THE NEW BAROQUE ORGAN

5/1

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At the Orgelpark

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Orgelpark Research Report 5/1

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Orgelpark and VU University

[§1] The Orgelpark is a concert venue in Amsterdam. Its aim is to integrate the organ into musical life in general. The Orgelpark initiated the Orgelpark Research Program in 2008.

[§2] The Orgelpark Research Reports are published in cooperation with the Chair Organ Studies at VU University Amsterdam.

E-books

[§3] Publications about music gain when they include sound examples. Therefore, the Orgelpark Research Reports are "electronic books", to be read online. Reading is easy: just use any standard web browser.

[§4] The Research Reports are accessible for free at www.orgelpark.nl.

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More information

[§7] For more information, please visit www.orgelpark.nl and www.vu.nl.

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Introduction

Orgelpark Research Report 5/1: Third Edition

[§8] This is the third edition of Orgelpark Research Report 5/1. During the preparation of the first edition in 2014, electronic publishing technology was still rather young. As a result, the e-book versions of the Orgelpark Research Reports had a so-called "reflowable" format. Therefore, the Reports were given paragraph numbers instead of page numbers; otherwise, referencing (identifying) text fragments would be impossible.
[§9] As soon as the publishing technology was advanced enough to give the Reports a fixed layout, the second edition of this Report was published: each page now got its own page number. This third edition is the same as the second edition. Whereas the first and second editions required sophisticated e-book readers, the third edition can be read using a standard web browser.

References

[§10] Since the first edition of Report 5/1 had paragraph numbers instead of page numbers, edition 2 kept the paragraph numbers, as does edition 3.
[§11] It is advised to use the paragraph numbers to reference text fragments in this Report, so that users of the first edition will be able to keep track.

The New Baroque Organ

[§12] The Orgelpark is equipped with impressive organs for music both of the 15th and 16th centuries and the 19th and 20th centuries. The Orgelpark has decided to build a Baroque organ to facilitate historically informed performances of Johann Sebastian Bach's organ works as well.
[§13] At the same time, the Orgelpark aims to inspire musicians, composers and other artists to make new music with its organs; each year,

the Orgelpark commissions several compositions. As the digital console the Orgelpark developed to play the pneumatic Sauer organ in new ways has turned out to be a success, it has been decided to provide the New Baroque Organ with a similar 21st century "interface" as well.
[§14] The New Baroque Organ will therefore have two consoles: A mechanical action console integrated in the organ case, and a detached 21st century digital console. Applying the 16th century innovation of the spring chest makes such dual action possible. Electro magnets on each pipe valve allow extended control of the organ from the digital console.

Sharing knowledge

[§15] The Orgelpark published a first press release about the project of the New Baroque Organ in October 2013. In order to develop the plan as transparently as possible, the Orgelpark started a series of colloquia and symposia. Furthermore, it kept a blog for a few years, aimed at including anyone interested in joining in the discussion. One of the main shifts that could be witnessed, was our decision to skip the original idea of a North German Baroque organ inspired by Arp Schnitger (1648-1721) as our main reference. Instead we took the work of Zacharias Hildebrandt (1688-1757) as a point of departure. The main argument was that Johann Sebastian Bach knew Hildebrandt and his organs personally, and that he even might have been involved in planning the large Hildebrandt organ at Naumburg.
[§16] The New Baroque Organ project at the Orgelpark is carried out by a team comprised of Loek Dijkman [Orgelpark, president], Sylvia de Munck [Orgelpark], Johan Luijmes [Orgelpark, artistic leader], Hans Fidom [Orgelpark Research / VU University Amsterdam], Peter Peters [Maastricht University], and Hans Elbertse [Organ builder]. A reference group has been set up as well, in which organ builders, musicians, composers, musicologists, art historians, philosophers etc. take part; the authors included in this Report are members of the reference group.

Contributions

[§16] This is Part 1 of Orgelpark Research Report 5. It presents extended text versions of the ten lectures given at the three colloquia that took place in the spring of 2014 at the Orgelpark. Each of these colloquia addressed a different

aspect of the New Baroque Organ project. The first colloquium, on March 22, focused on general and artistic research aspects of the project; the second one, on May 3, discussed temperament issues; the third one, on May 17, was dedicated to questions regarding the electronic devices the organ might include.
[§17] The lectures on March 22 were given by two members of the project team: Hans Fidom and Peter Peters. Both introduce the project in extensive essays, addressing artistic, aesthetical, technological, and historical issues.
[§18] The lectures on May 3 addressed the question whether the organ should have two temperaments, for example by providing it with more than twelve pipes per octave, and what temperament(s) would be preferable. We invited four experts to discuss this issue: Jos de Bie, Koos van de Linde, Ibo Ortgies, and Kristian Wegscheider. In light of their valuable contributions, the discussion showed that choosing "just" one temperament might be more appropriate, the main argument being that pipes that would have to function in two temperaments require a slightly different voicing than the other pipes.
[§19] The discussions during the colloquium on May 17 were as well inspired by a question posed by the Orgelpark, this time to four musicians, composers, and improvisers who are using electronic equipment in addition to organs. We asked Jacob Lekkerkerker, Robert ten Heumen, Anne La Berge, and Ernst Oosterveld, which features the new organ would need in order to facilitate the way they would like to make music on it. They all are experienced users of the Sauer organ and the options its digital console offers them.

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[§20] For practical reasons, this Report will consist of several parts. E-books should not become too large, and we prefer to publish the contributions to the discussions concerning the New Baroque Organ project as soon as possible.

I

Hans Fidom - Digital Historicism: the New Baroque Organ at the Orgelpark

[§21] The Orgelpark is to build a new organ with a dual function: to facilitate historically-informed performances of baroque organ music, more specifically the music of Johann Sebastian Bach, and to inspire composers and musicians to create new music. This essay addresses the ways in which this initiative has developed so far.

Introduction: The Challenge of the 21st Century

[§22] Organs are not only musical instruments but also machines. Given that many organs have been preserved, in some instances for as long as six centuries, this duality allows them to render an especially fascinating aspect of Western history literally audible: their sounds provide clues as to how artistic wishes may have played a role in prompting technological developments through the centuries and vice versa. Three examples. The development of the note-channel wind-chest[1] in the 16th century allowed for the first time the inclusion of other instruments' sound colours in the organ. Two: the introduction of pneumatic relays in the 19th century made it possible to equip organs with far more large pipes (providing low frequencies) than ever before. Three: once able to control electricity in safe

1 A "chest", or, more precisely, a "wind-chest" is essentially a large, cuboid wooden box, enabling the organist to control the distribution of air from the bellows, whose function it is to increase its pressure slightly, to the pipes; by pressing the keys and operating the stop knobs, the organist operates valves in the wind-chest. In note-channel wind-chests, each key-controlled valve in turn controls a group of pipes, producing the sound colours that belong to that key. An additional device, the stop control, enables the organist to engage or cancel each sound on that wind chest.

and reliable ways, an achievement of the early 20th century, all kinds of playing aids were invented, enabling organists to change sound colours quickly and easily. Listened to from this perspective, each organ becomes a mirror of its time and place, as the popular saying – at least among organ experts – goes.[2]

[§23] The 21st century challenges us to rethink the interdependence of sound and technology regarding organs. The parameters this time are more complex, however. On the one hand, digital technology suggests new ways of making music using organ pipes. Recent experiences indicate that musicians find it most inspiring to be able to freely reorganise an organ's sonic material and to enhance its spectrum by sampling and manipulating it using laptops and loudspeakers. At the same time, the 21st century has also seen another innovation regarding organbuilding: the Göteborg Organ Art Center developed the concept of "process reconstruction", aimed at understanding the working methods 17th and 18th century organbuilders applied to their trade. One of the fascinating achievements of this project is the four manual organ in the Örgryte Nya Kirka in Gothenburg, inaugurated in 2000 and built according to Arp Schnitger's rediscovered and reapplied techniques. Another example is housed in the Orgelpark: the reconstruction of the organ built in 1479 by Peter Gerritsz in the Nicolaïkerk in Utrecht[3] is the result of meticulously "reconstructing" the way Gerritsz built the original instrument five and a half centuries ago. Projects like these suggest that the idea of uncovering and relearning ancient organbuilding skills is a very promising one.

[§24] It was against this background that, in December 2012, the idea of building a new organ in the Orgelpark was born. As historically informed

2 One of the main recent and relevant organ-musicological titles is in fact 'The Organ as a Mirror of its Time / North European Reflections, 1610-2000'; a collection of essays, edited by Kerala Snyder (Oxford University Press, 2002).

3 The organ was inaugurated in 2012. It was built by Reil Orgelmakers, Heerde. The research was carried out by Wim Diepenhorst, on behalf of the Dutch National Heritage Agency, the 'Rijksdienst voor het Cultureel Erfgoed'. As building such a replica had been one of the great wishes of his colleague Rudi van Straten, the organ is called officially the 'Van Straten Organ'.

performances of both medieval and romantic music had repeatedly proved successful in the Orgelpark, not the least thanks to the Gerritsz organ reconstruction, the Aristide Cavaillé-Coll-inspired Verschueren organ (2009) and the restored Sauer organ (1922/2006), the need for an organ of comparable historic quality for 17th and 18th century music, especially that of Johann Sebastian Bach, became ever clearer. At the same time, the Orgelpark is one of the most important contemporary music venues in the Netherlands; the digital console of the Sauer organ, added to the instrument in 2011, allows the application of MIDI-protocols to play the organ and/or the use of the Orgelpark's sound system as an integral part of the instrument.

[§25] Both of these concepts were taken into consideration during the discussions about the new organ. Could they be combined in a single instrument? Our experiences with the Sauer organ gave us some indications of the rich potential presented by the combination of an existing historical sound concept with a means of manipulating its sound resources through the application of digital technology. The question which arose was this: would it be possible to build a historically-informed baroque organ and apply 21st century technology to it without compromising its 18th century concept?

[§26] The solution seemed to be provided by the idea of equipping the organ with "spring chests", an early form of note-channel wind-chests, developed in the 16th and 17th century. An essential characteristic of this type of wind-chest is that it provides a valve for every pipe. Controlling these valves electrically by adding an electromagnet to each would maximize the organist's control over the pipes: the sound of any pipe would be combinable with that of any other pipe, in any order. Traditional organ systems are designed to allow pipes to be used as parts of larger groups, so-called "stops", each representing a specific sound colour; such stops are, in turn, assigned to specific manuals. Whereas the digital technology applied to the Sauer organ allows the organist to use the stops freely, on whichever manual he or she might choose and thus allowing previously impossible stop combinations, the use of spring chests in the new baroque organ would allow the organist to disassociate every single pipe from its specific stop as well, thus representing the next step in the process.

[§27] After extensive discussion of this solution, the Orgelpark has indeed decided to build a new organ. It will be playable from at least two consoles; a completely mechanical one, integrated into the main case of the instrument and the digital console used to play the Sauer organ, which will of course require renovation in order that the new organ can also be played from it. The organ will reference the instruments built by Zacharias Hildebrandt in the 18th century, not least because Johann Sebastian Bach commented favourably on them but also because the Orgelpark's steering group for the "New Baroque Organ", (the current working title for the project), agrees that these instruments sound breathtakingly beautiful.
[§28] What follows is, in essence, a series of extended footnotes to what has already been stated. The first section maps the history of the application of historic organ concepts in new instruments, an archetypal facet of 20th century organbuilding. The subsequent counterpoint is provided by a short discussion of several contemporary organ concepts developed fairly recently. The third and fourth paragraphs consider the construction of the proposed organ in more practical details, with particular regard to the Hildebrandt sound concept and the effect digital technology will have on the player's ability to access that concept.

The application of historic techniques in new organs

[§29] Although organbuilders have, since the late 19th century, increasingly accepted 17th and 18th century organ concepts as important sources of inspiration, they generally preferred, at least until the early 1970s, to combine such age-old technology and sound concepts with modern ways of constructing organs, including the making and voicing of organ pipes. Developments during the inter-war era led to the development of the organ style known as "neo-baroque" in the years following World War II.[4] Dutch organ expert and organist Lambert Erné summarised its characteristics in 1956 by describing the sound of his beloved and then brand new organ in the Nicolaïkerk in Utrecht in a catchy little poem. The organ was built by the Danish firm Marcussen, undisputedly one of the main players during the period in which the neo-baroque style was in the ascendency. The first verse of Erné's poem reads:

> Hier staat nu 't orgel van de Deen
> Zo scherp als dit vindt ge er geen.
> Al gaat het u door merg en been,
> voor ons blijft het toch nummer één![5]

[§30] Indeed, the sounds of neo-baroque organs differ significantly from those of "real" baroque organs, which are, to say the least, somewhat more elegant. Or, to paraphrase the idea that organs mirror their times: the sound of Erné's organ reflects the energy that fuelled the rebuilding of society after the war.
[§31] As was to be expected, at least with hindsight, some organists and organbuilders began to consider the differences between baroque and neo-baroque in a negative light: new organs should resemble, if not emulate, the sound of historic organs. In the 1970s, this development came to be labelled "historicism", which, by the way, has nothing to do with the same word used by 19th century philosophers such as Hegel. Rather it refers simply to a way of building (and playing) organs in accordance with the precepts of what came to be known as "historically informed performance practice" or, the other common label, "early music".
[§32] An event that signified this change in attitude was the Arp Schnitger Memorial Festival at the Der Aa-kerk in Groningen in 1969 during which experts from all over the world gathered around the famous Schnitger organ, admired its wondrous sounds and agreed that striving for such beauty represented a far better goal in the designing of new organs than trying to develop new concepts. Thirty years later, instruments such as the organ in the Örgryte Nya Kirka in Gothenburg and the Gerritsz organ replica at the Orgelpark document the subsequent landmark in this development:

4 Hans Fidom (ed.). *Orgels van de wederopbouw*: Zutphen: Walburg Pers, 2006.

5 Here is the organ built by the Dane / As sharp as this one you'll find none / Even if it sets your teeth on edge, / We still think it's the very best! Translation by Stephen Taylor, d.d. 10 March 2014.

these organs sound, at least to a significant number of listeners, like historic organs.

[§33] This historicism in organbuilding was, however, not the only way the organ world dealt with historic organs in the context of building new ones (and, indeed, restoring old ones). One of the earliest and best known organists advocating baroque organs and organ music as sources of inspiration was Albert Schweitzer. As an organ student of Charles-Marie Widor at St Sulpice in Paris, he taught Widor to consider the texts of Bach's chorale preludes in order to understand the music; the result was his book on Johann Sebastian Bach.[6] With regard to organbuilding, however, it is Schweitzer's companion Emil Rupp who deserves special mention here. Rupp considered Schweitzer "his friend" and claimed to have initiated the so-called "Alsatian Organ Reform" together with him. Be that as it may, Schweitzer rejected the concept of reform altogether and the initial result of the "Alsatian Organ Reform" was that it inspired leading organbuilder Oscar Walcker to add baroque-ish sounding stops to his otherwise German romantic organ concept. In doing so, Walcker slightly compromised the unity of his organs as an integrated artistic whole in which every sound colour plays its specific role. In other words, Walcker accepted, even if only to a limited extent, that one might also view organs as a rather random collection of sound colours.

[§34] Insignificant as it may seem at first sight, this aesthetic re-orientation was soon to germinate what would ultimately become mainstream 20th century organbuilding. Large and influential organbuilding workshops, not to say factories, such as Steinmeyer and Klais, were among the first to follow Walcker's example, prompted no doubt by the possibility of smoothening the strict attitudes to organbuilding the "Orgelbewegung" had come to signify during the inter-war years. The Orgelbewegung's theories as expressed by, among others, Hans Henny Jahnn, Wilibald Gurlitt and Christhard Mahrenholz, resembled those of Schweitzer and Rupp to a considerable extent, the difference being that the Orgelbewegung' protagonists were taking the next step in applying them in practice. In

6 Albert Schweitzer. *Johann Sebastian Bach*. Wiesbaden etc.: Breitkopf & Härtel, 1908.

other words, a number of new organs were equipped with slider chests (the 17th century successor of the spring chest), mechanical action (i.e. the system connecting keys and wind chests) and a baroque-orientated sound concept. This appeared rather frightening to many potential organ buyers, the majority of whom were, understandably enough, quite conservative church council members. In particular, organbuilder Hans Klais developed a smart way of respecting both the Orgelbewegung's energy and his clientele's reluctance, by adding Orgelbewegung inspired stops to his otherwise still romantic organs.

[§35] After the Second World War, neo-baroque organbuilders gave in to this trend as well. The Marcussen organ at the Oskarskyrkan in Stockholm, built in 1949, includes a huge swell division; a well-considered neo-baroque translation of Cavaillé-Coll's "Récit", whilst later Marcussen organs document ever-freer ways of equipping enclosed manual divisions. Today, most large organs, whether built by Klais, Rieger, or any other mainstream organbuilder, represent mixtures of several baroque and romantic concepts.

The development of new organs in the 20th century

[§36] Whether the new organs followed strictly the principles of the neo-baroque style, or whether their concept was more mainstream, several organists, composers and organbuilders failed to be convinced of their merits as vehicles for contemporary music. As a consequence, several serious experiments in designing a 'contemporary' organ were undertaken. Texts such as Die Zukunft der Orgel by Arnold Schönberg (1904) or Die Orgel sprengt die Tradition by György Ligeti (1966)[7] undoubtedly played their roles in stimulating this development. Schönberg suggested nothing less than reinventing the organ completely by reducing its size to about "1 1/2 times as large as a portable typewriter", making it "playable by at least two to four" musicians simultaneously, having significantly fewer stops than traditional organs, and facilitating, in turn, a huge dynamic range,

7 Roman Summereder published many of these texts in his referential book *Aufbruch der Klänge*. Innsbruck: Helbling, 1995.

"for only dynamics make for clarity".[8] Not a word, by the way, about the "Klangfarbenmelodie" he introduced a few years later and which, due to its seeming suitability for the organ, seems at least to nuance the significance of his ideas about organs.[9] Ligeti was attracted to the organ by its "yet not investigated possibilities regarding sound colours",[10] but far more by its "deficiencies – its clumsiness, rigidity and ruggedness."[11] His conclusion: the organ is a giant prosthesis. "It challenged me to find out how one might learn to walk again with this prosthesis."[12]

[§37] One of the main examples documenting how Ligeti met that challenge is his famous composition Volumina. Ligeti acknowledges that the musical idiom of Volumina is far from traditional, and that, as such, it represents a problematic point of view, as "the organ [...] is burdened by tradition. Traces of this burden are to be found in my work as well,"[13] namely in the coming into existence of an "architecture that is merely a structure, lacking a tangible building. Strictness and solemnity is all that remains from the organ tradition; anything else gets lost in wide, empty spaces, the 'Volumina' of musical form."[14]

8 Glenn E. Watkins, "Schoenberg and the Organ". *Perspectives of New Music* 4/1 (1965). 119-135 (119).

9 Arnold Schönberg. *Harmonielehre*. Leipzig/Wien: Universal, 1911.

10 "Bisher noch unerforschten Klangfarben-Möglichkeiten."

11 "Ihre Mängel – ihre Unbeholfenheit, Steifheit und Eckigkeit."

12 "Es reizte mich, herauszufinden, wie man mit dieser Prothese von neuem gehen lernen kann."

13 "[...] die Orgel [...] durch Tradition vorbelastet ist. Spuren dieser Vorbelastung befinden sich auch in meinem Werk."

14 "[...] Architektur,die bloß aus Gerüstzeug besteht, der aber ein greifbares Gebäude fehlt. Strenge und Erhabenheit allein bleiben aus der Orgeltradition übrig; alles andere verschwindet in den weiten, leeren Räumen, den 'Volumina' der musikalischen Form.' Quotes from György Ligeti, "Die Orgel sprengt die Tradition". *Melos* 33/10 (1966). 311-313 (313). Original title: "Einführung zu meinem Orgelwerk 'Volumina'." Ligeti's *Volumina* was one of three compositions assigned for the Pro Musica Nova days Radio Bremen had organised in 1962; the other two were *Interferenzen* by Bengt Hambraeus and *Improvisation ajoutée* by Mauricio

[§38] Following on from comparatively peripheral initiatives such as the organ Hans Henny Jahnn designed for the Lichtwarkschule in Hamburg in 1931, on which all stops were divided into male and female categories, the organ inaugurated in 1972 at St Peter's in Sinzig was the first to meet the requirements articulated by Ligeti. It was designed by composer and organist Peter Bares, and built by Oscar Walcker's grandson Werner Walcker-Mayer. After Bares had been fired from Sinzig in 1985, he was appointed at the Kunststation St.-Peter in Cologne in 1992, where he immediately started to redesign the Willi Peter organ according to the ideas developed at Sinzig, equipping the instrument with wind manipulation devices, a plethora of percussion instruments, programmable mixtures, unusual harmonics and even new stop families, such as the "Saxophones" - to name just a few of his many inventions. The organ was inaugurated in its new form in 2004. The improvisations by Bares, and especially those by his successor Dominik Susteck, document how this organ has inspired new music. As Randall Harlow says: "Listening to Susteck play the Cologne instruments, one is struck by a rich plasticity of sound. The strange high partials blend seamlessly with the shimmering percussion, building to a great roar, or sinking through warbling tones detuned through a shifting wind supply, a sound reminiscent of early Penderecki, Stockhausen's electronic soundscapes, or contemporary spectralist composers such as Tristan Murail or Kaija Saariaho."[15]

[§39] Whereas Bares and Walcker applied electricity as a means to facilitate their ideal organ, the rise of historicism inspired organists such as Daniel Glaus to try and extend the organ's dynamic possibilities in a completely different way. The project "Innov-Organ-Um", initiated by Glaus and launched in 1999, aimed to build a mechanical organ at which the organist could manipulate the wind pressure in the pipes, and hence their sound

Kagel. Roman Summereder published Ligeti's text in *Aufbruch der Klänge* (Innsbruck: Helbling, 1995. 175-178). Cf. Daniela Philippi. *Neue Orgelmusik / Werke und Kompositionstechniken von der Avantgarde bis zur pluralistischen Moderne*. Kassel etc.: Bärenreiter, 2002.

15 Randall Harlow. *Recent Organ Design Innovations and the 21st-century "Hyperorgan"*. 17. (published on http://www.huygens-fokker.org).

colours and dynamics, by varying the key pressure. It resulted in several research organs, built by organbuilder Peter Kraul.[16]

[§40] Yet another concept, once again completely differently orientated, is the self-tuning organ presented by organbuilder Voigt (Germany) in 2013 and constructed according to a system developed by Werner Mohrlok in which all pipes are equipped with devices enabling immediate adjustment of the tuning according to the music being played: sensors detect the combination of keys played by the organist, analyses which tuning would make the intervals sound pure and adjusts the tuning of the respective pipes – all in a split second. As a result, this organ (always) sounds purer than any organ to have come before it. As such it is reminiscent of the so-called "Fokker organ" housed in the Muziekgebouw in Amsterdam,[17] which provides the organist 31 with keys per octave, thus allowing music-making with pure intervals. However, the Fokker organ is far more than just a new take on a traditionally-orientated instrument like the Voigt organ; its specific purpose is rather to facilitate microtonality.[18]

[§41] Microtonality was also a goal sought by one of the most recent organ projects: the Woehl organ at Piteå, Sweden, inaugurated in 2012 and designed to include a so-called "harmonics division", invented by the project's initiator, Hans-Ola Ericsson. The division is intended to contain a little over 1000 pipes, allowing, for example, to assign even more than 31 pipes to one octave.

[§42] Arnold Schönberg's call for a portable organ has been answered especially in France. Among the organs designed by organist Jean Guillou,

16 Michael Eidenbenz, Daniel Glaus und Peter Kraut (ed.). Frischer Wind – Fresh Wind. Die Forschungsorgeln der Hochschule der Künste Bern – The Research Organs of Bern University of the Arts. Saarbrücken: Pfau, 2006.

17 Originally built by organbuilder Bernard Pels and installed in the Teyler's Museum in Haarlem in 1950; since 2009 in Amsterdam having been restored and rehoused by organbuilding firm Pels & Van Leeuwen.

18 More on this organ, and other contemporary organ concepts: Randall Harlow. *Recent Organ Design Innovations and the 21st-century "Hyperorgan"*. Published on http://www.huygens-fokker.org.

his most recent ideas illustrate a tendency to divide the instrument and make it both mobile and playable by more than one organist – Guillou names it "L'Orgue à Structure Variable".[19] The idea is comparable to that of the "Modulorgue", designed by Daniel Birouste and Michaël Fourcade, partly in reaction to composer Jean-Louis Florentz's ideal "Orgue-Mutations".[20] Each "module" of Birouste's, literally modular, organ is basically a free-standing swell box housing a universal chest and a set of pipes; the modules can be connected to, and played from, a separate console. Each pipe is entirely independently manipulated via its own electrically-operated valve, the movement of which is controlled by the way in which the organist presses the keys. The concept was presented for the first time in 2007 in Aspiran.[21]

[§43] The idea of manipulating combinations of pipes by controlling them individually was simultaneously being elaborated in Germany by Bene Aufterbeck and Thomas Stöckl, who together established their Sinua company in 2007. At the heart of their achievements is the organ at St Peter and Paul in Ratingen, Germany. The instrument, originally installed by Romanus Seifert in 1953, represents the aforementioned mainstream baroque-romantic sound concept; not really interesting in itself, but

19 Jean Guillou. *The Organ, Remembrance and Future*. Lyon: Symetrie, 2010. A quote, taken from Guillou's official website (www.jean-guillou.org): "Tradition can die by repeating itself. Real tradition is created by inventions which meet the audacity of their origins. Therefore the twenty-first century organ has to be built! It is questionable if, in our time, it is reasonable to devote millions of Euros or Dollars to building 'old' instruments that no longer touch an increasingly reduced audience. If the pipe organ has to continue to grow, it must meet two requirements: [it must] have the qualities of a great organ, built according to the knowledge of the tradition; [it must] respond to a new aesthetic, including its mobility and possibility of installation in any possible site."

20 Béatrice Piertot. "Jean-Louis Florentz / Mysterieus en complex: orgelmuziek van een vrijdenker." *Timbres* 15 (2013). 14-19.

21 More on this organ, and other contemporary organ concepts: Randall Harlow. *Recent Organ Design Innovations and the 21st-century "Hyperorgan"*. Published on http://www.huygens-fokker.org.

becoming rather interesting as soon as the Sinua software is activated, for example to help compose new stops, to enhance the dynamic qualities of the organ, or to have a group of organists play it, instead of just one.

[§44] Indeed, the integration of digital technology in organs renders the possibilities seemingly endless. Øyvind Brandtsegg of the Norwegian University of Science and Technology, Trondheim,[22] has developed ways of using his voice to play organs instead of playing the keys in the normal manner. This, needless to say, leads to a radically different perspective on the art of improvisation and, indeed, what it means to be an organist at all. In fact, it might even be possible to dance organ music as this would only require the integration of modern gaming software and hardware with an organ's MIDI-system. Extending this theme, yet another line of enquiry is suggested by simple software such as Zenph, enabling the playing of MIDI-instruments via the internet.

