at the same time, resulting in six to nine different tones, keeping a density average stable. Besides creating a balance between distinctive intervals and sound clusters, the widely spread spatial setup played an important factor. As the distance between the sounding instruments was quite large, the position of the listener played an important role in the perception. The distance to each respective instrument has a direct correlation with the instrument's volume. Therefore—whenever there is a total of nine organ pipes audible—the position of the listener effects the weight of the intervallic relationships. Meaning, that the listener could experience an emphasis on thirds and fifths when moving to location A, but with the same set of organ pipes, have a different listening experience when moving to location B. However, if we start to move around, the same process occurs, but in a gradual transition of perception. Besides that, irregular aspects of 'acoustic' amplification are inherent in the piece.

Two organs, both located in a different part of the exhibition space

The group of organ pipes that was included within this project was selected based on each organ pipe's sound colour and speech. As described earlier, most pipes come from different types of registers, and therefore have different sound colours. Apart from the evident difference in sound colour as a result of the various register types, another factor played an important role during the decision making process. As most organ pipes that were used were *open*, some of them were *stopped*. The latter produces tones that sound an octave lower than *open* organ pipes that have the same length. However, the *stopped* organ pipes produce less harmonics, and are less receptive to the WP fluctuations that characterise my instruments.

Furthermore, the organ pipes were intonated according to the WP level that was provided by the organ from which they originate. As every contemporary organ operates on a different WP level, all organ pipes reacted slightly different to the WP that was provided by my instruments. For example, organ pipes that were intonated according to a WP level that is higher than my instruments are capable of delivering, they produce a lower amplitude. In addition to that, a flue pipe is not able to reach its initial pitch, whenever it is not provided with sufficient WP. Therefore, I decided to use organ pipes that showed similar behaviour, as re-intonating the organ pipes is a technique that I am not yet familiar with.

As I had chosen to include the pitches *A-B-C-D-E-F-G*, I filtered all pipes with one of these pitches out of my collection. Hereafter, I listened to each individual organ pipe carefully, and based on their speech and sound colour, I made a selection of twenty-five pipes. The selection is distributed over 4 octaves, and ranges from C—130 Hz—to C'''' (Figure 3.2).



| *Figure 3.2.* Distribution of twenty-five organ pipes over five instrumenhts.

3.2. *Breath*

Different from *Staande Golf*, *Breath* is a work that combines a pre-arranged composition for 25 organ pipes with live electronics. *Breath* premiered during November Music 2021 at the Willem Twee Toonzaal, as part of the FAQ festival program. As the project was financially supported by the municipality of 's-Hertogenbosch, this performance was the last step of the project, which shifted my focus from designing the instruments, to composing and finding a musical language for the instruments.

Audio Example 6 Recording of *Breath*, as performed during November Music (2021).
www.oscar-peters.com/AE_06/

Similarly to Ligeti's *Volumina*, I used a scheme, which defined the nature of each cluster. The nature of the clusters that were used in *Breath* were derived from Ligeti's descriptions. The descriptions about various clusters that were defined by Ligeti (Chapter 1.2), point out the difference in harmonic content for each cluster, as well as their dynamic behaviour. Even-though this approach seems very similar, there is a major difference. About altering the WP (*wind pressure*) throughout *Volumina*, Ligeti writes, *"Even in places where this is not specifically noted in the musical text: it is important to use the possibilities of the mechanical organ to produce "intermediate sounds" with fluctuations in intonation ... the additional "impurities" created by playing possibilities are welcome for the character of this music".* The use of these techniques is fundamental to the discourse this music, however, since e.g. clusters with moving contours require constant action of the interpreter, these techniques often remain on a secondary level. While the possibilities that my instrument provide can be seen as an homage to the *extended* organ techniques that were uncovered during the years prior to the 1962 Radio Bremen concert, there is one radical difference. Rather than controlling the WP for an entire register at once, my setup enables the precise control over each individual organ pipe's WP. As a result of this, I can both create static and moving clusters—similar to Ligeti's classification of clusters. Even-though there are plenty of differences, these instruments provide possibilities that explore the character of this music further than Ligeti was able to while working met the contemporary organ.

While the aim of the composition was set, I needed to develop a musical grammar in order to distribute and arrange these clusters. Inspired by e.g. Giacinto Scelsi's *Xnoybis*, I decided to implement a simultaneous process of gradual change in different aspects of sound. As a result, these changes produce alternations within the focus of the composition/or listening. An example of this strategy could be the alternation of different types of clusters, that each have their specific sonic qualities.