[§45] It is important to stress at this point that most Dutch contemporary organ music was and is composed for original baroque organs. Apparently, composers find themselves impressed and inspired by the sheer beauty of such organs more than by the results of the complex and confusing history of 20th century organbuilding.[23]

Artistic aspects of applying digital technology

[§46] Despite all these developments, organ concepts have, until now, been traditional; in other words they document the rule that organs consist of several "works" (or divisions, or manuals, or whatever else they may be called), which in turn are defined by their specific collection of sound colours (stops). As has been said, the digital technology applied to the Sauer organ allows the organist to disconnect the stops from their manuals, making previously impossible sound colour combinations possible. The use of spring chests in the new baroque organ will allow the organist to disconnect

22 Internet: http://prosjekt.idi.ntnu.no/sart/ and http://www.researchcatalogue.net/view/48123/53022.

23 Hans Fidom, "Dutch 20th Century Organ Music." In Christopher Anderson, ed., *20th Century Organ Music*. Routledge: Routledge University Press 2011. 194-218.

every single pipe from its specific stop as well, and hence represent the next step in integrating digital technology in organs.

[§47] One of the most attractive aspects of enabling organists to combine pipes freely, is that they will be able to design sound colours organs were not able to produce until now. It will, for example, be possible to assign a well-chosen set of pipes to a key of a given manual, and have the computer calculate which other pipes would need to sound on the adjacent keys in order to produce a comparable sound colour. Furthermore, it will be possible to assign melody couplers at will, accentuating the top note of the music (or the bottom one) – without having to worry about the problem earlier electro-pneumatic versions of such auxiliaries suffered from, namely that they required extremely legatissimo playing: the computer will be able to determine what the top (or bottom) line is, even if played staccato. It will be possible to control the speed of the tremulants, and thus build all sorts of undulating sounds; to sustain a given sound without having to touch the respective keys longer than a brief moment; to manipulate the wind pressure and the amount of wind the pipes are supplied with etc etc.

[§48] However, all of these these options are basically just refinements of traditional organ playing aids. Far more innovative is the attack and delay control organists will gain. Imagine making the organ dynamic by having more pipes sound for just a moment when touching a key, allowing for percussive effects to make, for example, the contour of a musical line clearer. In turn, it will allow for a controlled time delay, by letting the organ build up a sound colour pipe by pipe per key. It will be possible to add acoustic effects, by having the sound die away, leaving only a very soft sound after a given time. It will be possible to have the organ remember what has been played, allowing the organist, as it were, to double or triple his hands and feet. As the keyboards of the digital console at the Orgelpark are also touch sensitive, they allow pipes to speak at different times in the movement of the key – a well prepared organist hence might be able to control the volume of the organ simply through his touch. And so on… All of these examples have already been conceived and tested extensively by Ansgar Wallenhorst, organist of the aforementioned organ at Ratingen.

[§49] Additional worlds of possibilities open up as soon as computers are connected to the console, with implications both for the organ itself and for

recording, sampling and thus manipulating its sound through the use of microphones and loudspeakers. It is tantalising to consider these next steps for a moment and fantasise about the ways adding loudspeakers might enhance the acoustics of the Orgelpark, as several sophisticated acoustic systems are today available. One could also image a situation which might allow for combining samples of organs elsewhere, perhaps even that at Naumburg, with the new organ's acoustic resources at the Orgelpark itself.
[§50] As for the interface needed to control all these options, there is no need to fear overload of the Orgelpark console with hundreds of knobs, as the touch screens applied at Ratingen seem to work flawlessly. In fact, one might almost feel the need to replace the console's music desk with a touch screen as well – experiences by Kevin Bowyer indicate that this particular innovation has also made progress.[24]

Concluding remarks

[§51] In essence, the New Baroque Organ with be just that: a baroque organ, albeit with spring chests and electro-magnets in the note channels. These elements will, however, be designed in such a way that both the sound and the touch of the organ will stress its baroque credentials and, as a consequence, the mechanical console will provide a familiar musicking environment to the player. Playing the organ via the digital console, on the other hand, will take the player out of his comfort zone. Indeed "anything goes" will be the order of the day and the instrument will thus put the artistic vision of the player to the test. The same will be true of course of the composers and for other musicians and artists who choose to play the organ via a computer. In turn, the new organ will challenge researchers to map the way organists, composers and other artists will find (fight?) their ways into the sound world of the new instrument. What sounds do they choose? Why? To what extent do traditional/conservative notions play a role? To what extent dare they look for new horizons? What do they consider convincing and what not? And, not least, what role do their listeners play in discussing questions like these? Of course, such questions are relevant to both performances of baroque music and of new music – or indeed other music; it will not be forbidden to play the Buxheimer Orgelbuch or Liszt's Ad Nos on the organ, the latter perhaps even including sounds from the Sauer organ, similarly controllable via the digital console.
[§52] Prior to this, however, the building process will also challenge researchers. As its sound will be a major point of reference, it seems appropriate to rethink the casting of the pipe metal thoroughly, as well as the ways the pipes are made. Consequently, the next topic will be the skill of the voicers. How will they make the pipes sound as desired? What sonic skills will they need, apply and develop during the process? What will be considered as 'desirable', by whom, and why?
[§53] These are exiting times. To make sure that the decision-making process works as well as possible, the Orgelpark has decided to set up a reference group of experts, including not only experts from the field of organbuilding, but also musicians and composers. In order not to exclude anyone interested to take part in the process, a dedicated weblog has been launched in 2013.
[§54] Many questions are, as yet, unanswered of course. In the course of the project, they will be discussed at dedicated meetings in the Orgelpark, including one day colloquia and the annual international Orgelpark symposia. All contributions to these discussions will be published in the Orgelpark Research Reports.

24 Kevin Bowyer. "E-reader technology at the University of Glasgow." *Organist's Review* 100/3 (2014). 36-39.

Abstract

The 21st century challenges us to rethink the interdependence of sound and technology regarding organs once again. On the one hand, digital technology suggests new ways of making music using organ pipes. At the same time, the 21st century has also seen another innovation regarding organbuilding: the Göteborg Organ Art Center developed the concept of "process reconstruction", aimed at understanding the working methods

17th and 18th century organbuilders applied to their trade. The Orgelpark wants to connect both worlds in its "New Baroque Organ": it needs to be fit for Johann Sebastian Bach's organ music and inspire new music. The solution seems equipping the organ with "spring chests". Controlling the individual pipe valves electrically by adding an electromagnet to each maximizes the organist's previously unimaginable control over the sound resources; playing the organ by the mechanical console will provide the "sound and feel" of an original baroque organ. To be sure, applying historic organ concepts in new instruments is an archetypal facet of 20th century organbuilding, as is the subsequent counterpoint, provided by several contemporary organ concepts developed fairly recently.

The new organ will challenge researchers to map the way organists, composers and other artists will find (fight?) their ways into the sound world of the new instrument. What sounds do they choose? Why? To what extent do traditional/conservative notions play a role? To what extent dare they look for new horizons? What do they consider convincing and what not? Of course, such questions are relevant to both performances of baroque music and of new music. The building process will challenge researchers. As its sound will be a major point of reference, it seems appropriate to rethink the skill of the voicers. How will they make the pipes sound as desired? What sonic skills will they need, apply and develop during the process? What will be considered as 'desirable', by whom, and why? The Orgelpark Research Reports will document the research.

Hans Fidom

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II

Peter Peters - How to Build an Authentic Replica? The New Baroque Organ in the Orgelpark as a Research Organ

[§55] The first time I visited the United States, in 1989, my travel companions and I drove in a rented car through the desert on the border between California and Nevada. A road sign indicated the ghost town Calico, a center of silver mining in the nineteenth century, and we decided to take a look. The small town was rebuilt as a tourist attraction. Visitors could experience the past by walking through the streets, entering a saloon or buying Western hats or Native American headwear. This merchandise was advertised as "authentic replicas". The term stuck in my mind, even more so since I was reading Umberto Eco's *Travels in Hyperreality*. As a semiotician, Eco explored situations in which it was difficult to distinguish reality from the simulation of reality. A hyperreal postmodern world, Eco argued, is characterized by a seamless blend between the real and fictional, especially when the material and the digital are merged.[1]

[§56] When thinking of a title for this brief essay about the new Baroque organ that is to be built in the Orgelpark in Amsterdam, the story about Calico came to my mind. The orgel park, as a venue, aims to give the organ a new place in musical life. It has two Romantic organs, a neo-Baroque organ and a recently built replica of the oldest organ in the Netherlands, the Peter Gerritsz organ from 1479. In the spring of 2013 the Utopa Foundation that funds the Orgelpark decided that a new organ has to be built to fill the gap between medieval music and Romantic and contemporary music. It should be designed in such a way that music from the Baroque period can be

1 U. Eco. *Travels in Hyperreality: Essays*. New York: Harcourt Brace Jovanovich, 1986.

played on it, especially music by Johann Sebastian Bach. At the same time, it was decided that the new organ should not just be a 'Bach organ'; these can be found in other places in the Netherlands, such as Dordrecht. The organ should also make its sound material accessible in an innovative way, thus giving composers the possibility to create new music for the instrument.
[§57] This dual goal gives the project a complexity that raises many questions that resonate with the vexed concept of "authentic replica". Even though the new instrument will not be a replica of any existing organ, the ambition is to recreate the sound qualities of the organs that Bach heard or played. Knowledge of seventeenth and eighteenth century organ building practices, as well as knowledge about performance practices at that time, will be necessary to reach that goal. On the other hand, the organ will be an authentic organ in the sense of being unique, offering possibilities to performers and composers that cannot be found anywhere in the world. As such, it can be linked to the kind of innovative organs that the American organist and organ scholar Randall Harlow has called 'hyper organs'.[2] It is this combination of history as a reference and future music as an ambition that makes this project fascinating.
[§58] In what follows, I will present the new organ not only as a musical instrument, but also as a device that generates questions and answers. As such, I argue that it could attract many interested publics: organ players, composers, and organ music audiences of course, but also scholars working on sound, innovation, artistic research, and listening practices. I focus first on the "open" design of the new organ and its hybrid character. Then I will discuss it as a radical innovation. Third, I explore its possible status as being both a musical instrument and an instrument of knowledge. Finally, I reflect upon two contexts of use of the organ, historically informed performance practices as well as twenty first century musicking.[3]

2 R. Harlow. *Recent Organ Design Innovations and the 21st-century "Hyperorgan"*. Retrieved from http://www.huygens-fokker.org/docs/Harlow - Recent Organ Design Innovations and the 21st Century Hyperorgan.pdf

3 C. Small. *Musicking: The Meanings of Performing and Listening*. Middletown, CA: Wesleyan University Press, 1998.

The Baroque organ as a 21th century "hyperorgan"

[§59] Of all musical instruments, the organ has the longest history of innovation. It has incorporated new ideas and practices in music making, as well as new technologies and organological insights for centuries.[4] As such, organs can be seen as aesthetic and technological mirrors of their time.[5] From the earliest blockwerk organ, basically a wooden box with ranks of pipes, to the 'hyper organs' of today, a twofold common thread can be distinguished: an extension of the sound material that the organ could generate, as well as well as innovative ways to make this sound material accessible. An example of creating new sound material is adding new stops to the organ or/and new ranks of pipes that share sound colour and timbre. These sounds have in turn been made accessible in new ways through novel keyboard designs and the key and stop action.[6] Organ builders have always incorporated the latest technologies and craftsmanship in their work, be it the pneumatic and electric action in nineteenth century organs, or more recently, MIDI interfaces to play an organ at a distance today.
[§60] Randall Harlow (2011) has given an overview of some recent innovations in organ design. The first is the thirty-one-tone organ by Adriaan Fokker that is based on the tuning experiments by the seventeenth-century physicist Chistiaan Huygens.[7] Other examples that Harlow analyses are the organs designed by Peter Bares in the St Peter's in Cologne (Germany) that focus on a vast array of stops thus enabling maximum tone

4 N. Thistletwaithe. "Origins and development of the organ". In N. Thislewaith & G. Webber, eds., *The Cambridge Companion to the Organ*. Cambridge: Cambridge University Press, 1998. 1-17.

5 K.J. Snyder. *The organ as a mirror of its time: North European reflections, 1610-2000*. New York: Oxford University Press, 2002.

6 This is the mechanism that transfers the movement of a key or a stop to the valve and slider or spring chest that enables the pressured air to flow into the pipe.

7 This organ has been divided the octave into 31 tones, which enables the performer to play compositions with just intonation instead of the equal temperament that is common today. A characteristic feature of the organ that is now in the Muziekgebouw aan het IJ is its console having many more keys than a traditional keyboard. During a recent restoration, the organ has been given a MIDI interface, and it can now be played directly from a computer.

color; the prototype organs built by Peter Kraul in Bern (Switzerland) that enable the organist to control the organs wind thus enhancing the expressive qualities of the instrument; the "Modulorgue" built by Daniel Birouste and Michaël Fourcade in Aspiran (France) that use digital valve technology to enable the organ player to use pipes in every combination; and finally, the new symphonic organ built by Gerald Woehl in Piteå (Sweden) that basically offers organs from three periods in one case. According to Harlow, all these innovations reflect that fact that "composers have been interested in instruments capable of micro control over the broadest range of musical parameters, be it in search of spectral flexibility or total serialization."[8]

[§61] The new Baroque organ in the Orgelpark belongs in the series of hyperorgans that Harlow describes. Its innovation does not concern the Baroque sound material it offers – as noted, other organs have been built with that aim – as well as in the way it makes this sound material accessible. The basic design strategy is to build a new organ modeled after a historic organ. At this moment, this reference organ is the large instrument of three manuals and fifty-three stops in the Wenzelskirche in Naumburg, Germany. Zacharias Hildebrandt, a student of the famous German organ builder Gottfried Silbermann, built this organ in 1743-1746. The organ was examined and approved by Johann Sebastian Bach in 1746. The instrument was restored and reconstructed between 1993 and 2000 by Hermann-Eule-Organbuilding of Bautzen. As said, the new organ cannot be an exact replica because of the smaller spatial dimensions of the Orgelpark, but its sound character as well as the aesthetic ideas behind its disposition, such as a large number of 8′ stops, will be followed as much as possible.

[§62] The radically new element in the design of the Baroque organ is the use of spring chests instead of the much more common slider chest. In an ordinary organ, each manual has its own wind chest, a wooden box on which the various ranks of pipes stand. Inside the box there is a pallet for every note on the keyboard. Pressing a key will open this pallet. If all the stops are drawn, all pipe ranks will sound. Each wind chest has a mechanism allowing the performer to choose which ranks of pipes will

8 Harlow 2011 [cf. note 2]. 20.

sound, and which will be silent. Normally this will be a wooden slider that has holes in it that match the various pipes. If closed, wind will not flow in the pipe rank. The archaic alternative to the slider chest is the spring chest, which has small valves for each individual pipe that are all opened when a stop is drawn. This system can be found especially in Italy, and also in a small number of organs in Northern Europe, e.g. the Nieuwe Kerk in Amsterdam.[9] If the individual small valves are operated by electromagnets, it is possible to play any combination of pipes.[10] Thus, the new organ has two faces: it can be played as a Baroque organ modeled after the Naumburg organ, and it is a "hyperorgan" that provides the organ player and the composer with a range of yet unheard sounds and possibilities.

The new Baroque organ as a radical innovation

[§63] How can we think of the new organ as not just an incremental innovation that introduces novelties in existing instruments, but also a radical innovation that has not yet been tested and used? What are the chances and pitfalls in the process of designing and building it? Recently, scholars from Science & Technology Studies (STS) have studied musical instrument development and have added to the work of organologists. In doing so, they have contributed to discussions on what counts as a genuinely new musical instrument, as well as to explanations for the rise of such instruments. STS scholars have also studied settings of musical instrument design that are beyond the dominant paradigm of organologists. One example is the recent interest in STS for the use and development of musical instruments in the context of the laboratory. Another example is the study of contemporary practices of "retro-innovation": the reconstruction of early musical instruments, such as the replica design and restoration, and the reinvention of obsolete instruments.[11] STS thus offers a vocabulary for studying the design and building of the new Baroque organ.

9 S. Bicknell. "Organ construction". In N. Thislewaith & G. Webber , eds., *The Cambridge Companion to the Organ.* Cambridge: Cambridge University Press, 1998. 18-30.

10 See the article by Hans Fidom for a more elaborate explanation of this mechanism.

11 K. Bijsterveld & P. Peters. "Composing Claims on Musical Instrument Development: A Science and Technology Studies' Contribution". *Interdisciplinary Science Reviews* 35/2 (2010). 106-121.

Characteristic of radical innovations is that the design and construction process cannot be conceived as the ballistic trajectory of a bullet than can be calculated in advance. Instead, there is a learning process with outcomes that are to some extent unpredictable.

[§64] Building on theoretical and empirical research of both historical and contemporary innovations, conceptual models were developed to document and monitor radical innovation processes. The claim of these approaches is that they increase the chances of successful innovations.[12] Two examples of these models have been compared as to the specific arrangements of interaction that influence the innovations that are actually produced.[13] The first example is Strategic Niche Management, a theory of innovation that claims that radical technological innovations such as electric cars can only be developed in niches protected from brute market forces.[14] The second example departs from the notion of the niche as an incubator in which vulnerable new technologies can develop before they are introduced onto the market. It claims that the process of radical innovation should be seen as a learning process and it is only by confronting a new idea or a new technology with the harsh realities of the outside world that an innovator will learn how a new technology can become successful. This confrontation with existing reality can be staged through a series of dialogues between an innovator and an evaluator.[15] In both cases, the aim is to develop a radical new technology, but the arrangements are opposed: a closed niche versus an open and constructive "therapeutic" dialogue.

12 M. Akrich, M., Callon, B. Latour, A. Monaghan. "The key to success in innovation part II: The art of choosing good spokespersons". *International Journal of Innovation Management* 6/2 (2002). 207-225.

13 A. Hommels, P. Peters, W.E. Bijker. "Technotherapy or nurtured niches? Technology studies and the evaluation of radical innovations". *Research Policy* 36/7 (2007). 1088-1099.

14 J. Schot, F.W. Geels. "Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy". *Technology Analysis & Strategic Management* 20/5 (2008). 537-554.

15 H. Valve, R. McNally. "Articulating Scientific Practice with PROTEE STS, Loyalties, and the Limits of Reflexivity". Science, *Technology & Human Values* 38/4 (2013). 470-491.

[§65] Following the second approach, pitfalls in the design process of the new organ can be identified. The main pitfall is the idea that the outcome of the innovation process can be predicted fairly accurately. Instead, particular attention should be paid to obstacles and barriers. As Valve & McNally argue, "innovation projects have an unfortunate tendency to make claims and decisions without fully explaining them on the basis of evidence from tests or trials, with the consequence that potentially viable project variants are ruled out without testing, while unviable variants are sustained through lack of vigorous testing. This class is intended to challenge the project team to justify its decisions and choices on the basis of evidence from trials involving varied and independent humans and nonhumans."[16]

[§66] The design process of the new organ has been set up as an open process and intends to include as many relevant insights and actors as possible. In the core group, expertise on organ playing, organology, organ design and building, creating concert programs, artistic research and STS are represented. Next to that, symposia are organized with experts from different relevant fields who are invited to comment on the plans. Finally, a blog has been set up to attract the attention of relevant communities, such as organists, organ experts, or even concert audiences.

The Baroque organ as an experimental situation

[§67] The new Baroque organ is not just a radical innovation, it is a radical innovation of an artistic technology. The success or failure of the new organ will not be primarily being judged in terms of its mechanical or electronic merits. Rather, the question will be whether it does indeed match the sound quality of the Naumburg organ, and if musicians and composers recognize it as an artistically interesting instrument. The debate on the artistic and sound qualities of restored and new organs is pervasive in the organ world. Nowhere else, it seems, can we find the level of intensity of the controversies around the qualities of organs, and the new Baroque organ will not be an exception.

16 Valve & McNally 2013 [cf. note 15], 476.

[§68] The design choices that are made for the new Baroque include many aspects that will have an impact on the sound qualities and artistic value of the new instrument. Traditionally, organ design and restoration result from close collaboration between the organ builder, the organ adviser or organologist, and the organ musician. When it comes to building a new Baroque organ, knowledge of seventeenth century organ building practices and performance practices is of great importance. The Swedish organist and organ teacher Hans Davidsson argued in 1993 that replicating antique organs became desirable in the twentieth century as a reaction against modern organs produced by industrial methods. He writes that when organs became subjected to industrial production techniques "the main aim was no longer to attain the highest quality possible; instead factors such as capacity and profit became predominant (…) piece by piece, the accumulated experience of the skilled craftsmen disappeared. Thus the end result came to be determined more by the production process itself than by aesthetical or stylistic aims."[17]

[§69] Recovering the "true" sound of the organ requires returning to building techniques that were displaced over a century ago. In this sense, building techniques can be intricately connected to the musical dimensions of the organ. The complaint raised by Davidsson is that modern building techniques interpret these objects simply as technologies and not musical technologies. Replicating organs from the fifteenth, sixteenth, and seventeenth centuries is an attempt to recover the musical dimensions that have been lost through modern building techniques that efficiently rationalize production by decontextualizing these objects from musical culture. The ideas of Davidsson were materialized in the building of a Baroque organ in the Örgryte New Church in Gothenburg, Sweden. This instrument is a replica of the case of the 1699 Schnitger organ in the Lübeck

17 H. Davidsson. *The North German Organ Research Project at the School of Music and Musicology, University of Göteborg*, 1993. 9. Retrieved from http://musikforskning.se/stm/STM1993/STM1993_1Davidsson.pdf.

Dom and surviving pipework in the Schnitger organ in the Hamburg St Jacobi church. It was built by GOArt, the organ research centre of the University of Gothenburg.

[§70] The aim of the GOArt project was to gain the knowledge and experience necessary to construct, in a Swedish church, an organ the way it might have been built by Arp Schnitger in late seventeenth-century Northern Germany. This organ had a façade with long 32′ pipes that would not have fit in the church in Örgryte. The Lübeck Dom organ case was chosen because it was the right size for the church in Sweden. Using the old pipework from the Hamburg organ as the main study material for the new organ, the ambition was to come as close as possible to the "pattern language" of Schnitger: "So, using the most coherent collection of pipework to survive from any Schnitger organ, we tried to learn about the craft processes that produced the original object, in order to perform them well enough to build a new object in the same language as the original."[18]

[§71] Elsewhere I have analysed the GOArt project as an example of artistic research.[19] This emerging field departs from the separation of the sciences and the arts as it evolved in the nineteenth century. Rather, the work of artists can result in knowledge, works of art can be presented as knowledge claims.[20] When we reflect on this practice of doing artistic research we are often trapped in dualisms: art and science, words and worlds, art practice and art writing, discursive and embodied knowledge, original art works and their representations. To look more in detail at the first dualism, between art and science, one often finds oneself rehearsing cliché notions of what characterizes art as well as science. Art becomes a paragon of

18 J. Speerstra. "An Introduction to the North German Organ research Project". In Joel Speerstra, ed., *The North German Organ Research Project at Göteborg University*. Gothenburg: Göteborg Organ Art Center / Göteborg University, 2003. 15-20./ 18-19.

19 P. Peters. "Research Organs as Experimental Systems: Constructivist Notions of Experimentation in Artistic Research". In M. Schwab, ed., *Experimental Systems. Future Knowledge in Artistic Research* (pp. 87-101). Leuven: Leuven University Press, 2013.

20 H. Borgdorff. "The Production of Knowledge in Artistic Research". In M. Biggs & H. Karlsson, eds., *The Routledge Companion to Research in the Arts*. London: Routledge. 44-63.

unmethodological, autonomous and intuitive work, while science appears uncreative, methodological and articulate.[21] The design and construction of the new Baroque organ, however, raises problems and questions that cannot be reduced to the dualism of science and art. Rather, the organ should be thought of as an experimental system, a term introduced by the historian of science Hans-Jörg Rheinberger.

[§72] Experimental systems are characterised by the objects of investigation, or "epistemic things", and the experimental apparatus that consists of elements that are well understood, the "technical objects".[22] In an article in the Neue Zürcher Zeitung in May 2007, Rheinberger compared experimental systems to spider webs. They are arrangements in which we are able to catch something, though we do not know exactly what that something is, or even when it will come. Experimental systems are "surprise generators," Rheinberger claims, or "machines for making a future:" "They are not simply experimental devices that generate answers; experimental systems are vehicles for materializing questions. They inextricably cogenerate the phenomena or material entities and the concepts they come to embody. Practices and concepts thus 'come packaged together'."[23] The essence of this quotation is the assertion that in scientific experiments propositional knowledge cannot be separated from the material assemblage that is set up. It is precisely in and through creating this material assemblage that our understanding takes shape. From this perspective, there is no reason to treat the experimental setting of a research organ differently than a biological experiment. The question then becomes: What kinds of understanding are made possible through the research organ; and, more importantly for the debate on artistic research, what are the aesthetic dimensions of these understandings?

21 R. Benschop, P. Peters, B. Lemmens. "Artistic Researching: Expositions as Matters of Concern". In M. Schwab & H. Borgdorff, eds., *The Exposition of Artistic Research: Publishing Art in Academia*. Leiden: Leiden University Press, 2014. 34-51.

22 H.J. Rheinberger. *Toward a History of Epistemic Things: Synthesizing Proteins in the Test Tube*. Stanford, CA: Stanford University Press, 1997. 24-31.

23 Rheinberger 1997 [cf. note 22], 28.

[§73] The epistemic thing in the Baroque organ project, I would say, is the unique combination of knowledge, aesthetic ideals, and skills that are required to design and build an organ that "transports" the Naumburg organ to the Orgelpark in Amsterdam and makes its sound material accessible in innovative and artistically interesting ways. To put it in more general terms, the experimental system of the Baroque organ, as a research organ, enables us to articulate problems as artistic, and to construct discursive and material arguments for aesthetic choices.

[§74] Why do we find some sounds more interesting and pleasing than others? Why do we want to hear the sound of old pipes? Does one hear the difference in sound quality between a pipe standing on a slider chest or a spring chest? What is the artistic importance of this difference? To answer these questions, future knowledge has to be developed and lost skills may have to be learned. The results of this research cannot be categorised a priori as scientific or artistic. The design and building of the new Baroque organ will help to extend our understanding of artistic research as a way to produce knowledge through creating art.

The Baroque organ and hybrid musicking

[§75] As an artistic and musical technology, and as an instrument of knowledge, the new Baroque organ assumes a context of use. How can we be sure it will innovate organ-building practices and practices of organ playing, composing, and listening? How will it relate to changing performance practices? To answer these questions, we have to look beyond the organ as a material object located in the Orgelpark. Since the 1970s, musicologists have expanded their field of study into what is called new musicology. This approach questions the focus on 'music itself'. New musicology analyses music making and music listening as situated activities, and draws upon other disciplines, including the humanities and the social sciences, to study practices of what Christopher Small has called "musicking", turning the noun "music" into a verb:

> To musick is to take part, in any capacity, in a musical performance, whether by performing, by listening, be rehearsing, or practicing, by providing material for performance (what is called composition), or by

> dancing. (…) Using the concept of musicking as a human encounter, we can ask the wider and more interesting question: What does it mean that this performance (of this work) takes place at this time, in this place, with these participants?"[24] (Small, 1998, pp. 9-10)

[§76] Following this broad definition, the new Baroque organ, once built, will lead to new practices of musicking. On the one hand, these will built on the historically informed performance practice. Since Paul Hindemith's call to perform early music "with the means of production that were in use when the composer gave it to his contemporaries," historical performance practice of music has gradually become an essential part of modern music culture. Musicians and audiences became historians, studying the musical practices of the time they want to (re)perform and experience. Historical performance practice also required the restoration of original musical instruments and the rediscovery of old techniques and materials to build replicas of 'authentic' instruments. Recently, both performers and scholars have turned their attention to performance spaces, exploring the design and acoustic characteristics of buildings like churches and concert halls. (Re)constructing the material and spatial basis of historical performance practice also involves modern scientific and technological knowledge like electro-acoustical measurements and computer models of old instruments.
[§77] On the other hand, the new Baroque organ translates aspects of complex historical musical cultures in order to create new cultures of performance and listening for the twenty-first century. Not only will the organ offer the possibility to play every pipe individually in any combination through the MIDI console, it will also be wired so that it can be amplified electrically. An aspect of the design plan is to have loudspeakers in the organ case. This enables the somewhat mind-boggling situation where the organ pipes could be sampled to give the organist or the composer the possibility to combine the material sound of the organ with the digital samples that can be manipulated. Using the virtual organ software developed by Hauptwerk,[25] it

24 Small 1998 [cf. note 3]. 9-10.

25 www.hauptwerk.com.

is possible to play a sample set of the historic Naumburg organ in combination with the actual sound of its present day counterpart in the Orgelpark.
[§78] This combination of the material and digital might be one of the more defining aspects of the musicking practices that could evolve around the new Baroque organ. An example of these practices is the Organ Augmented Reality (ORA) project, which revolves around an audio and visual augmentation of an historical church organ to enhance the understanding and perception of the instrument:

> ORA has been presented to public audiences at two immersive concerts. The visual part of the installation was based on a spectral analysis of the music. The visuals were projections of LED-bar VU-meters on the organ pipes. The audio part was an immersive periphonic sound field, created from the live capture of the organ sounds, so that the listeners had the impression of being inside the augmented instrument. The graphical architecture of the installation is based on acoustic analysis, mapping from sound levels to synchronous graphics through visual calibration, real-time multi-layer graphical composition and animation. The ORA project is a new approach to musical instrument augmentation that combines enhanced instrument legibility and enhanced artistic content.[26]

[§79] I quoted this web article at length to point out the differences between a language game that accompanies the upstream journey to the origins of Bach's organ music and the instruments on which he played it, and the vocabulary that describes the downstream journey into a future of augmented realities and digitally mediated experiences. As a conceptual, material and artistic link between past and future, managing the hybridity of the new Baroque organ – open and flexible, yet offering resistance – could well be the main challenge in the process of bringing it from the drawing table to the North balcony of the Orgelpark.

26 C. Jacquemin, R. Ajaj, S. Le Beux, C. d'Alessandro, M. Noisternig, B.F.G. Katz, B. Planes. "Organ Augmented Reality: Audio-Graphical Augmentation of a Classical Instrument". *International Journal of Creative Interfaces and Computer Graphics* (IJCICG), 1/2 (2010). 51-66 / 51.

Coda

[§80] The Baroque organ is still a plan. On the table are sketches, calculations, and minutes of meetings. Basic design decisions have been taken. The organ will have the spring chest mechanism, and a mechanical key action as well as an electromagnetic key action that can be played from the MIDI console. The team that will carry out the Baroque organ project at the Orgelpark has travelled to visit organs in Sweden and Germany with the goal to learn more about historic examples of the spring chest mechanism, and to listen to and compare organs that have been built by organ builders such as Schnitger and Hildebrandt, as well as a Baroque organ recently built by the Dutch organ builder Flentrop in Hamburg.

[§81] During these journeys some of the elements in earlier descriptions of the plan have changed. From the Arp Schnitger organs associated the North-German school, the sound ideal shifted to the Hildebrandt organ in Naumburg that became a primary reference. Issues of tuning have been discussed. The original idea of a dual tuning – both quarter comma meantone and a well tempered tuning in one organ – has developed into a one tuning concept, such as the Neidhardt 3, a temperament that may have been used by Hildebrandt. Hans Elbertse, the organ builder in the team, has built a prototype model of a spring chest with electromagnetically controllable valves. This model can be used to study the effect of the innovative key action on the sound of the organ pipes, but also to see how the electro-mechanical handling of the valves reacts.

[§82] Yet many decisions still have to be taken. More has to be learned. In this learning process the changes of our plan will reflect the different expectations that are projected on the new instrument. It should be an organ to play Bach, and it should offer as yet unknown possibilities to musicians and composers. With the completion of the organ the learning process has not ended. The goal of the project is an organ that is not only built, but that will used in innovative ways. How to build it as an authentic replica? That would be the central question for me.

[§83] Listening to David Franke, who played a Bach chorale on the Hildebrandt organ in the Wenzelskirche in Naumburg, I was moved by the beauty of the music and the sound of the instrument. I felt that this was how Bach wanted the organ to sound. These were the actual keys on which he played, the stop knobs that he drew out to test the "lungs" of the new organ. It was the opposite of walking through the streets of Calico. It was a historical sensation as the Dutch historian Huizinga defined it, "not as a re-experiencing, but as an understanding that is closely related to the understanding of music, or rather of the world by means of music."[27]

27 J. Huizinga. "The Task of Cultural History". In Johan Huizinga, *Men and Ideas*. New York: Meridian Books, 1959. 51-76.

Abstract

The new Baroque organ that is to be built in the Orgelpark in Amsterdam will be designed in such a way that music from the Baroque period can be played on it, especially music by Johann Sebastian Bach. At the same time, the organ makes its sound material accessible in an innovative way, thus giving composers the possibility to create new music for the instrument. It is this combination of history as a reference and future music as an ambition that makes this project fascinating. In this article, I will present the new organ not only as a musical instrument, but also as a device that generates questions and answers. As such, I argue that it could attract many interested publics: organ players, composers, and organ music audiences of course, but also scholars working on sound, innovation, artistic research, and listening practices. I focus first on the "open" design of the new organ and its hybrid character. Then I discuss it as a radical innovation. Third, I explore its possible status as being both a musical instrument and an instrument of knowledge. Finally, I reflect upon two contexts of use of the organ, historically informed performance practices as well as twenty first century musicking. (Small, 1998) The combination of the material and digital might be one of the more defining

aspects of the musicking practices that may evolve around the new Baroque organ. Conceived of as a conceptual, material and artistic link between past and future, however, managing the hybridity of the new Baroque organ – open and flexible, yet offering resistance – could well be the main challenge in the project.

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III

Kristian Wegscheider - The "Secret" of Tuning Methods in Organbuilding in the 17th and 18th centuries

[§84] During my research on the great Silbermann organ in the Freiberg Dom (D) in connection with its restoration in 1981-1983, I was infected by the "meantone tuning" virus. During examination of the pipe lengths of the Silbermann organ, I discovered that the Third C-E beat at exactly the same frequency as its associated Fifth, C-G. Like many other organbuilders and organ researchers, I suspected at that time that a mean-tone tuning with pure Thirds was employed in early Gottfried Silbermann instruments. I had of course already read the work of Georg Andreas Sorge, including his description of the Silbermann tuning, but these writings concern the later instruments of the Master.[1]

"New Equal Temperament"

[§85] Pleased with the "discovery" of this synchronicity between the Third and Fifth, I baptised this tuning the "New Equal Temperament" – according

1 This text appeared earlier in *ISO Journal* 20 (June 2004. 14-53), and is reproduced here with kind permission of the International Society of Organbuilders. The *Journal* contains scientific material concerning organbuilding techniques as well as articles of general interest about the organbuilding world such as congresses, publications, cultural events and persons. ISO members automatically receive all three yearly publications. ISO membership is reserved for organbuilding companies and their suppliers, but non members may subscribe in order to receive the ISO Journal. Contact: publisher@internationalorganbuilders.com. ISO-translation of Wegscheider's original German text: François Uys. The text is published here in original spelling, which may deviate from the one used otherwise in the Orgelpark Research Reports.

to the measurements taken on the pipework, Thirds and Fifths indeed beat at equal frequency. This "equal beating" occurs when one diminishes the Fifth with 1/5 Pythagorean Comma. Overjoyed with this, I informed all interested organ friends and colleagues about my "discovery/ invention", but learned quite quickly that this tuning had already been described in the 17th century in Italy and France where it was manifestly in use, if not a widely employed practice, and indeed even traceable in the Netherlands.

[§86] A little disenchanted, I asked myself the following question: How did Silbermann, or for that matter the old organbuilders, manage to lay this temperament – without electronic tuning devices? Maybe with a monochord or pendulum, or possibly by comparing the beat frequency to the pulse rhythm? – I was very dubious about this. There must have been control intervals, or a means of comparing beat frequency that helped to determine the tuning easily, but with precision.

[§87] Concerning the 1/5-Comma Pythagorean tuning, probably used by Silbermann in his organ in the Freiberg Dom, the matter seemed relatively simple. After four consecutive Fifths, one obtains the first Third and when the latter beats as fast as the Fifths, one is about right. But in fact all the Fifths, or lower Fourths, of this 1/5 Comma tuning have different beat frequencies when they are diminished by the identical fraction of a Comma. Though theoretically this is perfectly correct, it is however very impractical and very difficult to tune or to divide. After countless attempts I arrived at the conclusion that the so-called "old organbuilders" simply adjusted the audible beating frequencies to identical values, or to have easily checkable ratios (1:2, 2:3, 1:3, etc).

[§88] After practical experimentation, I was amazed to discover that in reality one perceived these strictly equal-beating Fifths scarcely as defects at all, or at least as not disturbing. These are not much more than theoretical defects, really.

[§89] Tunings that are in practice quite easy to lay quickly become, in theoretical terms, an inextricable lacework of Fifths and Thirds: the numerical values of geometrical intervals, when expressed in tables, become quite different and have many numbers after the decimal point. It was my conviction then that these tables did little more than make matters even more confusing. Even though these "equal beating", or rather, proportionally beating tunings, are not easily described in tables, I was convinced that the old organbuilders really did lay them in this fashion. Neither in my dissertation Guidelines towards the Conservation of Historically Important Organs,[2] nor in 1982 did I dare propose this "beat frequency tuning" as a Silbermann tuning, since most historical and theoretical material that has arrived to our day is expressed in Comma-divisions.

[§90] My interpretation of the text by J.A. Sorge about the Silbermann-tuning was the following: various values for the Comma-divisions now had to be taken into account for the dimension of Fifth intervals. This also largely conformed to the model of beat frequencies and more or less corresponded to the measured lengths of the surviving pipes. Even though it was extremely laborious to lay the temperament according to the beat frequencies without the help of an electronic tuning device, at least it was now possible to establish a good theoretical representation.

[§91] So, the Fifths were diminished by 3/12, 2/12 and 1/12 Pythagorean Comma. Since in 1982 I did not yet own a tuning device; the number of beats per second were carefully calculated and the tuning laid by means of a stop watch. I have always heard the following from Jürgen Ahrend: "Tuning is a technical process." A stop watch is also a technical instrument. One can therefore count up to ten beats and then measure the lapse of time. A number of years later, in collaboration with Hartmut Schütz, we prepared "Thoughts on Equal Beating Temperaments".[3]

[§92] Simultaneously, at the beginning of the 1980s when I worked on the Silbermann organ in Freiberg and "discovered" the 1/5 Comma tunings,

2 Kristian Wegscheider, Helmut Werner. *Richtlinien zur Erhaltung wertvoller historischer Orgeln: zum Gebrauch für Orgelbauer, Denkmalpfleger, Organisten* (Studien zur Aufführungspraxis und Interpretation von Instrumentalmusik des 18. Jahrhunderts [e.g. Special Contributions to the Studies on the Execution and Interpretation of 18th Century Music] XII). Blankenburg/Harz: Kultur- und Forschungstätte Kloster Michaelstein, 1981.

3 This article was published in the special editions 3, 4 and 5 of the series *Sonderbeiträge zu den Studien zur Aufführungspraxis und Interpretation der Musik des 18. Jahrhunderts* (e.g. Special Contributions to the Studies on the Execution and Interpretation of 18th Century Music). Blankenburg/Harz: Kultur- und Forschungstätte Kloster Michaelstein, 1998.

the American organbuilder Charles Fisk started the plans for his Stanford University organ (California, USA). Inspired by the Meantone tuning with lightly beating Thirds that the company Orgelbau Schuke (Potsdam) had employed in Halle (Marktkirche, choir organ), in collaboration with Harald Vogel, Fisk retained a 1/5 Comma variant in this organ with dual temperament.
[§93] Shortly before, in 1975, Herbert Kellner published his "Bach"-tuning that equally had its roots in the 1/5 Comma division. John Brombaugh experimented with similar tunings and Jürgen Ahrend was then occupied with the restoration/reconstruction of the Schnitger organ in Norden (D), an exciting work that still today compels my admiration. He too, in a joint decision with the organ committee, chose a type of welltempered tuning with mean-tone characteristics, using 1/5 Comma Fifths in his personal variant. Jokingly, I retrospectively refer to these years as the beginning of the 1/5 Comma phase.
[§94] An historical source was often quoted at this time and considered as evidence for the 1/5 Comma variant, apparently advocating the distribution of the Wolf Fifth and the use of slightly sharpened Major Thirds. This is the report of organbuilder Johann Siburch's reaction to the objections by two important Hamburg organists, Jacob Prätorius and Heinrich Scheidemann, from January 1641, on the occasion of the approval of the organ in the Liebfrauenkirche in Bremen (D).
[§95] The clerk only quoted what Siburch "declared on each of the points in the following way." Under point 5 we find the following: "He will attempt as well as possible to tune the same Fifth pure between a and d, to augment the Thirds and to move the beating Fifths elsewhere."[4] According to Harald Vogel and Cor Edskes, amongst others, Siburch's answer to the criticism of the two Hamburg musicians implies that the tuning did not have pure, but beating (augmented) Thirds. Furthermore, the expression "move the beating Fifths elsewhere" is thought to mean that the mean-tone "Wolf" Fifth is no longer present and that the intervals are stretched.
[§96] One may of course read and interpret this source in this way, but I believe that another interpretation is possible and indeed even more probable. If

4 Quote: Uwe Pape and Winfried Topp. *Orgeln und Orgelbauer in Bremen*. Berlin: Pape Verlag, 2003. 182.

Siburch tuned starting from the note F (in the first half of the 17th century, this note was in general still an important reference for pitch, used as a starting point for temperaments), he consequently tuned F-C, C-G and G-D, probably leaving the Fifths tuned too pure. In order to tune the Third F-A pure, the biggest part of the syntonic comma now found itself placed at the end of the circle of Fifths on the Fifth interval D-A. If one allows this theory, Siburch's answer to the criticism by Prätorius and Scheidemann is very easily decoded. He intends to render the Fifth D-A as pure as possible, that is by tuning D lower, certainly also the G and maybe also the C. But to avoid retuning the entire organ, the Thirds on F#, B and E remain as they are and therefore become relatively sharp. The phrase "move the beating Fifth elsewhere" therefore refers to the beating Fifth D-A. This interpretation (brought to my attention, and justly so, by Ibo Ortgies) is therefore equally plausible, possibly even more probable, since the consultant Adolph Compenius from Hannover, whose advice was asked in Bremen, wrote: "Since at present the Fifths in the so-called Octava should as far as possible not be too bad, to avoid the harmony becoming disagreeable, and now that we have tuned the octave, all the stops on all three manuals and the pedal should be tuned accordingly."[5]
The tuning laid by Siburch in Bremen, criticised by Prätorius and Scheidemann, is evidently a failed Prätorian mean-tone tuning. Siburch was a conservative organbuilder and probably stuck to the older tuning in which the Fifths are more pure, as can be found in 16th century sources. He could not or did not want to sacrifice the pureness of the most important Fifths in favour of purer Thirds "at present" in use. This is merely an example of the difficulty that resides in the correct, or at least not erroneous, interpretation of historical sources.

How did the organbuilders manage to lay temperaments?

[§97] Let's now get to the aim of this paper: how did the organbuilders of that time manage to lay temperaments? This question has preoccupied me since my apprenticeship years. The literature on temperaments would fill

5 Quote: Uwe Pape and Winfried Topp. *Orgeln und Orgelbauer in Bremen*. Berlin: Pape Verlag, 2003. 183.

several bookshelves. The statements are not always perfectly understood, and the attempt to render visually the mathematics experienced musically has led to a great number of circles, diagrams, curves and other such arrangements. Authors such as Ratte, Dupont, Billeter, Vogel, Lindley, Kellner, Fricke, Schütz, Greß, Norrback, Ortgies (to mention only a few) are known to those who have been interested by this problem. Almost all of these accounts use Comma indications for the Fifths and of course Cent indications for the individual tones and most important intervals. A few authors certainly point out practical ways to compare beat frequencies and supply organbuilders or harpsichord tuners with concrete indications on the way tunings may be laid entirely without electronic tuning aid, but geometrical proportions of the Comma division appear soon enough in the tables. How can one possibly describe or lay down on paper things that in practice are often quite simple?

[§98] One of the most beautiful historical sources dedicated to audible beat frequencies can be found in Mirror of Organbuilders and Organists by Arnold Schlick, published in 1511. Schlick was blind and exclusively concentrated on what could be heard of the intervals. His almost poetic indications (for example, F-c should "be lowered somewhat, within the limits of what the ear may suffer") have been interpreted in different ways by various musicologists and then translated in diagrams. From these diagrams, using Cent indications for individual tones, different Schlick interpretations were set on an organ or harpsichord by means of a tuning device. Only a few organbuilders have dared to follow the original descriptions.

[§99] Since the introduction of electronic tuning devices, the thoroughly researched theoretical and historical sources with their calculated Comma divisions have been applied by means of these tuning devices in organs and stringed keyboard instruments. There is nothing against this. Nobody will renounce this precious technical aid. However, it is very refreshing to ask oneself the following legitimate question (mostly asked by interested amateurs): how did the old organbuilders do this in earlier times? I often answer as a joke: "MPP" – monochord, pendulum and pulse. Since the description by Adlung[6] of Neidhardt's pitiful attempt to lay a well-tempered tuning with his monochord in

6 Jakob Adlung, *Musica mechanica organoedi.* Berlin: Birnstiel, 1768. 54-55.

Jena, doubts have appeared on this subject. Neither pendulum nor pulse rate are precise indicators. In fact, that leaves us really only the possibility to compare beat frequencies.

[§100] Apart from the few rare indications by Schlick, Prätorius, Werkmeister[7] and Printz on the beat frequency of intervals, in recent literature it is principally Herbert Anton Kellner[8] who pointed to the beat frequency comparisons or beat proportions between Fifths and Thirds and who in his reflections included practical tuning methods based on hearing. There are also other authors who have mentioned the possibility, or necessity, of comparing beat frequencies. In written reports, however, one again finds the precise Comma divisions for the different tunings.

[§101] When listening to experienced continuo players, I am often delighted by the rapidity with which they manage to lay a tuning and to control it through beat frequency comparisons. At the Akademie für Alte Musik in Bremen, it is the habit to tune in a practical manner rather than according to precise Comma indications. To employ the so-called Werkmeister III tuning on harpsichord or organ, one first of all lays a mean-tone tuning, according to Prätorius with Fifths diminished by a 1/4th Syntonic comma from C to E, then one re-tunes the E so that E-A becomes a pure Fourth, or Fifth. The remaining Fifths are pure, and only B-F# receives the "excess", or "loss" really, since this Fifth should of course be somewhat smaller than pure. A tuning laid in this manner meets practically all the requirements, although none of the calculated values for the Werkmeister III tuning corresponds to it. But it works and absolutely sounds like Werkmeister III!

[§102] Many of the numerous historical organbuilders between the 15th and the 18th centuries, and certainly a few more from the 19th, developed their own way of determining Fifths (Fourths) and Thirds in a practical way, to obtain a tuning that would be judged agreeable and adapted to the practice of the time. The key for success to each tuning is first of all the division of the four Fifths within a major Third, the Thirds F-A, C-E and G-B being of particular importance. For example, was the Third pure, did it beat as fast as the Fifths, or twice, three times or even four times as fast? Did the Fifths beat equally or

7 Spelling of the names 'Prätorius' and 'Werkmeister' according to the author's preference.

8 Herbert Anton Kellner. *Wie stimme ich selbst mein Cembalo?* Frankfurt: Bochinsky, 1975.

unequally in even-numbered ratios or simply arbitrarily unequal? Did one continue tuning in Fifths and Thirds? – these were the questions that required practical solutions and to which every organbuilder had to find his own answer.

[§103] To continue in this line of thought, I have tried to develop the following tunings exclusively from the proportions of their beat frequency. One arrives at striking results, which further enhance the already great number of tunings.

[§104] Let us now look at a few concrete tunings and their corresponding tables. If one gives a musician analytical tables of a particular tuning, he will throw his hands in the air: "I will have to hear this first." If one illustrates this with a few notes, he will at least be capable of imagining how it is assembled and what it would probably sound like. It is simply a question of practice. (In fact, a tuning table is far easier to interpret than even a simple piano score.)

[§105] To rid ourselves once and for all of the Fifths/Fourths discussion ("Is this a Fifth or is it a Fourth?" – "But after all, a Fourth is a descending Fifth?", etc…), the Fifths are indicated as such in the following tables, even when within an octave the Fifth F#-C# is really a Fourth. As we already know, the Fifth F#-c#0 beats at the same speed as the Fourth C#-F# (on condition that the octave is pure). Since in the following tunings we are principally interested in their respective beat frequencies, the beat frequency of the Fifth F#-c#0 is indicated as that of the Fifth F#-C#, given that both these are identical.

[§106] To keep the discussion simple and general, only Fifths and Thirds are mentioned in the tables. As mentioned before, one has to keep in mind that the descending Fourth beats at the same frequency as the ascending Fifth, for instance C-F beats at the same speed as F-c0, D-G at the same speed as G-d0, etc. Unless otherwise specified, all given beat frequencies refer to the interval of the third octave where a1 = 440 Hz. The indications on Third beat frequencies concern 4 notes lying in the fourth octave, that is g#1-c2, a1-c#2, b flat1-d2 and b1-d#2. In the text and in the tables mention is made of: Thirds on G#, A, B flat and B, that is the Thirds G#-C; A-C#; B flat-D and B-D#, or B-E flat. All notes in this article are indicated with capital letters, since they are easier to identify in the text. For those for whom this is problematic, please imagine the first octave of a Fifteenth. This is why the first column is labeled "Pitch 2′ ".

[§107] I trust that this simplification will be seen as such by my readers, and that it will not provoke further confusion. The beat frequency per second, and its multiples, are indicated for most of the tunings. Almost every tuning has its own fundamental frequency, identified with an n. For example, when the Third C-E beats at 3n and the Fifth C-G at n, that means that the Third C-E beats three times as fast as the Fifth C-G. Apart from the ratios 1:2, 1:3 and 1:4, the ratios 2:3 and 3:4 are also easily recognisable in my experience. If one can count three pulsations or beats per given time unit for a Third or a Fifth, one can equally count four pulsations for the same time unit. In tuning it is imperative that one should always bear in mind the fundamental proportions of different intervals within a pure interval. For instance the upper Fourth in a pure octave will beat twice as fast as the lower Fifth, that is G-c0 will beat twice as fast as C-G. The lower Fourth beats at exactly the same frequency as the upper Fifth, that is C-F beats as fast as F-c0. Within a pure Seventh, for instance C-B, the lower Third C-E will beat in a relationship of 4:3 with respect to the upper Fifth E-B. On the other hand, the lower Fifth C-G will beat in a relationship of 2:5 with respect to the upper Third G-B.

[§108] Every so often, the numbers in the tables corresponding to the beat frequencies will be preceded by a minus sign. In this case, this is the result of a calculation and by no means indicates an augmented or diminished interval. Whether a Fifth is larger or narrower than the pure interval, can easily be judged from the Cent value. The precise value for a pure Fifth is 701,955 Cents. The same argument is valid for the major Third since diminished Thirds do not appear in the quoted tunings. The interval for a pure Third is 386,31 Cents.

Temperament 1 – Equal beating

[§109] The so-called equal temperament has its roots in antiquity. It was already a current practice for musical ensembles in the 17th century, even if there were different variants. For the organ, however, this tuning only appears, with regional variants, toward the middle of the 18th century. For some years now, the idea of "equal interval tuning" has been employed. This implies that each of the Fifths is diminished by exactly 1/12 Pythagorean comma. In practice this means that the beat frequency of each of the consecutive Fifths gradually augments so that the Fifth C#-G# beats a little faster than C-G, D-A a little faster than C#-G#, etc. One can also render the beat frequency of each of the Fifths within the Octave identical, and it then becomes a tuning with real “equally beating” intervals. It is in fact like this that organs were tuned until the first half of the 20th century and also after World War II. The result (key character) is only very little different from the equal interval tuning (the Thirds don’t even vary by 1 Cent either way). In Temperament 1 this can easily be seen. One has to divide more or less equally the beating frequency, around 14 Hz (Pythagorean Comma), within the octave C-B (If not indicated otherwise, the pitch in all tables is A = 440 Hz on a 2′ stop [= a1 on an 8′ stop]).

[§110] In the 70s I was taught that the Fifths should beat a little slower than the Fourths, that is the Fifths on C, C#, D, D#, E beat about once per second, the Fourths F-C, F#-C#, G-D, G#-D#, A-E, B flat -F and B-F# are all a little faster:

Temperament 1
Equal temperament with equal beating Fifths.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	699,741	1,194	399,52	-11,92	299,80	-0,20	0,67
B flat	700,477	1,194	399,98	-18,47	999,54	-0,46	0,41
F	699,983	1,194	399,11	-12,96	500,02	0,02	0,89
C	699,322	-1,194	399,52	-10,02	0,00	0,00	0,87
G	700,197	1,194	400,06	-15,63	699,32	-0,68	0,19
D	699,608	1,194	400,42	-12,02	199,52	-0,48	0,39
A	700,389	1,194	400,91	-18,62	899,13	-0,87	0,00
E	699,865	-1,194	399,99	-13,07	399,52	-0,48	0,39
B	700,560	1,194	400,42	-20,20	1099,38	-0,62	0,25
F#	700,093	1,194	399,60	-14,26	599,94	-0,06	0,81
C#	699,470	1,194	399,98	-10,99	100,03	0,03	0,90
G#	700,296	-1,195	400,50	-17,08	799,50	-0,50	0,37

[§111] An interesting variant, meant to render the equal tuning a little livelier, can be found in Temperament 1A. Both the Fifths E flat-B flat and G#-E flat are pure. We immediately obtain an interesting key character with somewhat better Thirds on F and C, as well as G, B flat and D. In practice this tuning can hardly be recognised as an unequal temperament. Its beautiful tonal character will rather charm one. It is even possible to tune so-called Symphonic organs in this way:

Temperament 1A
Equal temperament with 10 equally beating Fifths, the Fifths G#-E flat and E flat-B flat are pure (C-E beats 6 times faster than the Fifths).