> **One of Scelsi's main strategies is to distribute salient traits among the parts so that they compete for attention. For instance, one part may be salient in pitch, another in loudness, and so on. The balance is, of course, affected by the degree to which each trait is emphasised (a fortissimo may intuitively be felt to 'outweigh' a subtle change of pitch, for instance).** [54]

If we look at *Breath*, we can identify many examples of this concept. For example, *Breath* begins with a well-tuned C-F interval, which gradually moulds into a static interval of C-F-G. Hereafter, the internal intervals are being distorted, due to individually increasing and decreasing WP. The first part [00:00-2:48] consists of static cells, that each focus on the development of harmonic progression. Even-though

54 Dickson, "Towards a Grammatical Analysis of Scelsi's Late Music," 223.

the general aim of this music is not to develop harmonic progression, it seemed interesting to start with well-tuned intervals, in order to create a reference to a more conventional harmonic palette of the instrument. The latter is often associated—apart from the organ's specific sound colour—with tonality, and a certain functional harmonic progression. Towards the ending of this stationary part [02:24-02:48], a cluster with a moving contour is introduced, which increases WP for all sounding pipes with a slowly rising slope —resulting in a change of sound colour. Hereafter, the previous familiarity and harmonic relationships are being distorted, as the piece proceeds into a tone cluster [02:48-05:36] comprising internal movements. As the internal—lushly sounding—relationships are being distorted, other sonic effects occur. For example, a total of four flue pipes [G-G'-B'-D], are present twice across the section, and each move independently according to their provided WP. Meaning that—as shown in Chapter 2.6—their pitch is being altered as they move, which results in various beating patterns as the difference in pitch between pipes with similar frequencies increase or decrease. This transition marks an important shift in focus, and a gradual change from a static behaviour to a cluster with internal movements.

3.3. Analysis *Breath*

In the chart below, an overview of the different segments of *Breath* are presented. For each segment, the type of cluster is specified, together with a written description. This scheme functions as a tool guide that can lead to more attentive listening, but also demonstrates the various processes of gradual change that were used throughout the composition.

Time	Cluster type	Description
00:00—02:24	Static cell	This section starts with a single flue pipe [C, 130,81 Hz], and moulds into a well-tuned C F interval. Hereafter a G is added to create some friction within the harmonic progression.
02:24—02:48	Cluster with moving contours	The section starts with the well-tuned C F G interval, but the WP for all pipes in this section is linearly increased to their maximum capacity. Resulting in multiple over-blown organ pipes and a radical shift in sound colour.
02:48—05:36	Cluster with internal movements	Additional organ pipes are added, and each organ pipe's WP is altered individually. However, there is an intended interaction between several pipes with nearby frequency's, causing beating patterns.

05:36—06:24	Cluster with moving contours	This section counters the individual movements with a curve that is applied to all sounding pipes. The WP is—similarly to section [02:24—02:48]—linearly increased to their maximum capacity.
06:24—08:48	Individual gestures	In contrast to all previous parts, this section remains very sparse. Although it can be seen as a cluster with internal movements, its function is different. In section [02:48—05:36] it remains hard to follow individual movements, but in this section, the individual pitch movements are clearly audible and perform gestures.
08:48—11:12	Cluster with moving contours	Some gestures from the previous part remain present, and the added organ pipes collectively follow a triangular shape that repeatedly increases WP for all twenty-five organ pipes. This passage connects the previous section to the static cluster that follows.
11:12—13:12	Static cluster	This section utilises all organ pipes for the first time in a static —well tuned—chromatic cluster. Whereas all previous parts contained movement, this section remains static. All organ pipes are well tuned during this section.
13:12—14:35	Static cluster	In contrast to the previous part, the WP of twenty-five organ pipes now increased to their maximum capacity. Resulting in a shift in sound-colour and over-blown organ pipes. In addition to this radical shift, a contemporary organ—playing a diatonic cluster that ranges from C to G''''—was added in order to create a very dense and loud part.
14:35—18:59	Cluster with internal movements	This section is marked by a gradual decline in dynamic behaviour and density, and the contemporary organ slowly fades out during the first couple of seconds of the section. The gradual decline that marks this section applies to all sounding organ pipes, however, all organ pipes follow their own individual movements. This results—opposed to a cluster with moving contours—in a non-linear behaviour.
18:59—22:34	Individual gestures	This section is defined by an overall decreasing frequency. The section starts with the highest organ pipe that was available to me, and gradually utilises the consecutive organ pipes one after another. As a result of short overlapping periods between the organ pipes, we hear short periods of varying beating patterns. Due to the sparseness of this section, we can clearly follow individual gestures and glissandi.