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	701,955	0,000	400,54	-12,84	298,26	-1,74	0,47
B flat	700,186	1,430	398,43	-16,40	1000,22	0,22	2,42
F	699,594	1,430	397,39	-11,22	500,41	0,41	2,61
C	698,802	-1,430	397,87	-8,78	0,00	0,00	2,20
G	699,850	1,430	398,52	-13,88	698,80	-1,20	1,01
D	699,144	1,430	398,96	-10,77	198,65	-1,35	0,86
A	700,078	1,430	399,53	-16,86	897,80	-2,20	0,00
E	699,450	-1,430	398,43	-11,58	397,87	-2,13	0,08
B	700,283	1,430	400,94	-20,95	1097,32	-2,68	-0,47
F#	699,723	1,430	402,61	-17,50	597,61	-2,39	-0,19
C#	698,974	1,430	403,08	-13,48	97,33	-2,67	-0,47
G#	701,960	0,004	403,70	-20,94	796,30	-3,70	-1,49

Temperament 2

[§112] Let us now consider two practical variants of a Prätorian mean-tone tuning. Theoretically at least, the four Fifths within the Third C-E should be diminished by exactly 1/4 Comma, so that each one has a distinct beating frequency. In practice, though, one can have the Fifths C-G and D-A beat at one frequency and also the Fifths (Fourths) G-D and A-E beat at another, creating a ratio of 2:3 between the two frequencies:

Temperament 2
Meantone temperament after Prätorius, a practical variant with two distinct Fifth beating speeds. The Fifths C-G and D-A beat in a 2:3 relation with respect to G-D and A-E.

Pitch	Fifths		Thirds		Position	Difference E.T.	
2′	[cent]	[beats]	[cent]	[beats]		[C = 0]	[A = 0]
E flat	696,273	3,095	386,31	0,00	309,98	9,98	20,53
B flat	696,884	4,130	386,31	0,00	1006,25	6,25	16,80
F	696,865	3,100	386,31	0,00	503,13	3,13	13,69
C	696,290	-2,580	386,32	0,00	0,00	0,00	10,55
G	696,271	3,870	386,31	0,00	696,29	-3,71	6,84
D	696,887	2,580	386,32	0,00	192,56	-7,44	3,11
A	696,872	3,870	386,31	0,00	889,45	-10,55	0,00
E	696,281	-3,230	386,31	0,00	386,32	-13,68	-3,13
B	696,280	4,830	427,38	-59,04	1082,60	-17,40	-6,85
F#	696,879	3,230	427,37	-44,13	578,88	-21,12	-10,57
C#	696,869	2,420	427,38	-33,00	75,76	-24,24	-13,69
G#	737,350	25,486	427,37	-49,35	772,63	-27,37	-16,82

[§113] One can also have the four Fifths beat at the same frequency (Temperament 2A), and note quite rapidly that the difference is not all that great, except that it is still easier to tune. All the same, the Fifth C-G beats a little faster. (Tuning 2A) The variant described by Werkmeister in 1679 is interesting in that both Thirds B- E flat and E flat -G are balanced:

Temperament 2A
Meantone temperament after Prätorius, a practical variant with one Fifth beating speed. C-G, G-D, D-A and A-E beat at the same speed.

Pitch	Fifths		Thirds		Position	Difference E.T.	
2′	[cent]	[beats]	[cent]	[beats]		[C = 0]	[A = 0]
E flat	697,403	2,480	386,31	0,00	308,85	8,85	20,41
B flat	695,867	4,960	386,31	0,00	1006,25	6,25	17,82
F	697,884	2,480	386,32	0,00	502,12	2,12	13,68
C	695,154	-3,098	386,32	0,00	0,00	0,00	11,57
G	697,406	3,098	386,31	0,00	695,15	-4,85	6,72
D	695,871	3,098	386,32	0,00	192,56	-7,44	4,13
A	697,887	3,098	386,31	0,00	888,43	-11,57	0,00
E	695,149	-3,875	386,32	0,00	386,32	-13,68	-2,11
B	697,409	3,870	427,38	-59,04	1081,47	-18,53	-6,96
F#	695,867	3,875	427,37	-44,15	578,88	-21,12	-9,55
C#	697,890	1,935	427,37	-33,00	74,74	-25,26	-13,69
G#	736,213	24,673	427,37	-49,38	772,63	-27,37	-15,80

Temperament 3

[§114] The so-called Kirnberger III is a tuning often mentioned and regularly used (at least for the harpsichord). The four Fifths between C and E are tuned in mean-tone (either according to the tuning described in Temperament 2 or to that in Temperament 2A). Because of the unpleasant E-major key, it is less suitable for the organ:

Temperament 3

Practical variant of Kirnberger III. C-E is pure, G-B and D-F# beat practically at the same speed.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	701,955	0,000	401,02	-13,31	294,13	-5,87	5,70
B flat	701,955	0,000	396,47	-13,77	996,09	-3,91	7,66
F	701,955	0,000	390,39	-4,13	498,04	-1,96	9,61
C	695,154	-3,098	386,32	0,00	0,00	0,00	11,57
G	697,406	3,098	393,12	-7,75	695,15	-4,85	6,72
D	695,871	3,098	395,71	-8,01	192,56	-7,44	4,13
A	697,887	3,098	401,79	-19,76	888,43	-11,57	0,00
E	701,955	0,000	405,86	-18,69	386,32	-13,68	-2,11
B	699,997	1,675	405,86	-28,04	1088,27	-11,73	-0,16
F#	701,955	0,000	407,82	-23,12	588,27	-11,73	-0,16
C#	701,955	0,000	407,82	-17,34	90,22	-9,78	1,79
G#	701,956	0,000	407,82	-26,01	792,18	-7,82	3,75

Temperament 4

[§115] Werkmeister III constitutes one of the most important well-tempered organ tunings. The trick of this tuning, compared to the Kirnberger III, is that the Third C-E beats lightly and that consequently the Thirds on E flat , A, E and B have identical proportions. If one makes the Thirds and Fifths beat at the same frequency, this tuning is really very easy to do:

Temperament 4

Practical variant on Werkmeister III. C-E and C-G, G-D, D-A beat at equal speed. Method: A-E is pure and C-E, C-G, G-D beat at 3,1 Hz. Control: A-D beats at 3,1 Hz.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	701,955	0,00	401,02	-13,31	294,13	-5,87	5,71
B flat	701,955	0,00	396,47	-13,77	996,09	-3,91	7,66
F	701,955	0,00	390,38	-4,13	498,04	-1,96	9,62
C	695,152	-3,10	390,38	-3,10	0,00	0,00	11,57
G	697,405	3,10	397,18	-12,39	695,15	-4,85	6,73
D	695,869	3,10	395,72	-8,02	192,56	-7,44	4,13
A	701,955	0,00	401,81	-19,77	888,43	-11,57	0,00
E	701,955	0,00	401,81	-14,83	390,38	-9,62	1,96
B	695,941	5,15	401,80	-22,24	1092,34	-7,66	3,91
F#	701,955	0,00	407,81	-23,12	588,28	-11,72	-0,15
C#	701,955	0,00	407,81	-17,34	90,23	-9,77	1,81
G#	701,949	0,00	407,81	-26,01	792,19	-7,81	3,76

[§116] Another practical variant is described in Temperament 4A. The graduated Fifth beat frequencies are a little better aligned with the theoretical values:

Temperament 4A
Werkmeister III with four Fifths diminished by 1/4 Pythagorean comma.
Method: A-E is pure, A-D and C-E beat equally (3 Hz), then C-G and G-D is fitted in between in a 2:3 relationship.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	701,955	0,00	401,95	-14,17	294,13	-5,87	5,90
B flat	701,955	0,00	396,08	-13,25	996,09	-3,91	7,85
F	701,955	0,00	390,19	-3,94	498,04	-1,96	9,81
C	696,090	-2,67	390,19	-2,95	0,00	0,00	11,76
G	696,083	4,00	396,06	-11,11	696,09	-3,91	7,85
D	696,063	3,00	396,09	-8,33	192,17	-7,83	3,94
A	701,955	0,00	401,98	-20,00	888,24	-11,76	0,00
E	701,955	0,00	401,98	-15,00	390,19	-9,81	1,96
B	696,116	5,00	401,99	-22,51	1092,15	-7,85	3,91
F#	701,955	0,00	407,83	-23,13	588,26	-11,74	0,03
C#	701,955	0,00	407,83	-17,35	90,22	-9,78	1,98
G#	701,963	0,01	407,83	-26,03	792,17	-7,83	3,94

[§117] When working with the mean-tone tuning in which the Fifths are diminshed by 1/5 Pythagorean Comma and the Thirds are allowed to beat lightly (for example the above-mentioned Freiberg Dom, Silbermann; Norden, Schnitger; Stanford University, Fisk), one wonders why these Thirds should actually be allowed to beat at all. Keeping each of the 11 Fifths somewhat narrower does not really improve the unusable Wolf Thirds on B, F#, C# and G#. Three reasons can however be invoked in favour of this 1/5 Comma tuning, amongst which the first is probably the main historical motivation:

- The pure Thirds are felt to be too rigid, too "hollow"-sounding; the opposition with the relatively strongly beating Fifths would be too big. Reference to this can be found in historical Italian sources (Antegnati, amongst others). In reality, the harmony between the Fifths and slightly beating Thirds is found to be particularly agreeable. In my opinion, the slightly beating Thirds are more compatible with the Italian language in particular and to the southern European languages in general. The pure Third is far better rooted in the north German mentality: straight, clear-cut and definite. I have often, jokingly, drawn a parallel with real black bread, unavailable in the South. The further one goes to the South, the whiter the bread becomes and the more the lightly beating Third is appreciated.
- Through the reduction by1/5 Comma, the distribution of the Wolf interval over two Fifths renders the Third B- E flat a little more "socially" acceptable, as Werkmeister describes in 1679. (See Temperament 5C.)
- The natural out-of-tuneness of an organ is not immediately noticeable when the Thirds already beat lightly anyway. An augmented Third cannot suddenly become diminished.

Temperament 5

[§118] Temperament 5 has exactly equal beating Fifths:

Temperament 5

Meantone temperament where the Thirds C-E and F-A beat at the same speed as the 11 Fifths; the Third G-B beats at twice the speed.

Pitch 2'	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	697,161	2,604	389,82	-3,18	306,41	6,41	15,21
B flat	698,751	2,604	390,79	-6,07	1003,57	3,57	12,38
F	697,674	2,604	388,87	-2,60	502,33	2,33	11,13
C	696,231	-2,604	389,74	-2,60	0,00	0,00	8,80
G	698,128	2,604	390,89	-5,20	696,23	-3,77	5,03
D	696,840	2,604	391,66	-4,55	194,36	-5,64	3,16
A	698,536	2,604	392,70	-8,13	891,20	-8,80	0,00
E	697,386	-2,604	390,67	-4,15	389,74	-10,26	-1,46
B	698,902	2,604	419,29	-47,38	1087,12	-12,88	-4,08
F#	697,877	2,604	417,55	-33,58	586,02	-13,98	-5,17
C#	696,502	2,604	418,42	-25,84	83,90	-16,10	-7,30
G#	726,011	17,324	419,60	-40,06	780,40	-19,60	-10,80

[§119] Temperament 5A is a variant of Temperament 5 and comparable to Temperament 2B. By distributing the Wolf over the Fifths E flat- B flat and G#- E flat, the Third H- E flat with 406,67 Cents becomes really very exploitable. It is a very interesting mean-tone tuning with a usable B-major key. B-major, dominant tonality in the relatively numerous pieces written in e-minor or E-major, is frequently a point of dispute. This temperament (5A) allows a successful compromise between the advantages and drawbacks of mean-tone tuning:

Temperament 5A

Comparable to temperament 2B: meantone tuning in which the Thirds C-E and F-A beat at the same speed as the 10 Fifths, G-B beats twice as fast. E flat is placed so that E flat-G and B (lower octave)-E flat beat equally, leading to B-E flat with around 406,5 Cents (proposal for Stellwagen).

Pitch 2'	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	709,783	-4,236	402,44	-14,58	293,79	-6,21	2,59
B flat	698,751	2,604	390,79	-6,07	1003,57	3,57	12,38
F	697,674	2,604	388,87	-2,60	502,33	2,33	11,13
C	696,231	-2,604	389,74	-2,60	0,00	0,00	8,80
G	698,128	2,604	390,89	-5,20	696,23	-3,77	5,03
D	696,840	2,604	391,66	-4,55	194,36	-5,64	3,16
A	698,536	2,604	392,70	-8,13	891,20	-8,80	0,00
E	697,386	-2,604	390,67	-4,15	389,74	-10,26	-1,46
B	698,902	2,604	406,67	-29,14	1087,12	-12,88	-4,08
F#	697,877	2,604	417,55	-33,58	586,02	-13,98	-5,17
C#	696,502	2,604	418,42	-25,84	83,90	-16,10	-7,30
G#	713,388	8,204	419,60	-40,06	780,40	-19,60	-10,80

[§120] When the Fifths that immediately precede and follow the Wolf in Temperament 5A are tuned pure, a variant is obtained that allows, when necessary, rapid passages in B-major and B flat-major on the flutes and gedackts – Temperament 5B. When the four Fifths that surround the Wolf are tuned pure in this system, one obtains an almost well-tempered tuning with mean-tone character – Temperament 5C. The temperament of the Schnitger organ in Norden (D) also belongs to the domain of 1/5 Comma tunings. The temperaments 5D and 5E are two practical variants, that can easily be laid without an electronic tuning device, in one case with equal beating Fifths (5D) and in another (5E) with Fifths beating in a 2:3 ratio (Temperament

5D, 5E). While I do not think that the variant proposed by Harald Vogel for the reconstruction of the possible original tuning of the organ in the Liebfrauenkirche in Bremen (D) is correct, I would like to indicate two very interesting temperaments, 5F and 5G, that one can lay without the use of an electronic tuning device.

Temperament 5B

Meantone variant with 9 equal beating Fifths (similar to the Silbermann organ measurements in the Freiberg Dom). C-E and F-A beat at the same speed as the 9 Fifths.

Pitch	Fifths		Thirds		Position	Difference E.T.	
2′	[cent]	[beats]	[cent]	[beats]		[C = 0]	[A = 0]
E flat	701,955	0,000	394,61	-7,52	301,62	1,62	10,42
B flat	698,751	2,604	390,79	-6,07	1003,57	3,57	12,38
F	697,674	2,604	388,87	-2,60	502,33	2,33	11,13
C	696,231	-2,604	389,74	-2,60	0,00	0,00	8,80
G	698,128	2,604	390,89	-5,20	696,23	-3,77	5,03
D	696,840	2,604	391,66	-4,55	194,36	-5,64	3,16
A	698,536	2,604	392,70	-8,13	891,20	-8,80	0,00
E	697,386	-2,604	396,12	-9,35	389,74	-10,26	-1,46
B	698,902	2,604	414,50	-40,43	1087,12	-12,88	-4,08
F#	697,877	2,604	417,55	-33,58	586,02	-13,98	-5,17
C#	701,955	0,000	418,42	-25,84	83,90	-16,10	-7,30
G#	715,763	9,946	414,14	-33,55	785,86	-14,14	-5,34

Temperament 5C

Well-tempered tuning with meantone characteristics, C-E and F-A beat at the same speed as the 7 Fifths. The Fifth G#-E flat is augmented.

Pitch	Fifths		Thirds		Position	Difference E.T.	
2′	[cent]	[beats]	[cent]	[beats]		[C = 0]	[A = 0]
E flat	701,955	0,000	397,82	-10,41	298,42	-1,58	7,22
B flat	701,955	0,000	393,99	-10,41	1000,37	0,37	9,17
F	697,674	2,604	388,87	-2,60	502,33	2,33	11,13
C	696,231	-2,604	389,74	-2,60	0,00	0,00	8,80
G	698,128	2,604	390,89	-5,20	696,23	-3,77	5,03
D	696,840	2,604	391,66	-4,55	194,36	-5,64	3,16
A	698,536	2,604	396,78	-13,34	891,20	-8,80	0,00
E	697,386	-2,604	400,20	-13,26	389,74	-10,26	-1,46
B	698,902	2,604	411,29	-35,81	1087,12	-12,88	-4,08
F#	701,955	0,000	414,35	-30,11	586,02	-13,98	-5,17
C#	701,955	0,000	414,35	-22,58	87,98	-12,02	-3,22
G#	708,481	4,702	410,07	-28,66	789,93	-10,07	-1,26

Temperament 5D

St. Ludgeri (Norden, D): practical variant with equal beating Fifths. The Thirds F-A and C-E beat at the same speed as the 7 Fifths. The augmented Fifths G#-E flat and E flat-B flat beat identically.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	705,672	-2,147	401,54	-14,71	294,70	-5,30	3,49
B flat	701,955	0,000	394,00	-11,13	1000,37	0,37	9,16
F	697,677	2,780	388,88	-2,79	502,32	2,32	11,12
C	696,234	-2,780	389,75	-2,79	0,00	0,00	8,79
G	698,131	2,780	390,90	-5,57	696,23	-3,77	5,03
D	696,843	2,780	391,67	-4,87	194,36	-5,64	3,16
A	698,538	2,780	396,79	-14,26	891,21	-8,79	0,00
E	697,389	-2,780	400,20	-14,17	389,75	-10,25	-1,46
B	698,904	2,780	407,56	-32,50	1087,13	-12,87	-4,07
F#	701,955	0,000	414,33	-32,14	586,04	-13,96	-5,17
C#	701,955	0,000	414,33	-24,11	87,99	-12,01	-3,21
G#	704,748	2,147	410,05	-30,60	789,95	-10,05	-1,26

Temperament 5E

St. Ludgeri (Norden, D): practical variant with two distinct Fifth beating speeds in a 2:3 relationship. The Third C-E beats at the same speed as the Fifth G-D. The augmented Fifths G#-E flat and E flat-B flat beat at equal speed.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	705,729	-2,179	403,03	-16,15	294,02	-5,98	2,35
B flat	701,955	0,000	394,35	-11,63	999,75	-0,25	8,08
F	698,291	2,380	389,97	-3,96	501,71	1,71	10,03
C	697,057	-2,380	389,24	-2,38	0,00	0,00	8,32
G	697,043	3,570	390,23	-4,76	697,06	-2,94	5,38
D	697,577	2,380	391,22	-4,46	194,10	-5,90	2,42
A	697,566	3,570	395,60	-12,64	891,68	-8,32	0,00
E	698,044	-2,380	399,99	-13,94	389,24	-10,76	-2,43
B	698,036	3,570	406,74	-31,22	1087,29	-12,71	-4,39
F#	701,955	0,000	414,43	-32,24	585,32	-14,68	-6,35
C#	701,955	0,000	414,43	-24,18	87,28	-12,72	-4,40
G#	704,791	2,179	410,77	-31,51	789,23	-10,77	-2,44

Temperament 5F

Liebfrauenkirche (Bremen, D), with the Fifth D-A pure and only two augmented Fifths. The Fifths beat in a 2:3 relationship. Possible tuning method : A-E and E-C beat equally (3n), C-G beat at 2n and G-D again at 3n. Control: D-A is pure. Free interpretation after Harald Vogel.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	706,725	-2,574	402,68	-14,77	293,60	-6,40	-0,90
B flat	701,955	0,000	392,22	-8,00	1000,33	0,33	5,82
F	697,715	2,574	392,22	-6,00	502,28	2,28	7,78
C	696,286	-2,574	391,39	-3,86	0,00	0,00	5,49
G	696,268	3,861	392,54	-7,07	696,29	-3,71	1,78
D	701,955	0,000	393,70	-6,27	192,55	-7,45	-1,96
A	696,884	3,861	393,70	-9,40	894,51	-5,49	0,00
E	697,435	-2,574	393,38	-6,73	391,39	-8,61	-3,12
B	697,423	3,861	404,78	-26,39	1088,83	-11,17	-5,68
F#	701,955	0,000	414,08	-29,77	586,25	-13,75	-8,26
C#	696,568	2,574	414,08	-22,33	88,20	-11,80	-6,30
G#	708,831	4,931	415,23	-34,77	784,77	-15,23	-9,74

Temperament 5G

Liebfrauenkirche (Bremen, D), possible variant: the Fifth D-A is pure, the Wolf is divided up, the Fifths are tempered in a 3:4:6 relationship. Possible tuning method: A-D pure, A-E, D-G, and E-C beat equally. Control: C-G should beat somewhat slower, in a 2:3 relationship. F-C, E-B and F#-C# also beat at slow speed, B-F# fast, E flat-B flat, B flat-F and C#-G# are augmented, beat at half the speed of A-E. G#-E flat results as a slow-beating augmented Fifth. C-B is almost a pure Seventh.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	705,536	-1,931	403,88	-15,84	292,41	-7,59	-2,10
B flat	704,338	-1,930	394,61	-11,22	997,95	-2,05	3,44
F	697,715	2,574	392,22	-6,00	502,28	2,28	7,78
C	696,286	-2,574	391,39	-3,86	0,00	0,00	5,49
G	696,268	3,861	392,54	-7,07	696,29	-3,71	1,78
D	701,955	0,000	393,70	-6,27	192,55	-7,45	-1,96
A	696,884	3,861	389,66	-4,25	894,51	-5,49	0,00
E	697,435	-2,574	398,77	-11,88	391,39	-8,61	-3,12
B	697,423	3,861	403,58	-24,67	1088,83	-11,17	-5,68
F#	697,916	2,574	411,70	-27,19	586,25	-13,75	-8,26
C#	705,994	-1,931	418,12	-25,54	84,17	-15,83	-10,34
G#	702,250	0,212	409,84	-28,34	790,16	-9,84	-4,35

Temperament 6

[§121] If one goes further in the direction of reducing the 1/5 Comma Fifths to finally arrive at only six reduced Fifths, one naturally approaches the real welltempered tuning. A tuning is considered to be welltempered if the worst Third does not exceed 408 Cents. This value, the socalled Pythagorean Third, is attained after four pure Fifths. The following tunings, 6, 6A and 6B, show three practical means of modifying the temperament by placing the 1/5 Comma Fifths in different places.

Temperament 6

Well-tempered tuning with slight mean-tone characteristics. C-E and F-A beat at the same speed as the six Fifths. Favours the flat tonalities better than Temperament 6A.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	701,955	0,000	397,82	-10,41	298,42	-1,58	7,22
B flat	701,955	0,000	393,99	-10,41	1000,37	0,37	9,17
F	697,674	2,604	388,87	-2,60	502,33	2,33	11,13
C	696,231	-2,604	389,74	-2,60	0,00	0,00	8,80
G	698,128	2,604	390,89	-5,20	696,23	-3,77	5,03
D	696,840	2,604	394,72	-7,16	194,36	-5,64	3,16
A	698,536	2,604	399,83	-17,25	891,20	-8,80	0,00
E	697,386	-2,604	403,25	-16,19	389,74	-10,26	-1,46
B	701,955	0,000	411,29	-35,81	1087,12	-12,88	-4,08
F#	701,955	0,000	411,29	-26,85	589,08	-10,92	-2,12
C#	701,955	0,000	411,29	-20,14	91,03	-8,97	-0,17
G#	705,429	2,505	407,01	-25,00	792,99	-7,01	1,79

[§122] In this way, a tuning which favours either flat tonalities on the one hand, or sharp tonalities on the other, is easily laid. Thanks to the comparison of beat frequencies between the Fifths and Thirds, these tunings are very easy to establish both on the organ and on the harpsichord. For each of the three tunings, six Fifths have to be tuned 1/5 Pythagorean Comma narrower, and consequently the Wolf Third too wide by1/5 Pythagorean Comma. I have employed Temperament 6B in a few organs and have each time been struck by its particular charm.

Temperament 6A

Well-tempered tuning with slight meantone characteristics. C-E beats at the same speed as the six Fifths, G-B at twice the speed. Favours the sharp tonalities.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	701,955	0,000	402,10	-14,27	294,13	-5,87	2,94
B flat	701,955	0,000	398,27	-16,20	996,09	-3,91	4,89
F	701,955	0,000	393,15	-6,94	498,04	-1,96	6,85
C	696,231	-2,604	389,74	-2,60	0,00	0,00	8,80
G	698,128	2,604	390,89	-5,20	696,23	-3,77	5,03
D	696,840	2,604	391,66	-4,55	194,36	-5,64	3,16
A	698,536	2,604	396,78	-13,34	891,20	-8,80	0,00
E	697,386	-2,604	400,20	-13,26	389,74	-10,26	-1,46
B	698,902	2,604	407,01	-29,63	1087,12	-12,88	-4,08
F#	701,955	0,000	410,07	-25,48	586,02	-13,98	-5,17
C#	701,955	0,000	410,07	-19,11	87,98	-12,02	-3,22
G#	704,201	1,616	410,07	-28,66	789,93	-10,07	-1,26

Temperament 6B
Well-tempered tuning with slight meantone characteristics. C-E beats twice as fast as the six Fifths, D-A is pure.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	701,955	0,000	396,96	-9,61	298,78	-1,22	3,29
B flat	701,955	0,000	392,80	-8,78	1000,74	0,74	5,24
F	697,308	2,820	392,80	-6,58	502,69	2,69	7,20
C	695,740	-2,820	393,75	-5,64	0,00	0,00	4,51
G	697,799	2,820	395,01	-9,87	695,74	-4,26	0,25
D	701,955	0,000	395,86	-8,11	193,54	-6,46	-1,96
A	698,252	2,820	395,86	-12,17	895,49	-4,51	0,00
E	697,006	-2,820	399,56	-12,65	393,75	-6,25	-1,75
B	698,648	2,820	408,03	-31,08	1090,75	-9,25	-4,74
F#	701,955	0,000	411,34	-26,84	589,40	-10,60	-6,09
C#	701,955	0,000	411,34	-20,13	91,36	-8,64	-4,14
G#	705,472	2,530	406,69	-24,55	793,31	-6,69	-2,18

Temperament 7

[§123] Carrying on in this way, one arrives at tunings with five Fifths reduced by 1/5 Pythagorean Comma. These tunings (7, 7A and 7B) truly belong to the group of well-tempered tunings, since there is not one single augmented Fifth. One of the best-known tunings of this category is the one published by Herbert Anton Kellner in 1975, also known under the name of "Bach-Kellner". This truly excellent tuning, easy to implement, is based on Werkmeister III but thanks to the use of 1/5 Comma Fifths is more supple and better adapted to a wider choice of music. A practical variant with four identical Fifth beating frequencies is shown in Tuning 7. The next tuning (7A) is a simplified version. The five diminished Fifths are tuned one after the other. This tuning is very easy and is also particularly wellsuited for the harpsichord. In organs where we employ two different tuning systems with 18 pipes per octave, I choose this well-tempered tuning – 7A. The temperament 7B is a further variant on 7, with the particularity that D-A is a pure interval. When pure, this often-employed Fifth D-A gives the tuning a particular colour. It is a recommended tuning for Continuo playing.

Temperament 7
A practical variant on the Bach-Kellner tuning. The Third C-E beats at the same speed as the four Fifths, the Fifth B-F# ensues: it beats almost twice as fast.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	701,955	0,000	402,10	-14,27	294,13	-5,87	2,94
B flat	701,955	0,000	398,27	-16,20	996,09	-3,91	4,89
F	701,955	0,000	393,15	-6,94	498,04	-1,96	6,85
C	696,231	-2,604	389,74	-2,60	0,00	0,00	8,80
G	698,128	2,604	395,46	-10,41	696,23	-3,77	5,03
D	696,840	2,604	393,91	-6,47	194,36	-5,64	3,16
A	698,536	2,604	399,03	-16,21	891,20	-8,80	0,00
E	701,955	0,000	402,44	-15,41	389,74	-10,26	-1,46
B	696,579	4,595	402,44	-23,12	1091,69	-8,31	0,49
F#	701,955	0,000	407,82	-23,09	588,27	-11,73	-2,93
C#	701,955	0,000	407,82	-17,31	90,22	-9,78	-0,97
G#	701,955	0,000	407,82	-25,97	792,18	-7,82	0,98

Temperament 7A

Well-tempered tuning in which the Third C-E beats at the same speed as the five Fifths; the Third G-B beats at twice the speed. Variant on the Bach-Kellner tuning. The Fifth G#-E flat is slightly diminished.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	701,955	0,000	402,10	-14,27	294,13	-5,87	2,94
B flat	701,955	0,000	398,27	-16,20	996,09	-3,91	4,89
F	701,955	0,000	393,15	-6,94	498,04	-1,96	6,85
C	696,231	-2,604	389,74	-2,60	0,00	0,00	8,80
G	698,128	2,604	390,89	-5,20	696,23	-3,77	5,03
D	696,840	2,604	394,72	-7,16	194,36	-5,64	3,16
A	698,536	2,604	399,83	-17,25	891,20	-8,80	0,00
E	697,386	-2,604	403,25	-16,19	389,74	-10,26	-1,46
B	701,955	0,000	407,01	-29,63	1087,12	-12,88	-4,08
F#	701,955	0,000	407,01	-22,22	589,08	-10,92	-2,12
C#	701,955	0,000	407,01	-16,67	91,03	-8,97	-0,17
G#	701,148	-0,581	407,01	-25,00	792,99	-7,01	1,79

Temperament 7B

Well-tempered tuning where the Third C-E beats at twice the speed of the four Fifths. The tone F# is placed so that the Third D-F# beats twice as fast as the Fifth B-F#.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	701,955	0,000	401,60	-13,79	294,13	-5,87	-1,36
B flat	701,955	0,000	397,45	-15,05	996,09	-3,91	0,60
F	701,955	0,000	397,45	-11,28	498,04	-1,96	2,55
C	695,740	-2,820	393,75	-5,64	0,00	0,00	4,51
G	697,799	2,820	395,01	-9,87	695,74	-4,26	0,25
D	701,955	0,000	394,73	-7,15	193,54	-6,46	-1,96
A	698,252	2,820	394,73	-10,72	895,49	-4,51	0,00
E	697,006	-2,820	398,43	-11,57	393,75	-6,25	-1,75
B	697,517	3,783	403,38	-24,40	1090,75	-9,25	-4,74
F#	701,955	0,000	407,82	-23,03	588,27	-11,73	-7,22
C#	701,955	0,000	407,82	-17,27	90,22	-9,78	-5,27
G#	701,956	0,000	407,82	-25,91	792,18	-7,82	-3,31

Temperament 8 – Vallotti

[§124] The so-called Vallotti temperament is employed particularly often, and apart from Vallotti himself, was also described in Italy by Tartini. It is also sometimes named after the Englishman Thomas Young (physicist and medical practitioner) who published this tuning in 1800. The tuning as described by Young is laid between F and B. It is extremely easy to do. The Pythagorean Comma is simply distributed over six Fifths, made narrower by the corresponding value; the other Fifths are pure. (Tuning 8) Temperament 8A is another practical variant of the Vallotti tuning, in which there are still more points of comparison of beat frequencies. The two tunings are comparable from a practical point of view.

Temperament 8

Vallotti: practical proposition with equal beating Fifths. The Third C-E beats 1,5 as fast as the 6 Fifths, in a 2:3 relationship.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference [C = 0]	E.T. [A = 0]
E flat	701,955	0,000	402,59	-14,71	294,13	-5,87	1,67
B flat	701,955	0,000	399,10	-17,31	996,09	-3,91	3,62
F	701,955	0,000	394,42	-8,23	498,04	-1,96	5,58
C	696,725	-2,378	391,30	-3,79	0,00	0,00	7,53
G	698,460	2,378	392,36	-6,88	696,73	-3,27	4,26
D	697,284	2,378	393,07	-5,75	195,19	-4,81	2,72
A	698,834	2,378	397,74	-14,57	892,47	-7,53	0,00
E	697,785	-2,378	400,86	-13,90	391,30	-8,70	-1,17
B	699,169	2,378	405,05	-26,81	1089,09	-10,91	-3,38
F#	701,955	0,000	407,83	-23,08	588,26	-11,74	-4,21
C#	701,955	0,000	407,83	-17,31	90,21	-9,79	-2,26
G#	701,968	0,000	407,83	-25,97	792,17	-7,83	-0,30

[§125] The tuning according to Thomas Young is given in Temperament 8B. This tuning is very close to that of Vallotti, but favours flat tonalities. The six Fifths are simply tuned between F and B. Musically it is a very attractive tuning. Another very agreeable tuning that I have often used with success in a number of organs also belongs to the “Vallotti” group. It is a modified variant with a pure Fifth over D-A. Going yet further by tempering seven Fifths equally, we obtain two very interesting and flexible tunings – Temperaments 8D and 8E. It would probably be far-fetched to trace these tunings back to Vallotti, but I would like to mention them here all the same.

Temperament 8A

Vallotti: practical solution with two distinct speeds for the Fifths. The Third C-E beats at twice the speed of C-G and D-F# twice as fast as the five Fifths. Method: A-D, D-G and A-E beat at the same speed. The Fifth G-C and the Third C-E beat in a 1:2 relationship. The Fifth G#-E flat is slightly augmented.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference [C = 0]	E.T. [A = 0]
E flat	701,955	0,000	403,47	-15,50	294,13	-5,87	1,26
B flat	701,955	0,000	399,77	-18,22	996,09	-3,91	3,21
F	701,955	0,000	394,83	-8,64	498,04	-1,96	5,17
C	697,600	-1,980	391,53	-3,96	0,00	0,00	7,12
G	698,260	2,514	391,48	-5,87	697,60	-2,40	4,72
D	697,016	2,514	392,22	-5,03	195,86	-4,14	2,98
A	698,655	2,514	397,16	-13,83	892,88	-7,12	0,00
E	697,545	-2,514	400,46	-13,52	391,53	-8,47	-1,35
B	699,009	2,514	405,06	-26,82	1089,08	-10,92	-3,80
F#	701,955	0,000	408,01	-23,26	588,08	-11,92	-4,79
C#	701,955	0,000	408,01	-17,45	90,04	-9,96	-2,84
G#	702,141	0,134	408,01	-26,17	791,99	-8,01	-0,88

Temperament 8B
Thomas Young: practical variant with six equal beating Fifths between the tones F and B, therefore favours the flat tonalities. Not quite correct from a historical point of view. The Third C-E beats twice as fast as the six Fifths.

Pitch 2′	Fifths [cent]	Fifths [beats]	Thirds [cent]	Thirds [beats]	Position	Difference E.T. [C = 0]	Difference E.T. [A = 0]
E flat	701,955	0,000	399,10	-11,56	297,87	-2,13	4,78
B flat	701,955	0,000	395,77	-12,81	999,82	-0,18	6,73
F	698,223	2,267	391,31	-5,07	501,78	1,78	8,69
C	696,967	-2,267	392,07	-4,37	0,00	0,00	6,91
G	698,622	2,267	393,08	-7,69	696,97	-3,03	3,88
D	697,500	2,267	396,41	-8,60	195,59	-4,41	2,50
A	698,979	2,267	400,87	-18,57	893,09	-6,91	0,00
E	697,979	-2,267	403,84	-16,76	392,07	-7,93	-1,02
B	701,955	0,000	407,82	-30,81	1090,05	-9,95	-3,04
F#	701,955	0,000	407,82	-23,11	592,00	-8,00	-1,09
C#	701,955	0,000	407,82	-17,33	93,96	-6,04	0,87
G#	701,955	0,000	404,09	-21,46	795,91	-4,09	2,82

Temperament 8C
Wegscheider: practical variant with six equal beating Fifths, but with D-A pure. Free interpretation after Vallotti or Young. The Third C-E beats twice as fast as the six Fifths. The Fifth G#-E flat is slightly diminished.

Pitch 2′	Fifths [cent]	Fifths [beats]	Thirds [cent]	Thirds [beats]	Position	Difference E.T. [C = 0]	Difference E.T. [A = 0]
E flat	701,955	0,000	398,57	-11,06	298,09	-1,91	1,06
B flat	701,955	0,000	395,03	-11,79	1000,05	0,05	3,01
F	697,996	2,400	395,03	-8,84	502,00	2,00	4,97
C	696,662	-2,400	395,84	-7,23	0,00	0,00	2,97
G	698,417	2,400	396,92	-12,04	696,66	-3,34	-0,37
D	701,955	0,000	397,65	-9,63	195,08	-4,92	-1,96
A	698,804	2,400	397,65	-14,45	897,03	-2,97	0,00
E	697,745	-2,400	400,80	-13,84	395,84	-4,16	-1,20
B	699,143	2,400	404,51	-26,04	1093,58	-6,42	-3,45
F#	701,955	0,000	407,32	-22,53	592,73	-7,27	-4,31
C#	701,955	0,000	407,32	-16,90	94,68	-5,32	-2,35
G#	701,457	-0,358	403,36	-20,55	796,64	-3,36	-0,40

Temperament 8D

Vallotti: strongly modified, with seven equal beating Fifths. The Third C-E beats three times as fast as the seven Fifths. Favours the flat tonalities. The Fifth G#-E flat is slightly diminished.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	701,955	0,000	400,22	-12,57	297,39	-2,61	2,64
B flat	701,955	0,000	397,32	-14,91	999,34	-0,66	4,60
F	698,704	1,973	393,45	-7,24	501,30	1,30	6,55
C	697,611	-1,973	394,11	-5,92	0,00	0,00	5,26
G	699,053	1,973	394,99	-9,87	697,61	-2,39	2,87
D	698,078	1,973	395,58	-7,89	196,66	-3,34	1,92
A	699,365	1,973	399,46	-16,77	894,74	-5,26	0,00
E	698,496	-1,973	402,05	-15,05	394,11	-5,89	-0,63
B	699,645	1,973	404,78	-26,45	1092,60	-7,40	-2,14
F#	701,955	0,000	407,09	-22,31	592,25	-7,75	-2,49
C#	701,955	0,000	407,09	-16,73	94,20	-5,80	-0,54
G#	701,228	-0,524	403,84	-21,15	796,16	-3,84	1,42

Temperament 8E

Vallotti: strongly modified, with seven equal beating Fifths. The Third C-E beats three times as fast as the seven Fifths. Favours the sharp tonalities. The Fifth G#-E flat is slightly diminished.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	701,955	0,000	403,48	-15,49	294,13	-5,87	-0,61
B flat	701,955	0,000	400,57	-19,29	996,09	-3,91	1,35
F	701,955	0,000	396,70	-10,52	498,04	-1,96	3,30
C	697,611	-1,973	394,11	-5,92	0,00	0,00	5,26
G	699,053	1,973	394,99	-9,87	697,61	-2,39	2,87
D	698,078	1,973	395,58	-7,89	196,66	-3,34	1,92
A	699,365	1,973	396,38	-12,83	894,74	-5,26	0,00
E	698,496	-1,973	398,97	-12,09	394,11	-5,89	-0,63
B	699,645	1,973	401,53	-21,78	1092,60	-7,40	-2,14
F#	698,871	1,973	403,84	-18,80	592,25	-7,75	-2,49
C#	701,955	0,000	406,93	-16,56	91,12	-8,88	-3,62
G#	701,061	-0,642	406,93	-24,85	793,07	-6,93	-1,67

Temperament 9

[§126] Concentrating on the ratios between Fifths and Thirds in tunings, for example the ratio of the beat frequency between C-E and C-G, we have up to now principally looked at the variants of 1:1 (1/5 Comma) and 1:3 (1/6 Comma). It is of course also possible to realise these tunings in such a way that the Third beats at twice the frequency of the Fifth. Temperament 9 shows such a variant with seven Fifths. Temperament 9A represents a welltempered variant with six Fifths.

Temperament 9

Well-tempered tuning with slight meantone characteristics and seven equal beating Fifths. Fifth-Third relationship 1:2. C-E beats at twice the speed of the 7 Fifths. G#-E flat is slightly augmented.

Pitch 2′	Fifths [cent]	Fifths [beats]	Thirds [cent]	Thirds [beats]	Position	Difference E.T. [C = 0]	Difference E.T. [A = 0]
E flat	701,955	0,000	399,19	-11,64	297,83	-2,17	4,62
B flat	701,955	0,000	395,88	-12,97	999,79	-0,21	6,57
F	698,260	2,245	391,47	-5,24	501,74	1,74	8,53
C	697,015	-2,245	392,22	-4,49	0,00	0,00	6,79
G	698,654	2,245	393,22	-7,86	697,02	-2,98	3,80
D	697,544	2,245	393,90	-6,45	195,67	-4,33	2,46
A	699,008	2,245	398,31	-15,29	893,21	-6,79	0,00
E	698,018	-2,245	401,25	-14,28	392,22	-7,78	-0,99
B	699,325	2,245	407,59	-30,48	1090,24	-9,76	-2,97
F#	701,955	0,000	410,22	-25,67	589,56	-10,44	-3,65
C#	701,955	0,000	410,22	-19,25	91,52	-8,48	-1,69
G#	704,355	1,729	406,53	-24,39	793,47	-6,53	0,26

Temperament 9A

Well-tempered tuning with slight meantone characteristics and seven equal beating Fifths. Fifth-Third relationship 1:2. C-E beats at twice the speed of the seven Fifths. G#-E flat is slightly diminished.

Pitch 2′	Fifths [cent]	Fifths [beats]	Thirds [cent]	Thirds [beats]	Position	Difference E.T. [C = 0]	Difference E.T. [A = 0]
E flat	701,955	0,000	402,88	-14,97	294,13	-5,87	0,92
B flat	701,955	0,000	399,58	-17,96	996,09	-3,91	2,88
F	701,955	0,000	395,17	-8,98	498,04	-1,96	4,83
C	697,015	-2,245	392,22	-4,49	0,00	0,00	6,79
G	698,654	2,245	393,22	-7,86	697,02	-2,98	3,80
D	697,544	2,245	393,90	-6,45	195,67	-4,33	2,46
A	699,008	2,245	398,31	-15,29	893,21	-6,79	0,00
E	698,018	-2,245	401,25	-14,28	392,22	-7,78	-0,99
B	699,325	2,245	403,90	-25,16	1090,24	-9,76	-2,97
F#	701,955	0,000	406,53	-21,68	589,56	-10,44	-3,65
C#	701,955	0,000	406,53	-16,26	91,52	-8,48	-1,69
G#	700,660	-0,932	406,53	-24,39	793,47	-6,53	0,26

Temperaments 10 & 11

[§127] Each of the ten following temperaments is well-tempered and attractive because of the different Fifth beating frequencies. They can easily be laid without an electronic tuning device, although one has to do a little more counting and comparing. Temperament 10 shows a practical variant of a well-tempered tuning with distinctive tonal character, very easy to do.

Temperament 10

Well-tempered tuning with three distinct Fifth interval sizes in a 1:2:3 relationship. C-E beats at the same speed as C-G and G-D.

Pitch	Fifths		Thirds		Position	Difference E.T.	
2′	[cent]	[beats]	[cent]	[beats]		[C = 0]	[A = 0]
E flat	701,955	0,000	399,58	-12,00	295,78	-4,22	4,85
B flat	701,955	0,000	395,17	-12,00	997,73	-2,27	6,81
F	700,310	1,000	391,24	-5,00	499,69	-0,31	8,76
C	695,360	-3,000	390,26	-3,00	0,00	0,00	9,07
G	697,544	3,000	393,35	-8,00	695,36	-4,64	4,43
D	698,025	2,000	396,59	-8,75	192,90	-7,10	1,98
A	699,330	2,000	400,52	-18,13	890,93	-9,07	0,00
E	698,449	-2,000	403,14	-16,09	390,26	-9,74	-0,67
B	700,785	0,000	407,07	-29,75	1088,71	-11,29	-2,22
F#	701,955	0,000	408,24	-23,56	589,49	-10,51	-1,44
C#	701,955	0,000	408,24	-17,67	91,45	-8,55	0,52
G#	702,378	0,305	406,60	-24,51	793,40	-6,60	2,47

Temperament 11

Similar to temperament 10. Well-tempered tuning with two distinct Fifth intervals in a 1:2 relationship. C-E beats at the same speed as the Fifth C-G and G-D (compensation between the sharp and flat tonalities).

Pitch	Fifths		Thirds		Position	Difference E.T.	
2′	[cent]	[beats]	[cent]	[beats]		[C = 0]	[A = 0]
E flat	701,955	0,000	401,22	-13,48	294,13	-5,87	3,21
B flat	701,955	0,000	396,81	-14,22	996,09	-3,91	5,16
F	701,955	0,000	392,88	-6,67	498,04	-1,96	7,12
C	695,360	-3,000	390,26	-3,00	0,00	0,00	9,07
G	697,544	3,000	393,35	-8,00	695,36	-4,64	4,43
D	698,025	2,000	395,42	-7,75	192,90	-7,10	1,98
A	699,330	2,000	399,35	-16,63	890,93	-9,07	0,00
E	698,449	-2,000	401,97	-14,97	390,26	-9,74	-0,67
B	699,614	2,000	405,43	-27,38	1088,71	-11,29	-2,22
F#	701,955	0,000	407,77	-23,03	588,32	-11,68	-2,61
C#	701,955	0,000	407,77	-17,28	90,28	-9,72	-0,65
G#	701,904	-0,037	407,77	-25,91	792,23	-7,77	1,30

Temperament 12

[§128] Temperament 12 is a well-tempered tuning with good balance between flat and sharp tonalities. The notes B and F# are not altogether easy to tune.

Temperament 12

Practical well-tempered tuning with various sized Fifth intervals. C-E beats twice as fast as the Fifths C-G and A-E. D is placed between G and A so that both Fifths beat equally. The Thirds F-A, G-B and D-F# beat twice as fast as the Third C-E. Notes B and F# are tuned from the Thirds.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	701,955	0,000	403,42	-15,47	294,13	-5,87	1,89
B flat	701,955	0,000	399,48	-17,83	996,09	-3,91	3,84
F	701,955	0,000	394,20	-8,00	498,04	-1,96	5,80
C	697,558	-2,000	391,58	-4,00	0,00	0,00	7,75
G	698,010	2,685	393,35	-8,00	697,56	-2,44	5,31
D	696,681	2,685	395,70	-8,00	195,57	-4,43	3,32
A	699,330	2,000	400,97	-18,71	892,25	-7,75	0,00
E	699,326	-1,500	403,60	-16,53	391,58	-8,42	-0,67
B	700,364	1,360	403,23	-24,23	1090,90	-9,10	-1,34
F#	701,955	0,000	404,82	-19,87	591,27	-8,73	-0,98
C#	701,955	0,000	404,82	-14,90	93,22	-6,78	0,97
G#	698,957	-2,159	404,82	-22,36	795,18	-4,82	2,93

Temperament 13

[§129] Temperament 13 recalls the 1/5 comma tunings. Here, however, the Third ratios are a little different. It has very pronounced tonal character, lightly favouring flat tonalities.

Temperament 13

Easily laid well-tempered tuning. The Third C-E beats at the same speed as the Fifths C-G, G-D, D-A and A-E. The Third F-A beats twice, and the Thirds G-B and D-F# three times as fast. The Fifths E-B and B-F# beat at half this speed; F is tuned from the Third A-F.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	701,955	0,000	400,38	-12,72	295,85	-4,15	4,66
B flat	701,955	0,000	396,55	-13,88	997,81	-2,19	6,61
F	700,236	1,045	391,43	-5,20	499,76	-0,24	8,57
C	696,231	-2,604	389,74	-2,60	0,00	0,00	8,80
G	698,128	2,604	393,18	-7,81	696,23	-3,77	5,03
D	696,840	2,604	395,48	-7,81	194,36	-5,64	3,16
A	698,536	2,604	400,59	-18,22	891,20	-8,80	0,00
E	699,672	-1,302	404,01	-16,92	389,74	-10,26	-1,46
B	700,431	1,302	406,45	-28,86	1089,41	-10,59	-1,79
F#	701,955	0,000	407,97	-23,27	589,84	-10,16	-1,36
C#	701,955	0,000	407,97	-17,45	91,79	-8,21	0,59
G#	702,105	0,108	406,25	-24,09	793,75	-6,25	2,55

Temperament 14 – pure Sevenths

[§130] The tunings with pure Sevenths are very interesting. A pure Fifth followed by a pure Third gives a straight-forward bracket within which the five Fifths can be distributed. One may choose this "bracket" between the notes C and B, or F and E. The pure Seventh can also be at the base of a mean-tone tuning, in which the Third C-E beats twice as fast as the Fifth C-G. In order to moderate the bad Thirds somewhat, one can render the Fifth that lies next to the Wolf pure.

Temperament 14

Well-tempered tuning with a pure Seventh C-B. The Third C-E and Fifths A-E and C-G beat at the same speed. D-F# beats twice as fast. Method: A-E, then E-C with identical beat, C-G-B pure, then G is retuned so that C-G beats at equal speed. The note D is placed between G and A to create two equal beating Fifths. Compare E-B and use the same beat frequency for B-F#.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	701,955	0,000	401,39	-13,62	294,13	-5,87	2,09
B flat	701,955	0,000	398,22	-16,13	996,09	-3,91	4,05
F	701,955	0,000	394,00	-7,80	498,04	-1,96	6,00
C	695,521	-2,925	390,16	-2,92	0,00	0,00	7,96
G	698,793	2,150	392,82	-7,40	695,52	-4,48	3,48
D	697,730	2,150	393,46	-6,08	194,31	-5,69	2,27
A	698,114	2,925	397,69	-14,50	892,04	-7,96	0,00
E	698,183	-2,150	401,53	-14,53	390,16	-9,84	-1,89
B	699,436	2,150	405,79	-27,88	1088,34	-11,66	-3,70
F#	701,955	0,000	408,31	-23,60	587,78	-12,22	-4,27
C#	701,955	0,000	408,31	-17,70	89,73	-10,27	-2,31
G#	702,447	0,354	408,31	-26,55	791,69	-8,31	-0,36

Temperament 14A

Meantone tuning variant with a pure Seventh and two pure Fifths inspired by the measured values at the Freiberg Dom organ with three distinct beating Fifths in a 2:3:4 relationship. Method: A-E and E-C have the same beat frequency, C-G and A-D beat at half this speed. Control: G-D identical to A-E and C-E; then F-C and E-B to A-E in a 2:3 relationship.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	701,955	0,000	395,44	-8,95	302,70	2,70	9,17
B flat	697,679	3,760	390,33	-5,91	1004,65	4,65	11,12
F	697,669	2,820	391,20	-5,37	502,33	2,33	8,80
C	698,136	-1,880	390,92	-3,79	0,00	0,00	6,47
G	696,850	3,760	390,17	-4,75	698,14	-1,86	4,61
D	698,543	1,880	391,20	-4,50	194,99	-5,01	1,46
A	697,395	3,760	389,17	-3,93	893,53	-6,47	0,00
E	697,383	-2,820	393,73	-7,65	390,92	-9,08	-2,60
B	697,881	3,760	414,39	-43,59	1088,31	-11,69	-5,22
F#	696,508	3,760	418,46	-37,39	586,19	-13,81	-7,34
C#	701,955	0,000	419,63	-28,99	82,70	-17,30	-10,83
G#	718,045	12,534	415,35	-37,84	784,65	-15,35	-8,88

Temperament 14B

Meantone tuning variant with a pure Seventh and two pure Fifths inspired by the measured values at the Freiberg Dom organ equally with three distinct beating Fifths in a 2:3:4 relationship. Method: A-E and E-C identical beat, C-G and A-D at half this speed. Control: G-D identical to A-E and C-E; then F-C and E-B to C-G in a 2:3 relationship.

Pitch	Fifths		Thirds		Position	Difference E.T.	
2′	[cent]	[beats]	[cent]	[beats]		[C = 0]	[A = 0]
E flat	701,955	0,000	395,41	-8,24	302,72	2,72	9,22
B flat	697,669	3,480	390,29	-5,40	1004,67	4,67	11,17
F	697,659	2,610	391,16	-4,92	502,34	2,34	8,84
C	698,127	-1,740	390,89	-3,47	0,00	0,00	6,50
G	696,838	3,480	390,13	-4,34	698,13	-1,87	4,63
D	698,535	1,740	391,16	-4,12	194,97	-5,03	1,46
A	697,385	3,480	389,12	-3,57	893,50	-6,50	0,00
E	697,373	-2,610	393,69	-7,03	390,89	-9,11	-2,62
B	697,872	3,480	414,46	-40,35	1088,26	-11,74	-5,24
F#	696,496	3,480	418,54	-34,61	586,13	-13,87	-7,37
C#	701,955	0,000	419,72	-26,83	82,63	-17,37	-10,88
G#	718,137	11,640	415,42	-35,03	784,58	-15,42	-8,92

Temperament 15

[§131] In a Festschrift in honour of Prof. Christian Ahrens in 2003, I described a temperament that I had reconstructed after the notes of the Bach-observer H.C. Snerha. Unfortunately, these notes were lost in a church fire. (The Festschrift has appeared in the *Köstritzer Schriften*, Nr. 2, Bad Köstritz 2003). The basis of this temperament lies in the pure Seventh between F and E. The tuning described in Temperament 15 gives the beat frequencies at pitch 415 Hz, while 15A depicts those for pitch 440 Hz.

Temperament 15 (a1 = 415 Hz)

Well-tempered tuning with a pure Seventh F-E according to the description of the Bach observer H.C. Snerha (1751). Favours flat tonalities and has a pure Seventh F-E. Method: A-F with four beats per second, A-E with three beats, F-E pure, C-G with two beats, G-D with four beats, D-A with two beats, F-C beats like E-B and the Third G-B beats three times the speed of the Third C-E.