22:34—24:02	Cluster with moving contours	As a short interruption of the previously described behaviour, a cell is introduced, containing the notes D F A. This section mainly functions as an introduction to section [27:14—31:50], but also reflects on previous sections [00:00—02:24] that explored similar harmonic relationships.
24:02—27:14	Individual gestures	After the short interruption, the behaviour which characterised section [22:34—24:02] is reintroduced, now continuing within the lower registers.
27:14—31:50	Cluster with internal movement	As the individual movements from the previous section reach the lowest organ pipes on my instruments, a cluster with internal movements is slowly fading in. However, in contrast to a similar section—[14:35—18:59]—I only utilised organ pipes within the range of C to G' (130.81 Hz - 392 Hz). Within this frequency specific range, multiple organ pipes that contain the same frequency coexist. Therefore, we hear similar behaviour as in section [02:48—05:36].
31:50—34:53	Moving contours	This section is characterised by a sawtooth-like shapes that are repeatedly applied to all pipes. This section emphasises an important mechanical quality of my instruments—which is described in chapter 2.5.
34:53—41:34	Static cluster +Moving contours	The specific sawtooth-like shapes that characterised the previous section are being repeated in a rhythmical manner. However, opposite to the previous section, these movements are now combined with a slowly evolving functional harmony. Through the use of harmony, I intended to reconnect with the first section [00:00—02:24] of *Breath*.
41:34—44:13	Cluster with internal movement	Similar to section [02:48—05:36], the harmonic—now also rhythmical—relations are distorted by altering each individual organ pipe's WP. Overall, the WP decreases during this section, resulting in a gentle fade-out.

3.4. Live-electronics

Within this composition, I have used five of my instruments, resulting in a total of twenty-five organ pipes. The selection of organ pipes remained similar to the selection I used within *Staande Golf*. This selection —that fits within a diatonic scale—covers a spectrum that ranges from 130.81 Hz to 2093 Hz. Therefore this selection only represents a small amount of the audible spectrum, and imposed a limitation during the compositional process. If we look at the lowest frequency—130.84 Hz—we find an organ pipe with a length of 1.2 metres. Even-though I would ideally like to include lower pitches, there are some practical issues that refrained me from doing so. If I would want to include an octave below—65.41 Hz—the organ pipe would be twice as long, thus resulting in a 2.4 metres tall organ pipe. Besides that, the weight that comes along with these taller pipes would not be supported by my instruments. In order to overcome these issues, sine waves were added for all twenty-five organ pipes. For each pipe, I included their fundamental frequency [e.g. 130.83 Hz], combined with an octave below [65.41 Hz] and an octave up [261.68 Hz]. These three sine waves per organ pipe, were programmed in Supercollider, and accessible through a midi controller. During the live performance, these 3 separate sine waves, were distributed over several loudspeakers that were on stage, facing the wall opposite to the audience. By letting the sine waves reach the audience through several diffusion patterns, the acoustics of the concert hall were emphasised, and the sine waves blended better with the acoustic sounds of the organ pipes. The volumes and spatial distribution were handled live on an audio mixer. The wave-form of an organ pipe often—until a 70% increase of WP—has a shape that is similar to the sine-wave. Therefore, it is hard to distinguish the additional sine wave from the organ pipes, when played at the same amplitude.

Besides expanding the spectrum, these sine waves were used to enforce beating patterns with their coherent organ pipe. As the coherent organ pipe would slightly vary in frequency as WP increased or decreased, the frequency of the sine wave remained the same—resulting in beating patterns with varying rhythmical intervals. Although this was taken into account during the compositional process, these effects were a result of the live-distribution (volume and spatial location) of the sine waves. The latter was not composed, but subject to live improvisation.

3.5. Site specific

In addition to my instruments and sine waves, the contemporary organ at the Willem Twee Toonzaal was used in order to create a loud, dense static cluster [13:12—14:35]. The cluster radically expanded both the frequency and dynamic-range. The cluster that was added on the contemporary organ consisted of an entirely sustained manual—C to G’’’’. Hereafter, various registers were chosen, which were mixed together, whilst using the—partially pulled—register stops. Through an extensive use of power-extension cables, I was able to enable and disable the wind-motor from my position on stage—a technique that is similar to the beginning and ending of Ligeti's *Volumina*. Within the cluster, the following registers were used:

Range	Name	C		G''''
4'.	Prinzipal	130.82	Hz	3135.96 Hz
8'	Gedeckt	65.41	Hz	1567.98 Hz
4'	Roerflöte	130.82	Hz	3135.96 Hz
2'	Prinzipal	261,64	Hz	6271.92 Hz

Another reason that motivated me to use the contemporary organ in the venue, was its location. While my instruments were positioned in a conventional setup—located on stage, facing the audience—the contemporary organ is located on the opposite side of the stage. Besides that, the organ is placed on a balcony, which is halfway over the audience: thus, resulting in an audible spatial location. The use of the organ remained unannounced, and therefore the use of spatially as a musical parameter was not anticipated by the audience. The result of this specific situation was quite effective, but remains site-specific. Therefore it cannot be exactly reproduced in other venues.

Conclusion

During the past years, my interest in the contemporary organ—and its sound producing pipes—has been growing. Whereas my first experiments orbited around the use of the contemporary organ as a musical vehicle, my interest slowly shifted toward instrument design. The latter is a topic that I did not intend on, but occurred naturally. However—in retrospect—these two practises proved to be intertwined, as the majority of design choices that I have made, originate from compositional strategies, or practical issues concerning the contemporary organ. For example, the experiments that I conducted on the contemporary organ, show many similarities with the techniques that were uncovered during the 1950s, and eventually lead to strategies on instrument design. Nonetheless, the techniques that were characteristic to the *New Organ Music,* define music of a certain era, and my intention has never been to reproduce these musics in any way. My instruments allow me to develop these techniques, and further explore the behaviour of the organ pipes. While *Breath* represents the first compositional output that was produced with these instruments, it only reveals a glimpse of possible artistic outputs. Whereas my attention previously shifted from composition towards instrument design, I now intend on repeating this process.

Within the coming year, I will focus on exploring the instruments, and develop a musical language. During this research, electro-acoustic music will be my main frame of reference in order to develop concepts about (sound-)composition, that could be transformed into the realm of organ music. However, the nature of this project is aimed towards future perspectives for the instrument, and therefore, it is important not to limit myself to any specific musical boundaries. Were, nineteenth-century, organ builder Aristide Cavaillé-Coll provided the organ with those specific sound colours that were required by the romantic period, I will continually assess my sonic strategies and their relevance within the context of other contemporary musics. Examples of these musics could be ranging from the drone-like soundscapes produced by artists like Charlemagne Palestine, to the spectralist works by Iancu Dumitrescu or Giacinto Scelsi. From contemporary electronic music by Kaitlyn Aurelia Smith to minimalist organ works produced by American composer Kali Malone.

Similar to the process that is described in *Chapter 2.1*, I intend to converge these new compositional strategies into instrument design. Within this process—that is based on the dialog between composer-performer and inventor—I will focus on creating an instrument that is more versatile than my current instruments. But more-importantly, these instruments should provide such detailed control over their sonic parameters, that new sound colours can be discovered, new dynamic and rhythmical gestures can be made, and new artistic possibilities open up.

Bibliography

Dack, John. “Technology and the Instrument.” In *Musik Netz Werke: Konturen der neuen Musikkultur*, edited by Lydia Grün and Frank Wiegand, 39-54. Bielefeld: Transcript Verlag, 2002.

Charlemagne Palestine, “Gesamtkunstwerk for Organ,” interview by Blake Hargreaves. Future Stops Podcast, Episode 18, May 25, 2021. https://futurestops.podbean.com/e/ep-18-%e2%80%94-charlemagne-palestine-gesamtkunstwerk-for-the-organ/.

Busch, Hermann J., and Martin Herchenröder. “The German Speaking Lands.” In *Twentieth-Century Organ Music*, edited by Christopher S. Anderson, 43-76. New York: Routledge, 2012.

Gjerde, Lars. “ The Forbidden Organ Concert.” PhD diss., University of Rochester, 2013.

Delaere, Mark. “Olivier Messiaen’s Analysis Seminar and the Development of Post-War Serial Music.” *Music Analysis*, no. 21 (2002): 35-51.

Herchenröder, Martin. “From Darmstadt to Stockholm: Tracing The Swedish Contribution to The Development of a New Organ Style.” In *The Organ As a Mirror of Its Time*, edited by Kerala J. Snyder, 303-323. New York: Oxford University Press, 2002.

Herchenröder, Martin. *György Ligeti’s Orgelwerke: Struktur und Assoziation*. Austria: Österreichischen Orgelforums 2/3, 1999.

Eidenbenz, Michael, Daniel Glaus, and Peter Kraut. *Fresh Wind: The Research Organs of Bern University of the Arts*. Saarbrücken: PFAU-Verlag, 2006.