Pitch	Fifths		Thirds		Position	Difference E.T.	
2′	[cent]	[beats]	[cent]	[beats]		[C = 0]	[A = 0]
E flat	701,955	0,000	400,89	-12,45	296,40	-3,60	5,59
B flat	701,955	0,000	394,66	-10,67	998,36	-1,64	7,55
F	699,688	1,300	390,50	-4,01	500,31	0,31	9,50
C	697,296	-2,000	388,59	-1,63	0,00	0,00	9,19
G	695,724	4,000	390,83	-4,84	697,30	-2,70	6,49
D	697,788	2,000	397,06	-8,63	193,02	-6,98	2,21
A	697,778	3,000	401,23	-17,95	890,81	-9,19	0,00
E	699,537	-1,300	405,40	-17,21	388,59	-11,41	-2,22
B	701,955	0,000	408,28	-29,69	1088,12	-11,88	-2,68
F#	701,955	0,000	408,28	-22,27	590,08	-9,92	-0,73
C#	701,955	0,000	408,28	-16,70	92,03	-7,97	1,23
G#	702,413	0,311	406,01	-22,45	793,99	-6,01	3,18

Temperament 15A

Well-tempered tuning with a pure Seventh F-E according to the description of the Bach-observer H.C. Snerha (1751). Identical to the tuning in 15, except for the pitch which is 440 Hz.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	701,955	0,000	400,93	-13,23	296,36	-3,64	5,58
B flat	701,955	0,000	394,69	-11,35	998,31	-1,69	7,53
F	699,735	1,350	390,51	-4,26	500,27	0,27	9,49
C	697,286	-2,125	388,53	-1,68	0,00	0,00	9,22
G	695,711	4,250	390,83	-5,14	697,29	-2,71	6,51
D	697,780	2,125	397,07	-9,17	193,00	-7,00	2,22
A	697,753	3,200	401,25	-19,06	890,78	-9,22	0,00
E	699,587	-1,350	405,45	-18,30	388,53	-11,47	-2,25
B	701,955	0,000	408,24	-31,42	1088,12	-11,88	-2,66
F#	701,955	0,000	408,24	-23,57	590,07	-9,93	-0,71
C#	701,955	0,000	408,24	-17,68	92,03	-7,97	1,25
G#	702,374	0,302	406,02	-23,81	793,98	-6,02	3,20

Temperaments 16-19 – Neidhardt

[§132] If one wishes to have an unequal temperament without moving too far away from equal temperament, Neidhardt tunings are a good suggestion. Two dates concerning the publications of Neidhardt are often confused – 1724 and 1732. In his book *A Passable and Good Temperament* (Göteborg, 2002), Johann Norrback explains the difference quite clearly. But how can one lay these Neidhardt tunings without an electronic tuning device in the organ? A few practical variants are proposed in the following tables: Tunings 16, 17, 18 and 19.

Temperament 16

Neidhardt 1 for villages, 1732. This tuning is a new variant compared to Neidhardt 1 of 1724. Method: A-E and A-D beat at the same speed, G-D at 2/3 this speed, C-G half the speed. Control: the Third C-E beats like the Fifth G-D. The Fifths B flat-F, B-F# and C#-G# beat like the Fifth C-G.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	701,955	0,000	403,68	-15,71	295,62	-4,38	3,05
B flat	700,466	1,206	400,14	-18,74	997,58	-2,42	5,01
F	701,955	0,000	394,53	-8,33	498,04	-1,96	5,47
C	699,304	-1,206	389,77	-2,63	0,00	0,00	7,43
G	698,414	2,412	392,42	-6,96	699,30	-0,70	6,73
D	694,852	3,618	394,55	-7,03	197,72	-2,28	5,15
A	697,203	3,618	401,66	-19,59	892,57	-7,43	0,00
E	701,955	0,000	403,90	-16,80	389,77	-10,23	-2,80
B	700,545	1,206	403,90	-25,19	1091,73	-8,27	-0,84
F#	701,955	0,000	405,31	-20,40	592,27	-7,73	-0,30
C#	699,445	1,206	403,82	-14,10	94,23	-5,77	1,66
G#	701,951	-0,003	406,33	-24,16	793,67	-6,33	1,10

Temperament 17

Neidhardt 1 for villages 1724 or Neidhardt 2 for small towns 1732. Practical variant with two distinct Fifth beats. Method: A-E, A-D, D-G and C-G beat at equal speed. Control: the Third C-E beats almost at twice this speed. The Fifths E-B, B-F# and E flat-B flat beat at exactly half this speed.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	699,788	1,170	400,51	-12,83	296,30	-3,70	3,62
B flat	701,955	0,000	399,23	-17,49	996,09	-3,91	3,41
F	701,955	0,000	394,64	-8,44	498,04	-1,96	5,36
C	696,808	-2,340	391,56	-3,99	0,00	0,00	7,32
G	698,515	2,340	394,66	-9,49	696,81	-3,19	4,13
D	697,358	2,340	396,73	-8,88	195,32	-4,68	2,64
A	698,883	2,340	401,33	-19,16	892,68	-7,32	0,00
E	699,904	-1,170	404,40	-17,30	391,56	-8,44	-1,12
B	700,586	1,170	404,83	-26,54	1091,47	-8,53	-1,21
F#	701,955	0,000	404,04	-19,03	592,05	-7,95	-0,63
C#	701,955	0,000	404,04	-14,27	94,01	-5,99	1,33
G#	700,338	-1,165	404,04	-21,41	795,96	-4,04	3,28

Temperament 18

Neidhardt 2 for small towns (1724) or Neidhardt 3 for large cities (1732). Practical variant with two distinct Fifth beating speeds. Method: A-D, G-D, C-G beat at the same speed, F-A beats about three times as fast. Control: the Fifth F-C beats at half the speed of C-G. The Fifths B flat-F, A-E, B-F#, F#-C# and C#-G# beat at equal speed.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	701,955	0,000	399,40	-11,83	297,47	-2,53	4,64
B flat	700,528	1,157	396,00	-13,12	999,42	-0,58	6,60
F	700,050	1,157	392,88	-6,66	499,95	-0,05	7,12
C	696,865	-2,314	393,26	-5,28	0,00	0,00	7,17
G	698,553	2,314	398,35	-13,71	696,86	-3,14	4,04
D	697,409	2,314	400,40	-12,02	195,42	-4,58	2,59
A	700,437	1,157	403,15	-21,50	892,83	-7,17	0,00
E	701,955	0,000	402,26	-15,26	393,26	-6,74	0,44
B	700,604	-1,157	402,25	-22,87	1095,22	-4,78	2,39
F#	700,153	1,157	403,60	-18,60	595,82	-4,18	3,00
C#	699,549	1,157	403,97	-14,24	95,98	-4,02	3,15
G#	701,943	-0,008	404,48	-21,93	795,52	-4,48	2,70

Temperament 19
Neidhardt 3 for large cities 1724 (not mentioned by Neidhardt after 1732). Practical variant with four distinct Fifth beating speeds. Method: A-E, then E-C that beats at about four times this speed, C-G and A-D beat at the same frequency. Control: The Fifth G-D should beat at around half the speed of the Third C-E. The Fifths B flat-F, B-F# and F#-C# beat at the same speed as A-E. The Fifths E flat-B flat and C#-G# beat at half the speed of C-G.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	700,104	1,000	399,90	-12,29	297,65	-2,35	4,09
B flat	700,287	1,350	397,78	-15,53	997,76	-2,24	4,19
F	701,955	0,000	395,52	-9,33	498,04	-1,96	4,48
C	697,554	-2,000	393,75	-5,65	0,00	0,000	6,44
G	697,985	2,700	398,15	-13,47	697,55	-2,45	3,99
D	698,025	2,000	400,54	-12,13	195,54	-4,46	1,98
A	700,184	1,350	402,37	-20,50	893,56	-6,44	0,00
E	701,955	0,000	402,06	-15,06	393,75	-6,25	0,18
B	700,379	-1,350	401,95	-22,43	1095,70	-4,30	2,14
F#	699,851	1,350	401,68	-16,51	596,08	-3,92	2,52
C#	699,875	1,000	402,11	-12,72	95,93	-4,07	2,37
G#	701,847	-0,078	404,19	-21,58	795,81	-4,19	2,24

[§133] The tuning referred to as Neidhardt IV is an equal temperament. Neidhardt proposes it for use at the Court. It is for this reason that the Silbermann organ in the Hofkirche (Court Church) in Dresden (D) was tuned according to Neidhardt IV (equal) at the recent restoration.

Temperaments 20-21: Silbermann

[§134] Silbermann apparently used various temperaments. According to the interpretation made of historical data and considering the pipe length measurements on six organs built by Silbermann, the expert on Silbermann, Prof. Dr. Frank Harald Greß, proposed a tuning in which the Third C-E beats four times as fast as the 11 Fifths. The result is an agreeable well-tempered tuning, where, in my opinion, the Third C-E beats clearly too fast. Temperament 20 describes this tuning for a pitch of 462 Hz:

Temperament 20
F.H. Greß: proposition for a Silbermann tuning (later tuning). C-E beats precisely four times as fast as the Fifths.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	698,701	1,848	395,61	-8,83	302,46	2,46	6,52
B flat	699,782	1,848	396,28	-14,17	1001,16	1,16	5,22
F	699,053	1,848	395,00	-9,24	500,95	0,95	5,00
C	698,079	-1,848	395,59	-7,39	0,00	0,00	4,06
G	699,366	1,848	396,38	-12,02	698,08	-1,92	2,14
D	698,497	1,848	396,91	-9,47	197,44	-2,56	1,50
A	699,646	1,848	397,62	-15,13	895,94	-4,06	0,00
E	698,871	-1,848	396,26	-9,97	395,59	-4,41	-0,35
B	699,896	1,848	408,01	-32,66	1094,46	-5,54	-1,48
F#	699,206	1,848	406,81	-23,11	594,35	-5,65	-1,59
C#	698,283	1,848	407,39	-17,80	93,56	-6,44	-2,38
G#	710,620	6,549	408,16	-27,62	791,84	-8,16	-4,10

[§135] Greß also proposes a further variant that has two pure Fifths, E flat - B flat and C#- G#. Temperament 20A describes this variant at pitch 440 Hz:

Temperament 20A
F.H. Greß: proposition for a Silbermann-tuning (later tuning) with two pure Fifths. C-E beats precisely four times as fast as the nine Fifths.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	701,955	0,000	398,87	-11,34	299,21	-0,79	3,27
B flat	699,781	1,760	396,28	-13,49	1001,17	1,17	5,23
F	699,053	1,760	394,99	-8,80	500,95	0,95	5,01
C	698,078	-1,760	395,58	-7,04	0,00	0,00	4,06
G	699,365	1,760	396,38	-11,44	698,08	-1,92	2,14
D	698,496	1,760	396,91	-9,02	197,44	-2,56	1,50
A	699,645	1,760	397,62	-14,41	895,94	-4,06	0,00
E	698,870	-1,760	399,93	-13,01	395,58	-4,42	-0,35
B	699,896	1,760	404,76	-26,42	1094,45	-5,55	-1,48
F#	699,205	1,760	406,82	-22,02	594,35	-5,65	-1,59
C#	701,955	0,000	407,39	-16,95	93,56	-6,44	-2,38
G#	703,701	1,257	404,49	-21,91	795,51	-4,49	-0,43

[§136] When one observes the mean values of the surviving pipework in six Silbermann organs, it seems probable that different Fifth values could have served as a point of departure. A reconstruction of the so-called later G. Silbermann temperament, if one may use these measurements as a base, is represented in Tuning 21. It is a practical variant that is relatively easy to lay even without an electronic tuning device:

Temperament 21
Well-tempered tuning after the measured values on the pipework of six Silbermann instruments (measurements and evaluations by Greß/Rühle). Possible tuning method: the Third C-E beats twice as fast as the Fifth A-E and around three times the speed of the Fifths B flat-F, F-C, C-G, G-D, DA and F#-C#. The Third F-A beats three times as fast as the Fifth A-E. The Fifths E flat-B flat, E-B and B-F# beat at half the speed of the other Fifths.

Pitch 2′	Fifths [cent]	[beats]	Thirds [cent]	[beats]	Position	Difference E.T. [C = 0]	[A = 0]
E flat	700,281	0,950	396,94	-10,09	301,03	1,03	5,37
B flat	699,721	1,900	395,95	-13,71	1001,31	1,31	5,65
F	698,972	1,900	394,63	-8,86	501,03	1,03	5,37
C	697,969	-1,900	393,86	-6,02	0,00	0,00	4,34
G	699,293	1,900	396,26	-11,88	697,97	-2,03	2,31
D	698,399	1,900	397,87	-10,33	197,26	-2,74	1,60
A	698,204	3,000	398,60	-16,45	895,66	-4,34	0,00
E	700,369	-0,950	400,46	-14,19	393,86	-6,14	-1,80
B	700,897	0,950	406,79	-30,83	1094,23	-5,77	-1,43
F#	699,130	1,900	406,18	-22,41	595,13	-4,87	-0,53
C#	700,069	0,950	406,77	-17,28	94,26	-5,74	-1,40
G#	706,699	3,587	405,67	-24,50	794,33	-5,67	-1,33

[§137] There are many further tunings that can be described in terms of practical beat ratios. Just the transition from Pythagorean to Prätorian temperaments in their different variants, according to sources such as Aaron, Zarlino, Salinas, Marinati, Banchieri or Grammetus, Agricola, Lublin, Ammerbach, Stevin, de Caus, Mersenne, to mention only a few, could offer material for numerous new and certainly interesting tables. This is also true for the temperaments by Bendeler (1-3) and by Werkmeister (4-6) that deserve to be examined closely and mentioned in practical interpretations.

Conclusion

[§138] I would like to end here, though. There are already more than enough suggestions. At the signature of the contract for the restoration of the Stellwagen organ in the St. Marien church in Stralsund (D) on February 2, 2004 (incidentally the 401st anniversary of Stellwagen's baptism), I managed to make contact with the great organbuilder Stellwagen. Thus he could communicate to me the tuning that he had planned. He did not have in mind a mean-tone temperament with pure Thirds, "otherwise I would not have built a complete first octave, that is with E flat/D#, F# and G# in the lower octave…" From evidence which is partly very difficult to interpret, I have reconstructed the following temperament:

Temperament Stellwagen

Tuning proposal for the Stellwagen organ in St. Marien, Stralsund (D). Meantone tuning where the Third C-E beats at the same speed as the 10 Fifths, the Third G-B beats exactly twice as fast. The note E flat is placed so that the Thirds E flat-G and B (one octave lower)-E flat beat at the same speed, producing a Third B-E flat of around 406,5 Cents. Comparable to the tuning in 5A, but with pitch at 465 Hz.

Pitch	Fifths		Thirds		Position	Difference E.T.	
2'	[cent]	[beats]	[cent]	[beats]		[C = 0]	[A = 0]
E flat	709,762	-4,465	402,43	-15,40	293,81	-6,19	2,60
B flat	698,754	2,750	390,80	-6,43	1003,57	3,57	12,36
F	697,677	2,750	388,89	-2,76	502,32	2,32	11,11
C	696,235	-2,750	389,75	-2,76	0,00	0,00	8,79
G	698,131	2,750	390,90	-5,51	696,23	-3,77	5,03
D	696,843	2,750	391,68	-4,82	194,37	-5,63	3,16
A	698,539	2,750	392,71	-8,61	891,21	-8,79	0,00
E	697,390	-2,750	390,68	-4,39	389,75	-10,25	-1,46
B	698,905	2,750	406,67	-30,79	1087,14	-12,86	-4,07
F#	697,880	2,750	417,53	-35,46	586,04	-13,96	-5,17
C#	696,506	2,750	418,40	-27,28	83,92	-16,08	-7,29
G#	713,379	8,663	419,57	-42,30	780,43	-19,57	-10,78

[§139] The idea about the compromise E flat/D# comes from Michael Prätorius who suggests the distribution of the Wolf over both the Fifths G#-E flat and E flat-B flat. This allows an acceptable B major tonality. I beg my kind readers to read this text with appropriately serious attention, although maybe with just a little pinch of salt.

Abstract

Studying Silbermann, Kristian Wegscheider was "infected" by the "Meantone tuning" virus. Not satisfied with the 1/5 Comma solution advocated by influential organ builders like Jürgen Ahrend and Charles Fisk, among other reasons because of the poor historic evidence, he tried to answer the question how organ builders were used to tune their organs in the early days. Today, complicated schemes and tables serve as references for tuning practices dependent on sophisticated electronic tuning equipment. Fair enough, but what if one only uses one's ears, counting beats? What would we learn from that regarding our understanding of the craft of, say, baroque organ builders? Undoubtedly, they will have chosen practical ways to tune organs. *The* key for success to each tuning appears the division of the four Fifths within a major Third, the Thirds F-A, C-E and G-B being of particular importance. Most probably, a set of questions served as rational references. For example: is the Third pure, does it beat as fast as the Fifths, or twice, three times or even four times as fast? Do the Fifths beat equally or unequally in even-numbered ratios or simply arbitrarily unequal? Might one continue tuning in Fifths and Thirds? These were the questions that required practical solutions and to which every organbuilder had to find his own answers.
Based on this insight, Wegscheider presents about 40 different temperaments, each offering its own advantages and, of course, disadvantages.

Kristian Wegscheider

Kristian Wegscheider was born in 1954 in a small village on the Baltic Sea near to Rostock and Stralsund. He did his organ building apprenticeship with the firm Jehmlich Orgelbau between 1975 and 1978. From 1976 to 1980 he continued his studies in organ restoration. He founded his own shop in 1989 where he actually employs about ten persons on a regular basis. His workshop focuses on restorations of historic organs and the construction of new instruments in historic styles.

IV

Jos de Bie - The New Baroque Organ at the Orgelpark: Temperament

[§140] In March 2013, Hans Fidom emailed me asking me whether it might be possible to equip the New Baroque Organ with the option to "switch" between two temperaments in order to favour both "old" and "new" music. A number of options present themselves.

Option 1: alternate temperaments (equal/unequal)

[§141] In the first instance, equal temperament was considered to be the best solution for new music, and something akin to the Neidhardt temperaments ideal for the older repertoire. Further investigation of this combination presents a number of problems, however. On an organ with a "switchable" temperament, there must be enough common notes (and, therefore, pipes) for the project to remain financially viable. Otherwise, one might as well buy two organs! This minimum number of common pipes should in principle be set at six which would result in 6 x 2 "doubled" pipes per octave, the total number per octave thus numbering 18.
[§142] In the first instance a situation was conceived whereby the organ would be able to switch between an equal temperament on the one hand and one of the Neidhardt temperaments on the other. However, when one investigates the division of the octave in the latter, one realises that the differences between notes in the Neidhart tunings and in equal temperament are very small indeed. This is especially true of Neidhart temperaments II and III (see the table below).[1]

1 Neidhardt I: 'Village'/1724 = 'For a small city'/1736. Neidhardt II: 'For a small city'/1724 = 'For a large city'/1736. Neidhardt III: 'For a large city'/1724. Neidhardt IV: 'Village' 1736.

[§143] In addition, the phenomenon tends to arise that even "correctly" tuned organs in practice demonstrate deviations in pitch of up to two cents, something which is of course equally true in both equal and unequal temperaments. As a consequence, in this case, the differences between equal and unequal temperaments would have been too small to justify the considerable extra expense of such an instrument.

Comparison of the Neidhardt tunings with equal temperament: same C

	C	C#	D	E flat	E	F	F#	G	G#	A	B flat	B
I	0	-6	-4	-4	-8	-2	-8	-2	-4	-6	-4	-8
II	0	-4	-4	-2	-6	0	-4	-2	-4	-6	0	-4
III	0	-4	-4	-2	-6	-2	-4	-2	-4	-6	-2	-4
IV	0	-6	-2	-4	-10	-2	-8	0	-6	-6	-2	-8

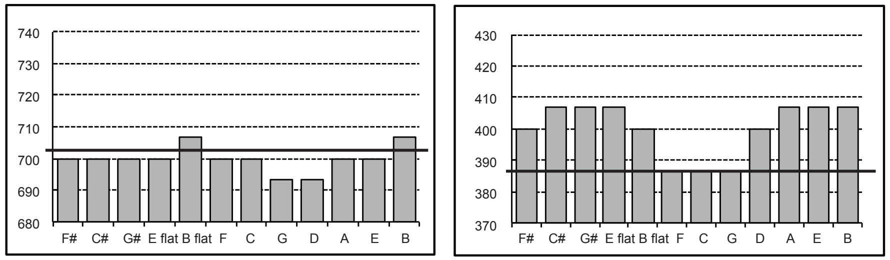
Comparison of the Neidhardt tunings with equal temperament: same A

	C	C#	D	E flat	E	F	F#	G	G#	A	B flat	B
I	+6	0	+2	+2	-2	+4	-2	+4	+2	0	+2	-2
II	+6	+2	+2	+4	0	+6	+2	+4	+2	0	+6	+2
III	+6	+2	+2	+4	0	+4	+2	+4	+2	0	+4	+2
IV	+6	0	+4	+2	-4	+4	-2	+6	0	0	+4	-2

[§144] A second prototype was then proposed by which a departure from equal temperament would be achieved by "sweetening" a number (three or four) of the major Thirds, namely those on F, G, C and possibly D.
[§145] There are no obvious solutions to the question of an organ with a dual-temperament system. Normally speaking, one takes a certain circle of Fifths as the point of departure, or a certain existing tuning system to which one might make a number of adjustments. The assignment in the case of the organ with two interchangeable tuning systems is to start from the division of the octave in equal temperament (a very rigid system indeed) and to keep six of the notes within that octave the same in the 'other' tuning system. In principle, it is desirable to keep A constant as the "tuning" note. Unfortunately, this is not always possible...
[§146] I began, therefore, by making a number of major Thirds better (i.e. smaller) within the context of the equally tempered octave. This can be done in three ways, either by raising the lower note of the major Third, by lowering the higher note of the major Third, or by combining both methods. This Third way has as its advantage that the pitch alterations can be restricted in order to avoid the appearance of the undesirable "Wolf" in the other intervals (most especially the Fifths).
[§147] Equally tempered major Thirds are separated by 400 Cents, a pure major Third by 386,3 Cents, a difference, therefore of 13,7 Cents. If we, for example, raise C from 0 to 7 Cents and lower the note E from 400 to 393 Cents, we end up with a pure major Third, C-E, of 386 Cents (rounded down).
[§148] We can apply the same method to F-A and G-B. In the case of F-A we are obliged to lower slightly the diapason (the pitch of a1). For solo organ music, this has no significant consequence as the deviation remains very limited (at most 440 Hz – 7 Cents = 438,2 Hz). When working with other instrumentalists, this could lead to problems, however. Should we wish, in addition, to sweeten a fourth major Third, for example D-F#, we would also have to alter the pitches of at least one or two more notes with the result that we would fail to meet our quota of six common notes. We could also apply smaller deviations to the notes in question, for example of +/– 5 Cents or 4 Cents, which would result in Thirds of 390, and 392 Cents respectively. Finally one could also potentially apply unequal values to the various Thirds. There are, therefore, many ways of tackling the problem but, if we limit ourselves to a maximum of six 'undoubled' notes, one is limited to three, more or less pure, Thirds. The "pay-off" is represented by the over-wide Thirds in other places, although preferably not wider than 408 Cents (= the Pythagorian value).

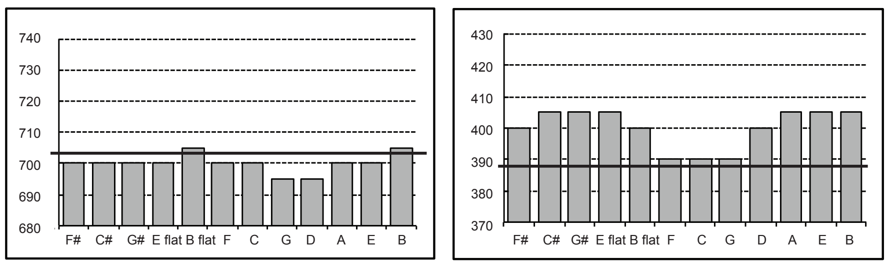
[§149] To illustrate the parameters of these different approaches, I have appended four examples:

Variant 1



[§150] Variant 1 contains three completely pure major Thirds of 386,3 Cents on the notes F, C and G as well as six major Thirds which come close to the Pythagorean value (407 Cents). In the circle of Fifths there are two which are very narrow indeed (693,2 Cents), on G and D respectively. In addition, there are two wide Fifths (707 Cents) on B-flat and B ; the remaining eight Fifths are 'equally tempered'(700 Cents).

Variant 2

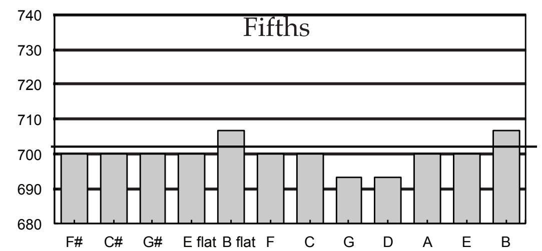


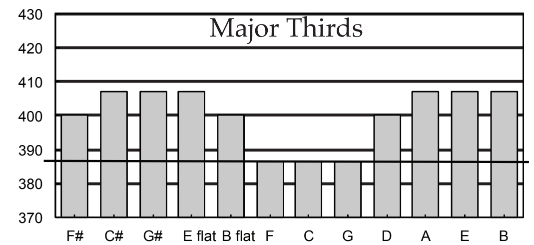
[§151] Variant 2 contains three mildly impure major Thirds, once again on F, C and G. These are 390 Cents and are, therefore, almost equal to the Thirds in 1/5th (syntonic) comma meantone. The deviations in the other intervals fall in the same places as in Variant 1 but the deviations themselves are smaller.

Equal temperament variant 1

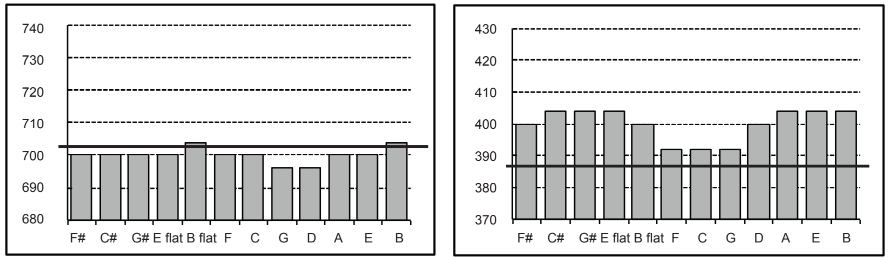
Principle: C, F & G +6,85 Cents; E, A and B –6,85 Cents; three pure major Thirds on F, C and G.

	Fifths	Thirds			Position	Seconds	
		Major	Minor			Major	Minor
F#	700	400	293,15	C	6,85	93,15	193,15
C#	700	406,85	293,15	C# / Db	100	100	200
G#	700	406,85	293,15	D	200	100	193,15
E flat	700	406,85	300	D# / E flat	300	93,15	206,85
B flat	706,85	400	300	E	393,15	113,70	206,85
F	700	386,30	293,15	F	506,85	93,15	200
C	700	386,30	293,15	F# / Gb	600	106,85	200
G	693,15	386,30	293,15	G	706,85	93,15	186,30
D	693,15	400	306,85	G# / Ab	800	93,15	200
A	700	406,85	313,70	A	893,15	106,85	200
E	700	406,85	313,70	B flat	1000	93,15	206,85
B	706,85	406,85	306,85	B	1093,15	113,70	206,85
				C	1206,85		
Total	8400	4800	3600			1200	2400



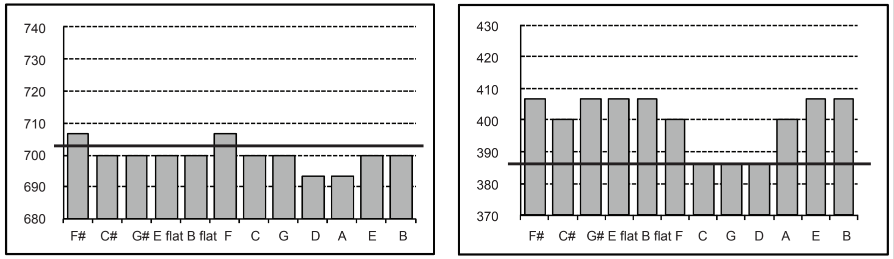


Variant 3



[§152] Variant 3 is a further "levelling" of the previous temperaments with, once again, three mildly impure Thirds, this time of 392 Cents, on the notes F, C and G, while the deviations of the other intervals are further weakened. This tuning system comes rather close to certain systems described by Neidhardt and Marpurg and has, in my opinion, no real meantone characteristics.