Hambraeus, Bengt. *Aspects of Twentieth-Century Performance Practise: Memories and reflections*. Uppsala: Royal Swedish Academy of Music, 1997.

Kane, Brian. *Sound Unseen: Acousmatic Sound in Theory and Practice*. New York: Oxford University Press, 2014.

Levy, Benjamin R. *Metamorphosis In Music: The Compositions of György Ligeti in the 1950s and 1960s*. New York: Oxford University Press, 2017.

von Lewinski, Wolf-Eberhard.“Die Orgel als Elefant oder Königin.”*Christ und Welt* 15, no. 22 (1962): 20.

Ong, Arvid, and Reinhard Kopiez. *The Perceptual Similarity of Tone Clusters: An Experimental Approach to the Listening of Avant-garde Music*. Hamburg: Sound and Music Computing Conference, 2016.

Iverson, Jennifer Joy. ”Historical Memory and György Ligeti’s Sound-Mass Music.” PhD diss., University of Texas, 2009.

Ligeti, György. *Volumina Für Orgel*. Frankfurt: Henry Litolff’s Verlag / C. F. Peters, 1967.

Iverson, Jennifer. “The Emergence of Timbre: Ligeti’s Synthesis of Electronic and Acoustic Music in Atmosph-ères.” *Twentieth-Century Music* 7, no. 1 (2010): 61-89.

Koenig, Gottfried Michael. “*Process and Form: Selected Writings on Music*,” edited by Kees Tazelaar. Transla-ted by Richard Barret. Hofheim: Wolke Verlag, 2018.

Ligeti, György, *Neuf Essais sur la Musique*. Genève: Éditions Contrechamp, 2001.

Sung, Anna. “The Cavaillé-Coll Organ and César Franck’s Six Pièces.” PhD diss., Arizona State University, 2012.

Huygens-Fokker Foundation Centre for Microtonal Research. “Adriaan Daniël Fokker.” Accessed March 9, 2022. https://huygens-fokker.org/whoswho/fokker.html.

Huygens-Fokker Foundation Centre for Microtonal Research. “Fokker Organ.” Accessed March 9, 2022. https://huygens-fokker.org/instruments/fokkerorgan.html.

Harlow, Randall. “Recent Organ Design Innovations and the 21st-century ‘Hyperorgan’.” PhD diss., Eastman School of Music, 2011.

Dickson, Ian. “Towards a Grammatical Analysis of Scelsi’s Late Music.” *Music Analysis* 31, no. 2 (2012): 216-241.

Appendix 1: Curriculum Vitae

Release “Breath”, 33-33 Records, London, UK	2022
Performance, Ubb Hill Festival, Ubbergen, NL	2021
Performance, November Music, ’s-Hertogenbosch, NL	2021
“Breath”, Composition for 25 computer controlled organ pipe	2021
Performance with Spoken Quartet, Cutting Edge Festival, The Hague, NL	2021
Performance with Spoken Quartet, Willem Twee Toonzaal, The Hague, NL	2021
Performance, Sonology Concert, Het Hem, Zaandam, NL	2021
Release “ZERO” EP, with Brothers Not Friends	2021
Performance, Podium Ongehoorde Muziek, Eindhoven, NL	2021
Artist-in-residence, Podium Ongehoorde Muziek, Eindhoven, NL	2021
“Staande Golf”, Sound Installation, Museum Het Valkhof, Nijmegen, NL	2021
Bi-monthly radio show with Brothers not Friends, Operator Radio, Rotterdam, NL	2021
Performance with Brothers not Friends, Future Intel, The Hague, NL	2021
Research Project, Funded by municipality ’s-Hertogenbosch, NL	2021
Performance with Spoken Quartet, Koorenhuis, The Hague, NL	2020
Release “CC/RUSH”, with Brothers Not Friends	2020
Premiere “Lost Cities” with Spoken Quartet, Bozar, Brussels, BE	2020
Premiere “Lost Cities” with Spoken Quartet, Jazz International, Rotterdam, NL	2020
Residency with Spoken Quartet, Brussels, BE	2020
“Totem”, Sound Installation, WEST, The Hague, NL	2020
“Holocene”, Fixed Media Composition	2020
Release “FAQ” EP, with Brothers Not Friends	2020
Residency with Spoken Quartet, Brussels, BE	2019
Residency, Rebecq, BE	2019
Performance, Willem Twee Toonzaal, ’s-Hertogenbosch, NL	2019