Variant 4



[§153] Variant (4) includes three pure Thirds on C, G and D and can be interpreted as a transposition (by one Fifth to the right, i.e. the diatonic sector of the circle of Fifths) of Variant 1.

[§154] The table below demonstrates that the four tuning systems described do indeed share six notes with equal temperament. If, however, we re-calculate these octave divisions from a common note of C, the four variants share only three notes with equal temperament. If we re-calculate from a common note of A, variants 1, 2 and 3 share three notes and variant 4 six notes with equal temperament. We will spare the reader the details of this re-calculation...

The division of the octave in Cents

Equal Temperament, variant 1, variant 2, variant 3 and variant 4

	C	C#	D	E flat	E	F	F#	G	G#	A	B flat	B
E.T.	0	100	200	300	400	500	600	700	800	900	1000	1100
1	6,85	100	200	300	393,15	506,85	600	706,85	800	893,15	1000	1093,15
2	5	100	200	300	395	505	600	705	800	895	1000	1095
3	4	100	200	300	396	504	600	704	800	896	1000	1096
4	6,85	100	206,85	300	393,15	500	593,15	706,85	800	900	1000	1093,15

[§155] Of the four variants described, we have appended a complete tuning diagram for the first (Variant 1) and, for the other three, a global diagram (Variant 2) in which the Fifth and Third graphics are illustrated next to each other in order that they can be easily compared.
[§156] There are, of course, a great number of other possibilities, for example with three unequal major Thirds, which could be also be assigned to other notes, but the consequence is either highly irregular temperaments or very mild ones with a much more "wohltemperiert" than meantone character. When all is said and done, this first set of options does not, in my opinion, offer an optimal solution for an organ on which a dual temperament system of equal and unequal tunings is desired.

Option 2: switchable tunings (well-tempered/meantone)

[§157] The combination of two unequal temperaments allows many more possibilities. Moreover, there are already a number of different organs with comparable systems, of which three will now be described:

- Stanford University Memorial Church – Fisk organ (1985)
- Omaha – St. Cecilia Cathedral – Pasi organ (2003)
- Allstedt & Wilschdorf – Wegscheider-organs (1990 & 1995)

Stanford

[§158] The organ in the Memorial Church at Stanford University (California, USA) was completed in 1985. The instrument was designed and built by Charles Fisk although he was to die prior to its completion. It is conceived in a sort of "North-German eclectic" style, and consists of 75 stops on four manuals and pedals. The organ was one of the first, and probably the best known, dual-temperament instruments. The tuning system(s) in question were developed by Harald Vogel. One manual, the Brustwerk, is tuned in 1/5 (Pythagorian) Comma meantone with split upper keys for the notes D# / E flat and G# / A flat.

[§159] The other manuals have a dual-temperament system juxtaposing meantone with a well-tempered system in which the seven white notes are common to both tunings and the five black notes can be "re-tuned" by means of a lever. There are, therefore, 17 pipes per octave; seven common and 2 x 5 "doubled".

[§160] Temperament A is 'wohltemperiert' and contains three pure Thirds on G#, E flat and B, seven Fifths, each of which are 1/5 Pythagorean Comma narrow (697,3 Cents) on F, C, G, D, A, E and C#, and two Fifths which are 1/5 P.C. wide (706,6 Cents) on F# and E flat.

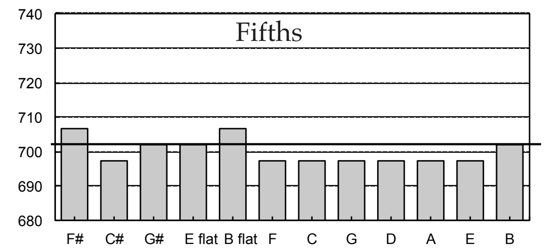
[§161] The curve plotted by the major Thirds has a satisfyingly clear U form, with three mildly wide Thirds (389 Cents) on F, C and G in the common keys, the Thirds becoming gradually wider in the less frequently used keys without ever "over-stepping" the Pythagorean value of 407,8 Cents.

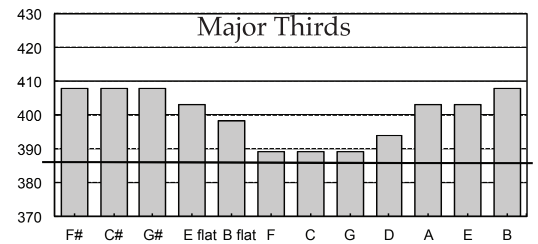
[§162] Temperament B is a sort of meantone tuning with eleven equal Fifths, each of which is 1/5 Pythagorean Comma (= 4.7 Cents) narrow, and one exceedingly wide Wolf Fifth on G# (730 Cents). This Wolf Fifth is somewhat smaller than that of the "classic" 1/4 Comma meantone tuning because the other Fifths are slightly larger (697,3 rather than 696,6 Cents). This has as a consequence that the eight major Thirds which, in "true" meantone tuning are completely pure, are here slightly wide (389 instead of 386,3 Cents), while, on the other hand, the four Wolf Thirds are somewhat narrower (421,9 rather than 427,4 Cents). The eight quasi-pure Thirds may become completely pure thanks to the phenomenon of "pulling" between organ pipes, should the acoustical circumstances be favourable, but whether this has ever been objectively quantified, I am unaware. A global analysis of both tuning systems can be seen below.

Stanford, Fisk organ (1985): Tuning A (well-tempered [Vogel])

Principle: three pure Fifths, seven Fifths -1/5 Pyth. Comma, two Fifths +1/5 P.C. The seven lower keys are tuned according to the 1/5 P.C. mean-tone temperament = Tuning B.

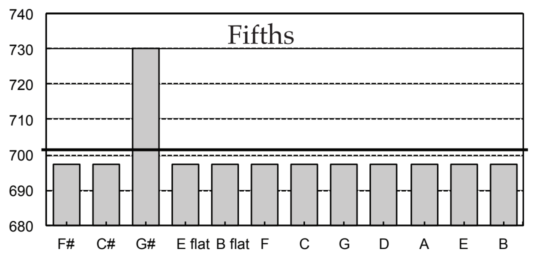
	Fifths	Thirds Major	Thirds Minor		Position	Seconds Major	Seconds Minor
F#	706,647	407,820	303,519	C	0	94,917	194,526
C#	697,263	407,820	294,135	C# / Db	94,917	99,609	199,218
G#	701,955	407,820	294,135	D	194,526	99,609	194,526
E flat	701,955	403,128	294,135	D# / E flat	294,135	94,917	208,602
B flat	706,647	398,436	298,827	E	389,052	113,685	199,218
F	697,263	389,052	289,443	F	502,737	85,533	194,526
C	697,263	389,052	294,135	F# / Gb	588,270	108,993	203,910
G	697,263	389,052	298,827	G	697,263	94,917	194,526
D	697,263	393,744	308,211	G# / Ab	792,180	99,609	203,910
A	697,263	403,128	308,211	A	891,789	104,301	194,526
E	697,263	403,128	308,211	B flat	996,090	90,225	203,910
B	701,955	407,820	308,211	B	1086,315	113,685	208,602
				C	1200		
Total	8400	4800	3600			1200	2400

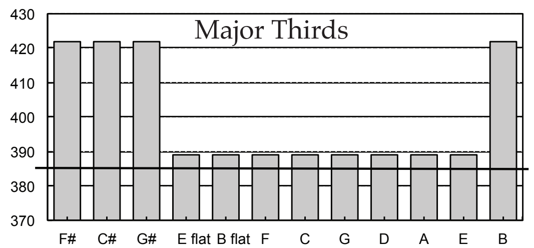




Stanford, Fisk organ (1985): Tuning B (1/5 Pyth. Comma mean-tone)
Principle: eleven Fifths -1/5 Pyth. Comma; one Wolf on G#. The seven lower keys are tuned well-tempered = Tuning A.

	Fifths	Thirds Major	Thirds Minor		Position	Seconds Major	Seconds Minor
F#	697,263	421,896	308,211	C	0	80,841	194,526
C#	697,263	421,896	308,211	C# / Db	80,841	113,685	227,370
G#	730,107	421,896	308,211	D	194,526	113,685	194,526
E flat	697,263	389,052	275,367	D# / E flat	308,211	80,841	194,526
B flat	697,263	389,052	275,367	E	389,052	113,685	194,526
F	697,263	389,052	275,367	F	502,737	80,841	194,526
C	697,263	389,052	308,211	F# / Gb	583,578	113,685	194,526
G	697,263	389,052	308,211	G	697,263	80,841	194,526
D	697,263	389,052	308,211	G# / Ab	778,104	113,685	227,370
A	697,263	389,052	308,211	A	891,789	113,685	194,526
E	697,263	389,052	308,211	B flat	1005,474	80,841	194,526
B	697,263	421,896	308,211	B	1086,315	113,685	194,526
				C	1200		
Total	8400	4800	3600			1200	2400





Stanford, Fisk organ (1985): common notes in Tuning A and Tuning B

	Tuning A	Tuning B
C	0	0
C# / D flat	94,92	80,84
D	194,53	194,53
D# / E flat	294,14	308,21
E	389,05	389,05
F	502,74	502,74
F# / G flat	588,27	583,58
G	697,26	697,26
G# / A flat	792,18	778,10
A	891,79	891,79
B flat	996,09	1005,47
B	1086,32	1086,32
C	1200	1200

[§163] A number of objections could reasonably be levelled at this system:

- The two temperaments used are not really “historic” in the sense that they are preserved in contemporary texts.
- The tempering of the Fifths in tuning B is accomplished using fractions of the Pythagorean Comma whilst the whole concept of meantone tuning is based on the syntonic comma (this is essential in order to achieve completely pure Thirds).
- In the case of tuning A, the left (chromatic) sector of the circle of Fifths is too irregular. For example, one sees a narrow Fifth on C# adjacent to a wide Fifth on F#. This irregularity could easily be removed through flattening the note C# by 4,6 Cents. As a result, the Fifths on C# and F# both become pure, the only disadvantage of this process being that the major Third on C# becomes somewhat wider. On the other hand, the major Third on A is improved.

Omaha

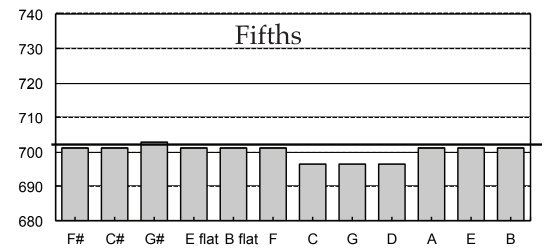
[§164] The organ of St Cecilia's Cathedral, Omaha (Nebraska / USA) was built by Martin Pasi in 2003 as his opus 14. It is an instrument of 55 stops on three manuals and pedals tuned in a well-tempered system. 29 of the stops can, by means of a switching system, also be played in meantone. These stops contain 20 pipes per octave of which four are common to both tunings (C, D, G and A), and 16 (2 × 8) are "divided".

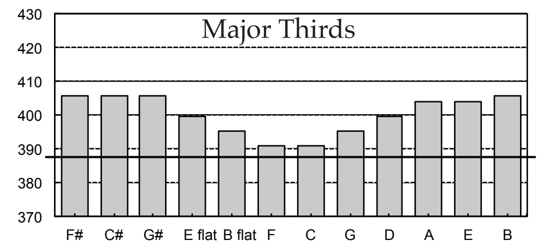
[§165] Tuning A is a so-called "well-temperament" ("wohltemperiert"). This contains nine Fifths each of which are one Cent narrow (circa 701 Cents) and are therefore "quasi-equal", and three meantone Fifths of 696,6 Cents on C, G and D. The curve plotted by the major Thirds includes two Thirds which are only slightly wide (+4.4 Cents) on F and C. The remaining Thirds plot a nice, clear curve, never reaching the Pythagorean value.

Omaha: Tuning A (well-tempered [Wegscheider/Pasi])

Principle: three Fifths (C-G-D-A) -1/4 Synthonic Comma; eight Fifths -1 Cent; Fifth on G#: +0,67 Cent. Four notes (C, D, G, A) are used in the meantone Tuning as well = Tuning B.

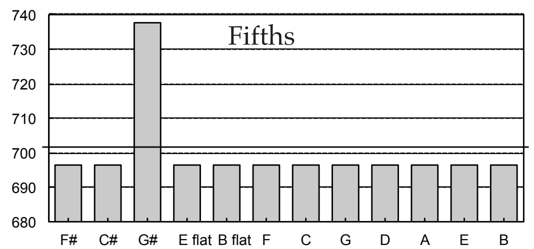
	Fifths	Thirds			Position	Seconds	
		Major	Minor			Major	Minor
F#	700,955	405,491	297,135	C	0	93,554	193,156
C#	700,955	405,491	297,135	C# / Db	93,554	99,602	203,581
G#	702,626	405,491	297,135	D	193,156	103,979	197,533
E flat	700,955	399,443	295,464	D# / E flat	297,135	93,554	201,910
B flat	700,955	395,066	295,464	E	390,689	108,356	201,910
F	700,955	390,689	295,464	F	499,045	93,554	197,533
C	696,578	390,689	297,135	F# / Gb	592,599	103,979	201,910
G	696,578	395,066	301,512	G	696,578	97,931	193,156
D	696,578	399,443	305,889	G# / Ab	794,509	95,225	203,581
A	700,955	403,820	310,266	A	889,734	108,356	201,910
E	700,955	403,820	305,889	B flat	998,090	93,554	201,910
B	700,955	405,491	301,512	B	1091,644	108,356	201,910
				C	1200		
Total	8400	4800	3600			1200	2400

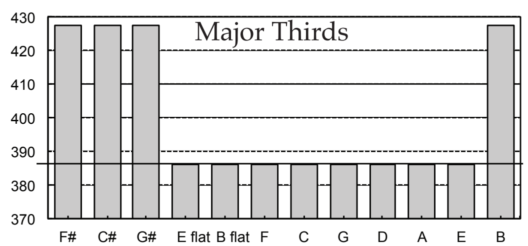




Omaha: Tuning B (1/4 Synthonic Comma meantone)
Principle: eleven Fifths -1/4 Syntonic Comma; Wolf Fifth on G#.
Four notes (C, D, G, A) are used in the well-tempered Tuning as well = Tuning A.

	Fifths	Thirds Major	Thirds Minor		Position	Seconds Major	Seconds Minor
F#	696,578	427,376	310,266	C	0	76,046	193,156
C#	696,578	427,376	310,266	C# / Db	76,046	117,110	234,220
G#	737,642	427,376	310,266	D	193,156	117,110	193,156
E flat	696,578	386,312	269,202	D# / E flat	310,266	76,046	193,156
B flat	696,578	386,312	269,202	E	386,312	117,110	193,156
F	696,578	386,312	269,202	F	503,422	76,046	193,156
C	696,578	386,312	310,266	F# / Gb	579,468	117,110	193,156
G	696,578	386,312	310,266	G	696,578	76,046	193,156
D	696,578	386,312	310,266	G# / Ab	772,624	117,110	234,220
A	696,578	386,312	310,266	A	889,734	117,110	193,156
E	696,578	386,312	310,266	B flat	1006,844	76,046	193,156
B	696,578	427,376	310,266	B	1082,890	117,110	193,156
				C	1200		
Total	8400	4800	3600			1200	2400





[§166] Tuning B is a pure 1/4 Comma meantone tuning (see the diagram above) with 11 Fifths which are 1/4 Syntonic Comma narrow and one dramatically wide Wolf Fifth (737,6 Cents) on G#. The interchangeable tunings at Omaha offer something for everyone: a highly regularised "wohltemperierte" tuning with reasonably significant similarities to Neidhardt II (= For a Small City, 1724), and, on the other hand, an orthodox meantone tuning. For me, the big problem here is that there are just four common pipes per octave with the result that the price of the organ is extremely high:

Omaha, Pasi organ (2003): common notes in Tuning A and Tuning B

	Tuning A	Tuning B
C	0	0
C# / D flat	93,55	76,05
D	193,16	193,16
D# / E flat	297,14	310,27
E	390,69	386,31
F	499,05	503,42
F# / G flat	592,60	579,47
G	696,58	696,58
G# / A flat	794,51	772,62
A	889,73	889,73
B flat	998,09	1006,84
B	1091,64	1082,89
C	1200	1200

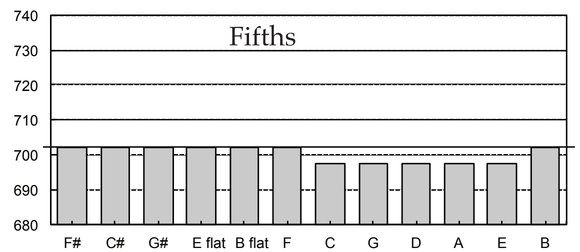
Wegscheider

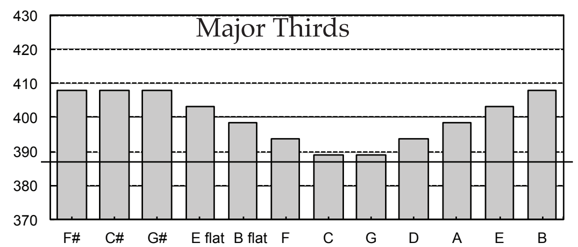
[§167] An interchangeable tuning system was developed by organbuilder Kristian Wegscheider (Dresden) and applied by him on two new organs, firstly in the Schlosskapelle, Allstedt (Thüringia) in 1990, a single manual organ with eight stops, and later in the Christoforuskirche in Dresden-Wilschdorf, a two manual and pedal organ with 14 stops, built in 1995.

Allstedt (1990) & Dresden (1995): Tuning A (well-tempered)

Principle: seven pure Fifths, five Fifths -1/5 Pyth. Comma.
Six notes (C, D, E , G, A, B) are used as well in Tuning B ("meantone").

	Fifths	Thirds Major	Minor		Position	Seconds Major	Minor
F#	701,955	407,820	303,519	C	0	90,225	194,526
C#	701,955	407,820	298,827	C# / Db	90,225	104,301	203,910
G#	701,955	407,820	294,135	D	194,526	99,609	194,526
E flat	701,955	403,128	294,135	D# / E flat	294,135	94,917	203,910
B flat	701,955	398,436	294,135	E	389,052	108,993	199,218
F	701,955	393,744	294,135	F	498,045	90,225	199,218
C	697,263	389,052	294,135	F# / Gb	588,270	108,993	203,910
G	697,263	389,052	298,827	G	697,263	94,917	194,526
D	697,263	393,744	303,519	G# / Ab	792,180	99,609	203,910
A	697,263	398,436	308,211	A	891,789	104,301	194,526
E	697,263	403,128	308,211	B flat	996,090	90,225	203,910
B	701,955	407,820	308,211	B	1086,315	113,685	203,910
				C	1200		
Total	8400	4800	3600			1200	2400

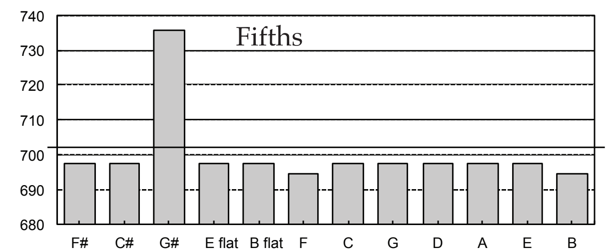


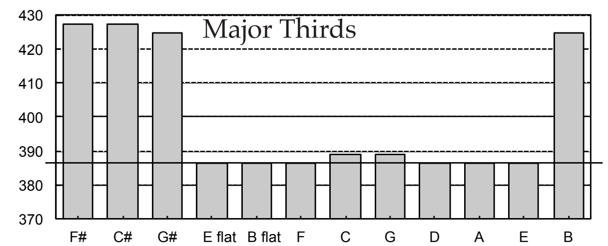


Allstedt (1990) & Dresden (1995): Tuning B ("meantone")

Principle: nine Fifths -1/5 Pyth. C., two Fifths -(2/5 P.C.-/-Schism) on F and B; Wolf Fifth on G#; six notes in common with Tuning A.

	Fifths	Thirds Major	Minor		Position	Seconds Major	Minor
F#	697,263	427,372	310,949	C	0	78,103	194,526
C#	697,263	427,372	310,949	C# / Db	78,103	116,423	232,846
G#	735,583	424,634	310,949	D	194,526	116,423	194,526
E flat	697,263	386,314	269,891	D# / E flat	310,949	78,103	194,526
B flat	697,263	386,314	269,891	E	389,052	116,423	191,788
F	694,525	386,314	269,891	F	505,475	75,365	191,788
C	697,263	389,052	310,949	F# / Gb	580,840	116,423	194,526
G	697,263	389,052	310,949	G	697,263	78,103	194,526
D	697,263	386,314	310,949	G# / Ab	775,366	116,423	232,846
A	697,263	386,314	308,211	A	891,789	116,423	194,526
E	697,263	386,314	308,211	B flat	1008,212	78,103	191,788
B	694,525	424,634	308,211	B	1086,315	113,685	191,788
				C	1200		
Total	8400	4800	3600			1200	2400





[§168] The system in question is an interchangeable pair of temperaments; on the one hand a "wohltemperierte" tuning (A) and, on the other, an almost perfect meantone temperament (B). The tunings have six common pipes per octave, namely C, D, E, G, A and B. In total, therefore, there are 18 pipes per octave, of which six are common and 12 (2 × 6) are doubled.
[§169] Tuning A is a "wohltemperierte" tuning with seven pure Fifths and five Fifths which are 1/5 Pythagorean comma narrow (697,3 Cents) on C, G, D, A and E. In fact, this is a historic tuning described in 1868 by Giacomo Ferdinando Sievers (1809-1878), a German piano maker who lived in Naples. This system is also closely related to the so-called Bach temperament of H.A. Kellner (1976).
[§170] Tuning B is closely related to the classic 1/4 Comma meantone tuning, encompassing six pure major Thirds and two Thirds which are slightly wide (+2.7 Cents on C and G). Assuming a pitch of a1 = 440 Hz, this equates to 2,1 and 3,1 beats per second in the middle octave. This in fact is very little when compared, for example, with equal temperament in which the Thirds in question have 10,4 and 15,6 beats per second respectively. In addition, there are, of course, four markedly wide Wolf Thirds on F#, C#, G# and B.
As far as the Fifths are concerned, there is one solitary Wolf on G# and 11 narrow Fifths, of which nine are 1/5 Pythagorian Comma narrow and two somewhat narrower still.
[§171] If one compares the division of the octave in this tuning B with that of 1/4 comma meantone, assuming the same A, it becomes clear that the maximum deviation is no more than 2 Cents (for the note C) whilst all of the other notes show minimal differences (less than 1,4 cents):

	C	C#	D	E flat	E	F	F#	G	G#	A	B flat	B
Wegsch. B	0	78,1	194,5	310,9	389,1	505,5	580,8	697,3	775,4	891,8	1008,2	1086,3
Meantone	2,05	78,1	195,2	312,3	388,4	505,5	581,5	698,6	774,7	891,8	1008,9	1084,9
Difference	-2,05	0	-0,69	-1,37	0,68	0	-0,68	-1,37	0,69	0	-0,68	1,37

Conclusions to be drawn from option 2
[§172] If one looks at the three interchangeable tuning systems described above, it seems to be clear to me that the Wegscheider tuning offers the best solution for a number of reasons:

- Both tuning A and tuning B are existent historic tunings, which lends them a certain legitimacy. A comparison between the two tunings is shown in the diagram below. The meantone found here does not, admittedly, correspond entirely to the "classic" 1/4 Comma meantone but the differences are so small that, in my opinion, no listener could tell the difference.

Allstedt & Dresden: common notes in Tuning A and Tuning B

	Tuning A	Tuning B
C	0	0
C# / D flat	90,22	78,10
D	194,53	194,53
D# / E flat	294,14	310,95
E	389,05	389,05
F	498,05	505,48
F# / G flat	588,27	580,84
G	697,26	697,26
G# / A flat	792,18	775,37
A	891,79	891,79
B flat	996,09	1008,21
B	1086,32	1086,32
C	1200	1200

- Both tuning systems A and B can in principle be set by ear. In each case, one begins by tuning five Fifths, each of which is 1/5-Pyth.

Comma narrow. As a result, the notes C, G, D, A, E are B are then set. In order to check whether these intervals are correct, one can carry out two "tests". Firstly, the Fifth C-G and the major Third C-E must beat at the same rate (2,1 beats per second assuming a pitch of a1 = 440 Hz); G-D and G-B must also beat at the same rate (3,1 beats per second). Tuning A is then tuned in pure Fifths from B, tuning B in pure major Thirds, likewise from B. In practice, this would mostly be done using an electronic tuner of course.

- Both tunings can be achieved by adding just six pipes for each octave (in Omaha, eight pipes are doubled in each octave).
- The Wegscheider temperaments found in Allstedt and Wilschdorf can be visited and experienced by travelling just a few hundred kilometers from the Netherlands, whilst California and Nebraska can only be visited by flying over the ocean...

Option 3: multiple manuals, each with a different tuning

[§173] One might consider an organ with two (or more) manuals, each of which is tuned in its own temperament. This is a choice which, in my opinion, is more logical than that chosen in Omaha where the two tuning systems share just four pipes per octave. The complicated technical situation which arises from the Omaha situation is perhaps as expensive as building two separate instruments, each with a different tuning, within the same organ case. An organ with different temperaments would allow, for example, "dialogues" between two manuals in different tuning systems and other such special effects. One could also couple manuals tuned in different temperaments which would produce undoubtedly bizarre results. Both of these possibilities seem to me to be only of interest in the context of "modern", experimental music. All in all, this is not a very interesting option in the context of today's organbuilding prices.

Option 4: a single temperament for the whole organ

[§174] A single temperament for the whole organ is undoubtedly the simplest solution and certainly also the cheapest. The crucial problem is of course which temperament to choose. This would certainly be a sort of compromise tuning as the organ is required to be adaptable to different

musical situations. A pure meantone temperament would not, I believe, come into consideration and neither would a truly equal temperament as a result of the organ's obvious implied links with the past.

[§175] In this instance, I would opt for a hybrid between "wohltemperiert" and meantone, or, in other words, a temperament with a number of pure Fifths which also includes a number of (quasi-) pure major Thirds, and in which both Wolf Fifths and Wolf Thirds would be avoided in order that the usefulness of the instrument would not be compromised.

[§176] The choice of tuning systems along these lines is rather large but the solutions are not all equally interesting. The key element is the avoidance of narrow Fifths being juxtaposed with wide ones; this results in a very "restless" tuning (Werkmeister IV is a good example). Other points of discussion would include the choice between pure or slightly wide major Thirds. If one wants strictly pure Thirds then one must also plan for narrower Fifths. Finally, it must once again be stressed that meantone derivatives with a reduced number of pure major Thirds are, first and foremost, French tuning systems and the question must be asked whether these would be appropriate for a "German"-inspired organ. Indeed, it is primarily French writers who described such temperaments, in which the solitary Wolf Fifth on G# in the original meantone would be divided among a number of Fifths. The result of this is that the number of pure major Thirds (originally eight) is reduced. There is, in fact, a whole series of versions of the French *Tempérament Ordinaire* with a reduced number of pure Thirds, for example just four (Rameau), sometimes two or three, or even, in the case of writers such as d'Alembert or Rousseau, just one.

[§177] In Germany, on the other hand, the method used to "weaken" the meantone temperament was rather different, namely the minimising of the tempering of the 11 narrow Fifths, for example to 1/5 or 1/6 (Syntonic) Comma or even less. As a result, these 11 Fifths become slightly wider whilst the solitary Wolf on G# of course becomes narrower. This is the case, for example, with the so-called (Gottfried) Silbermann-tuning; but, in practice a number of primarily (Southern) German historic organs show traces of similarly adapted meantone temperaments. The question, therefore, is whether the organbuilders in the North German region applied these "French" tuning systems (avant la lettre) with limited numbers of pure

Thirds. The surviving literature offers little evidence and, as far as I am aware, there has been no convincing physical evidence discovered in the organs themselves. This does not mean however that similar tuning systems haven't retrospectively been applied to various North German historic organs (primarily under the influence of Harald Vogel). The question isn't whether these are good or bad temperaments as such, but this modern application of such tunings has led to bizarre situations. An example is the Isnard organ (1774) of St Maximin en Provence being tuned in the same temperament as the Schnitger organ in Norden.[2]

[§178] To return then to the organ to be built for the Orgelpark, I believe that a tuning in the spirit of the French *Tempérament Ordinaire* could be interesting in the event that the organ, for whatever reason, ends up with a single temperament. My preference would be for the tuning described in the 1970s by the French organologist Henri Legros (1921-1982). This tuning system (see the diagram below) includes six pure Fifths, five meantone Fifths and one slightly large Fifth (705,4 Cents on E flat). The curve plotted by the Thirds includes two pure major Thirds (on C and G) and describes an elegant gradient as one progresses towards the more distant keys. This tuning system is, in my opinion, an ideal compromise between a well-tempered system and meantone.

[§179] It should be remarked that Legros also described a temperament with three pure major Thirds (on C, G and D) which is, in fact, identical to that applied to the Cosmae & Damiani organ in Stade in 1975.

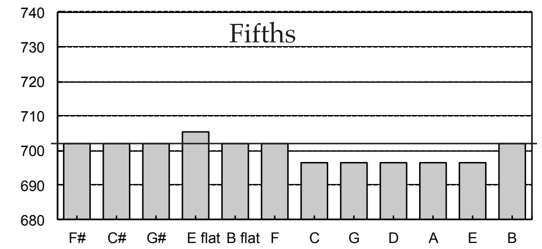
This bizarre similarity between French and (Northern) German temperaments is clearly illustrated in the next diagram.

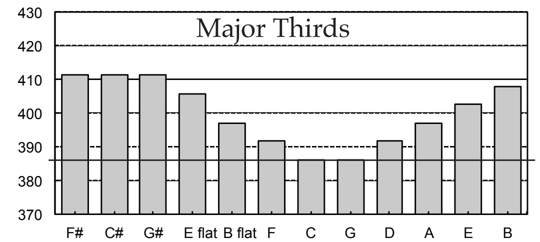
2 A paradox I highlighted in the article "Une question de tempérament" (*Connoissance de l'Orgue* 87-88 (1993)). The article unfortunately prompted no reactions.

Henri Legros: two pure major Thirds

Principle: six pure Fifths, five Fifths -1/4 Synthonic Comma, one wide Fifth on E flat.

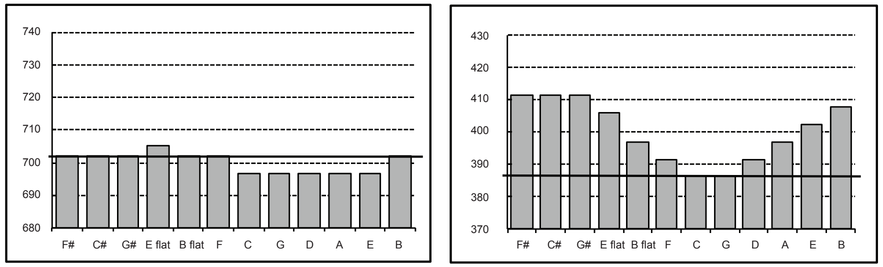
	Fifths	Thirds			Position	Seconds	
		Major	Minor			Major	Minor
F#	701,955	411,245	304,889	C	0	86,800	193,156
C#	701,955	411,245	299,512	C# / Db	86,800	106,356	203,910
G#	701,955	411,245	294,135	D	193,156	97,554	193,156
E flat	705,380	405,868	294,135	D# / E flat	290,710	95,602	207,335
B flat	701,955	397,066	290,710	E	386,312	111,733	198,533
F	701,955	391,689	290,710	F	498,045	86,800	198,533
C	696,578	386,312	290,710	F# / Gb	584,845	111,733	203,910
G	696,578	386,312	299,512	G	696,578	92,177	193,156
D	696,578	391,689	304,889	G# / Ab	788,755	100,979	207,335
A	696,578	397,066	310,266	A	889,734	106,356	193,156
E	696,578	402,443	310,266	B flat	996,090	86,800	203,910
B	701,955	407,820	310,266	B	1082,890	117,110	203,910
				C	1200		
Total	8400	4800	3600			1200	2400



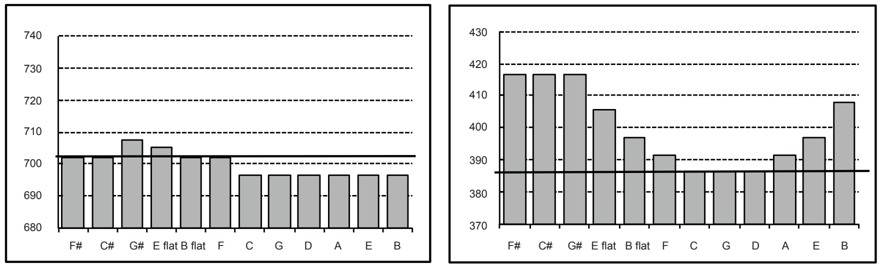


Meantone variants with reduced number of pure Thirds

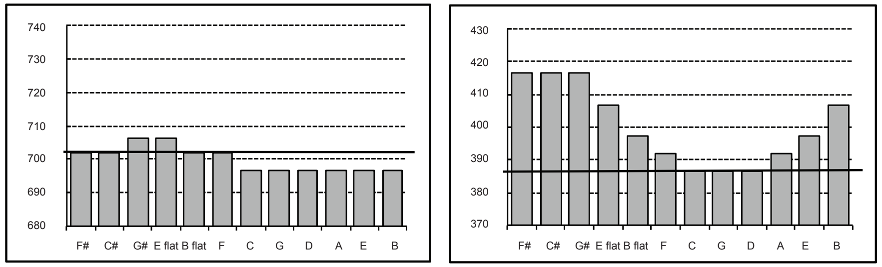
Henri Legros: two pure Thirds



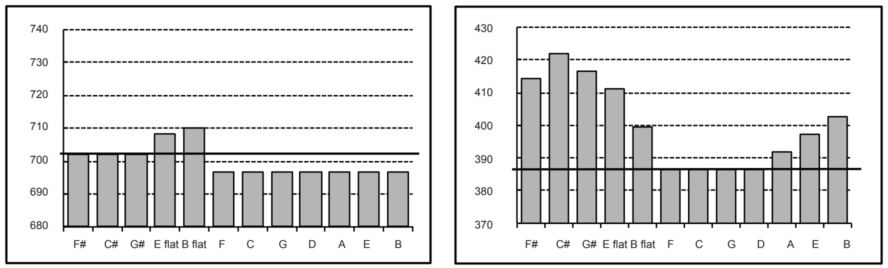
Henri Legros: three pure Thirds



Schnitger/Stade



Rameau (in F; transposed one Fifth)



Conclusions

[§180] From what has been said so far in this article I would like to suggest that there are just two possible options which should be considered for the new organ in the Orgelpark:

- A dual-temperament system with 18 pipes per octave in which case the preferred option would, in my opinion, be the system devised by Kristian Wegscheider, as previously described.
- A single temperament for the whole organ, in the event that a dual-temperament system proves impossible for whatever (technical or financial) reason. In this case I would like to propose the system developed by Henri Legros with two pure Thirds and six pure Fifths. In addition, there are, in my opinion, a number of other candidates: the tuning A used at Stanford University with the previously mentioned "correction" applied to the note C#, and Legros's other tuning system with three pure Thirds as applied at St Cosmae in Stade.

[§181] Finally, a number of practical observations. In order to be able to practically assess the merits of a temperament, one can now make use of the Hauptwerk software which allows the programming of various tunings and which offers a sound of reasonable quality. In the event that one should wish to experiment with already-installed pipework, one could use the method devised by P.Y. Asselin: in the case of cut-to-length flue pipes, one can attach rolled-up pieces of thick paper (or thin card) to the top of the pipe with an elastic band. Using this method, the pipework is first tuned a semitone lower and then gradually raised by sliding the pieces of paper or card, which act as paper tuning slides. The desired temperament can then be heard. This method can only be applied to flue pipes without tuning scrolls.
A question which arises from this discussion is whether someone can claim copyright on a specific temperament. I do not believe so as, throughout musical history, hundreds of tuning systems are described including some which appear again and again... I do consider it important, however, that the organbuilder shares the details of the applied tuning system with the client rather than hiding it behind a veil of secrecy.

[§182] A final remark: when an organ is delivered, it is important to measure the temperament as this process can throw up differences from the "announced" tuning system. This assessment is not really intended as a "test" of the organbuilder's skills (the ear is always, in principle at least, correct...) but, in the event of subsequent discussion, such an assessment can contribute to the solving of potential differences of opinion.[3]

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Abstract

There are four options regarding the idea to equip the New Baroque Organ the Orgelpark is planning to build to "switch" between two temperaments. Option 1 is to combine equal temperament with an unequal temperament, such as Neidhardt III for instance. Two problems present themselves: Neidhardt III and equal temperament share only a few notes, whereas the differences between these two temperaments are very small. Because of this I designed four variants to equal temperament, varying the values of major Thirds. Although these variants contain three "better" Thirds, they also present a lot of "bad" Thirds and an irregular circle of Fifths, compromising the usefulness of these temperaments. Option 2, combining a well-tempered and a meantone variant, offers much better possibilities. Indeed, such systems are actually applied at Stanford University Memorial Church, Omaha Cathedral (both USA), Allstedt and Dresden-Wilschdorf (both Germany). Especially the German solutions, developed by organ builder Kristian Wegscheider, appear promising: Wegscheider combines a 1/5 Pythagorean Comma well-tempered temperament and a variant to the "classic" 1/4 Syntonic Comma meantone temperament. As requiring more than 18 notes per octave (as Pasi's organ in Omaha) would make it more sensible to build two separate organs, a third option might be to equip the organ's manuals each with a different temperament. Equipping the organ with "just" one temperament might therefore be a worthwhile option after all as well. With regard to this fourth option I would opt for the temperament designed by Henri Legros (1921-1982), which includes six pure Fifths, five meantone Fifths and one slightly large Fifth (705,4 Cents on E flat). The curve plotted by the Thirds includes two pure major Thirds (on C and G) and describes an elegant gradient as one progresses towards the more distant keys.

Jos de Bie

Jos de Bie, general practitioner by profession, has always had an interest in keyboard temperament issues. Wondering how to understand the multitude of both historic and contemporary theories in the field do actually fit the way

temperaments function in the practice of organ builders, he received his PhD in 2003 at the Ghent University. The title of his dissertation (only available in Dutch) is: Historische orgelstemmingen – Theorie & Realiteit. The book consists of two impressive volumes including easy-to-read tables, designed by De Bie himself, as he considered the complexity of many theories and the way they are published prevents organ builders and musicians to apply temperaments in a sensible way. De Bie published about temperament issues on several ocsasions.

V

Koos van de Linde - What Temperament should the New Baroque Organ at the Orgelpark have?

[§183] The temperament to be applied to the new organ proposed for the Orgelpark, which will have spring chests inspired by the Oberwerk chest of the Huß/Schnitger-organ at Stade, St Cosmae, will inevitably form a compromise between the practice in North Germany around 1675 and the requirements placed on the instrument by its contemporary setting. In order to achieve the most convincing compromise, it will be necessary to examine both the historical and modern contexts in more detail.

The historical situation from the instrumental perspective

[§184] On the basis of my own investigations, I agree with Ibo Ortgies[1] that meantone temperament must have been the common tuning system in North Germany.[2] I will refer in general, therefore, to his arguments and conclusions whilst restricting myself to some additions and refinements.

The term "Praetorianisch"

[§185] I agree with Ortgies that the term "Praetorianisch" was apparently used to refer to quarter Comma meantone[3] temperament. There is no evidence that the concept of "Praetorianisch" included different, modified

1 Ibo Ortgies. *Die Praxis der Orgelstimmung in Norddeutschland im 17. Und 18. Jahrhundert und ihr Verhältnis zur zeitgenössischen Musikpraxis*. Göteborg: GOArt, 2004 (PhD)..

2 I also share his view that Buxtehude's organs were not retuned during his lifetime.

3 I will restrict the use of "meantone" to regular 1/4 Comma temperament in which a major second is exactly half of a pure major Third. The expanded definition of "meantone" as a temperament where the major second is half of a major Third even when that Third is impure, does not, in my opinion, make sense, because even Pythagorean tuning meets this criterion.

temperaments or even systems such as regular 1/5 or 1/6 Comma tunings. The theory, put forward by some authors,[4] that Praetorius himself is describing a modification (or even modifications) and that the term could therefore encompass departures from the classic 1/4 Comma tuning, is not convincing. Praetorius' suggestion of making the Fifths f#-c# and c#-g#[5] less impure than the others (but still flat!) seems to imply a departure from normal practice: in the preceding paragraph he nevertheless mentions that c#, f# and g# should be tuned as pure Thirds to a, d and e.[6] In any case, this slight modification is highly ineffective. The possibility of modifying e flat to become a more or less usable d# (the main goal of most modifications) is not mentioned at all and the systematic widening of Thirds is described as the practice of "the ancients" and thus apparently outdated.

[§186] Georg Preus' treatise *Grund-Regeln von der Structur und den Requisitis einer untadelhaften Orgel* (1729)[7] undoubtedly belongs amongst the most important sources concerning the temperament of the organs in Hamburg at that moment. He mentions that they were tuned "Praetorianisch". However, his description of this temperament is, in certain aspects, incompatible with pure meantone, which would discount the idea of "Praetorianisch" and meantone being synonymous. It is important, therefore, to examine the stated disadvantages of praetorian tuning in more detail. The problematic points are as follows:

4 Harald Vogel. "The organs and their tuning". Nicolaus Bruhns, Sämtliche Orgelwerke. Wiesbaden/Leipzig/Paris: Breitkopf & Härtel, [2008]. 63-67/65. Greta Moens-Haenen. "Ibo Ortgies: Die Praxis der Orgelstimmung in Norddeutschland im 17. und 18. Jahrhundert und ihr Verhältnis zur zeitgenössischen Musikpraxis". Svensk tidskrift för musikforskning 2005. Online: http://www.musikforskning.se/stm/STM2005/STM2005Recensioner.pdf [143-145/144]. 63-67.

5 And only these Fifths. His modification was much more restricted than many of the incomplete citations in certain publications suggest.

6 Michael Praetorius. Syntagmatis Musici Tomus Secundus. De Organographia. Kassel: Bärenreiter, 1968 (facs. of Wolfenbüttel: Elias Holwein, 1619). 155.

7 See Ortgies 2007 [cf. note 1]. 73.

- Both d#-g and b-d# are listed among the "bad" Thirds
- The system should contain some (i.e. more than one) bad Fifths

[§187] Could these observations point to a modification? The first observation definitely does not. A bad b-d# always produces an acceptable e flat-g and vice versa.[8] There is even a small range where both Thirds are usable. Therefore, characterising both as bad fails to describe a realistic situation. The second observation, on the other hand, could in itself indicate an ill-thought-out modification of meantone temperament. However, even when disregarding d#-g, four bad Thirds remain, so that no real advantage is gained to balance the additional bad Fifth(s). It is hard to imagine, therefore, that such a modification would have been applied.

[§188] Like Werckmeister, Preus was opposed to praetorian temperament and, with Werckmeister's caricature of it[9] in mind, one wonders if Preus too tried to exaggerate its disadvantages, although in a more subtle way. For any readers who do not realise that d# in organbuilding stands, in fact, for both d# and e flat, d#-g looks similar to the really bad c#-f, f#-b and g#-c.[10] The phrasing "some bad Fifths" could describe the realistic situation of inaccurate tuning, which causes some Fifths to exceed the critical impurity of

8 Criteria for acceptable deviations:

- Fifth: ≤ 1/4 Pythagorean Comma flat or sharp
- Major Third: ≤ 1 Syntonic Comma sharp
- Minor Third ≤ 1 Syntonic Comma flat

Even slight positive deviations in minor Thirds, and negative deviations in major Thirds are hardly tolerable.

9 See the table between the pages 38 and 39 in Andreas Werckmeister. *Musicalische Temperatur, oder Deutlicher und warer mathematischer Unterricht, wie man durch Anweisung des Monochordi ein Clavier, sonderlich die Orgel-Werke, Positive, Regale, Spinetten und dergleichen wol temperirt stimmen könne.* Utrecht: Diapason Press, 1983 (facs. of Quedlinburg: Calvisius 1691): "[...] die Unrichtige Temperatur da alle quinten 1/4 Comma schweben [...]".

10 That d#-g could be intended as d#-g#, being in fact e flat-g# and therefore a Third (Ortgies 2007 [cf. note 1]. 73) seems less likely. In this case Preus should have designated c#-f, f#-b and g#-c as Fourths (which they are in both notation and sound!).

-1/4 Comma, thus concealing the fact that this is not inherent to the tuning system itself.
[§189] Whether deliberate or not, Preus' partly erroneous description of the "Praetorian" temperament does not indicate any modification and, therefore, does not imply that such a departure from pure meantone temperament was synonymously referred to under the "Praetorian" label.

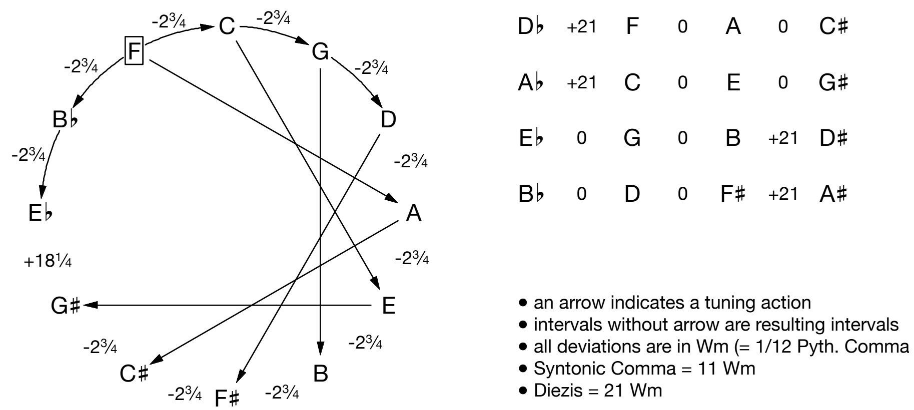
The "Scheidemann-Praetorius Temperatur"
[§190] An anonymous report concerning the organ inspection in Bremen's Liebfrauenkirche after its rebuilding by Johann Siburch in 1641 contains Siburch's own responses to the (lost) remarks made by the organ's examiners Heinrich Scheidemann and Jacob Praetorius. The following point is often interpreted as a tuning instruction from the experts to Siburch:[11]

> 5. will Er [Siburch] versuchen so viehl immer müghligen dieselbe Quinta zwischen a. vnd d. Rein zustimmen vnd die tertien zu schärffen vnd die schwebende Quinta an andere Öhrter zu bringen." [[...] He will try to tune the Fifth between d and a as pure as possible and to sharpen the Thirds and to move the beating Fifth to other places]

[§191] I agree with Ortgies that this text is not to be interpreted as a tuning instruction. In view of the considerable amount of work involved, an examination is not the right moment to express personal wishes concerning the temperament. If the organ had been well tuned in a common system, it is very likely that Siburch would have resisted the wishes of the experts, just as Gloger did in Harbung in 1710.[12] Moreover, the remark about the Fifth d-a is quite illogical in the context of a modified meantone temperament. It is, therefore, much more likely that the temperament was not properly set and that the Fifth d-a in particular was too impure.

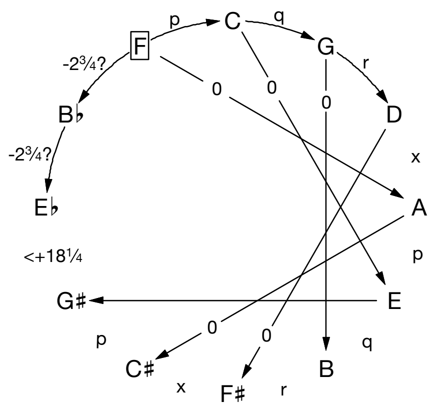
11 For the first time in Harald Vogel. "Tuning and Temperament in the North German School of the Seventeenth and Eighteenth Centuries." In Fenner Douglass, Charles B. Fisk, Owen Jander, Barbara Owen, eds., Charles Brenton Fisk, Organ Builder: Essays in His Honor. Easthampton: Westfield Center for Early Keyboard Studies, 1986. 237–266/241-242 and 254.
12 Ortgies [cf. note 1]. 72-73.

[§192] However, with the rejection of the idea of a "Scheidemann-Praetorius" tuning, the possibility of a common practice of modifying meantone temperament should not be automatically excluded. How otherwise could the remarks about sharpening the Thirds be explained? It seems plausible that the temperament resulting from the described procedure contains one or more sharpened Thirds. But was this really a well-planned modification of meantone temperament?
[§193] It is important to realise that, in the best case, the report describes the way in which Siburch intended to fulfil the requests of the experts and that his solutions were not necessarily theirs. Moreover, its author was probably neither a professional musician nor an organbuilder, so there is no guarantee that the text correctly reflects Siburch's technical remarks.
[§194] The only real criticism which can be levelled at the tuning described in this text is the fact that the Fifth d-a was unacceptably (i.e. more than ca. 1/4 Comma) flat. Let us assume that Siburch intended to tune meantone according to the first method described by Michael Praetorius.[13] A schematic reproduction:



13 Praetorius 1619 [cf. note 6]. 153.

[§195] If one leaves (one or more of) the Fifths f-c, c-g and g-d too pure and ignores the built-in checks, the Fifth d-a would indeed become rather flat:



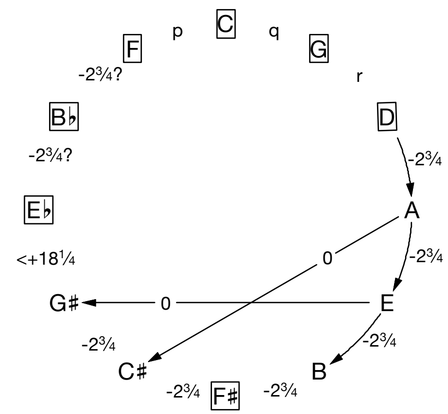
D♭	+21	F	0	A	0	C#
A♭	+21	C	0	E	0	G#
E♭	≥0	G	0	B	≤+21	D#
B♭	≥0	D	0	F#	≤+21	A#

- p, q and r probably all purer than -2¾, but in any case p+q+r > -8
- x < -3 (too flat)

[§196] In this case the d is too high, resulting in the Fifth d-a beating too strongly. This also results in an unacceptable f#-c#, but that Fifth is seldom used as part of a chord in modal music and therefore has no significant consequences. Because b flat is tuned as a meantone Fifth below f (and not as a pure Third below d), b flat–f is independent of d-a. The only consequence of a correct b flat–f will be that b flat–d is a little sharp, but still very good[14]. If e flat–b flat is tuned more or less correctly, e flat–g will be a little sharp too. After retuning d-a in the correct way (-1/4 Comma), Siburch had also to retune a-e and e-b. Otherwise, one of them would have become too flat. Since a and e had become higher, the originally pure Thirds a-c# and e-g# had become flat, which is unacceptable for a major Third. Therefore, both had to be "sharpened" to make them pure again. Finally, the sharpening of the notes a, e and b resulted in slightly sharp Thirds f-a, c-e and g-b, but these were still very good (in any case no worse than b flat–d, which prompted no criticism), so there was no need to correct them too, if perfection was not Siburch's goal.

14 In the worst case comparable with f-a in Werckmeister III, but probably better.

[§197] This procedure leads to a pure meantone temperament in the range d-a-e-b-f#-c#-g#, slightly milder beating Fifths in the range f-c-g-d and acceptable (-1/4 Comma or better) Fifths b flat–f and e flat–b flat. The result is an unintentional "modified" meantone temperament with slightly sharpened Thirds (e flat–g, b-flat–d, f-a, c-e and g-b):



D♭	<+21	F	>0	A	0	C#
A♭	<+21	C	>0	E	0	G#
E♭	≥0	G	>0	B	<+21	D#
B♭	≥0	D	0	F#	≤+21	A#

- notes in boxes have not been changed

[§198] In this way, instead of retuning almost all notes except f, Siburch had only to correct five notes per octave, achievable in all cases by shortening the pipes and thus saving several weeks of work!

[§199] One aspect remains problematic however, namely the mention of the Fifth, d-a, being tuned "as pure as possible". Did Siburch mean as pure as possible without making the other Fifths between a and f# unacceptably bad, i.e. exactly -1/4 Syntonic Comma and not more? The fact that "as possible" doesn't make sense in the context of an action as simple as tuning an interval perfectly pure, seems to justify this interpretation. What remains problematic, however, is the moving of the beating Fifth, d-a, to other places. Was this a somewhat clumsy manner of expressing the moving of the redundant impurity in this Fifth to "other places" (the chain of Fifths a-e, e-b and b-f#, which had previously been too pure)?

[§200] Although the text is too obscure (and is probably an inaccurate report of Siburch's original remarks) to allow an unambiguous interpretation, the above scenario proves at least that there is no reason to conclude that it implies a common practice of modifying meantone temperament.

Werckmeister's remarks about sharp Thirds in ancient organs
[§201] In the handwritten treatise *Kurtzer Unterricht, wie man ein Clavier stimen und wohl temperiren könne* (1715),[15] Andreas Werckmeister mentions that most major Thirds in ancient organs were tuned sharp. Rather than indicating a parallel use of pure and modified meantone temperaments in the period around 1700 (as Vogel concludes[16]) this seems to point to the pre-meantone practice described by Praetorius. One can imagine that, just like the delayed acceptance of well-tempered tunings in Werckmeister's time, meantone took its time to be generally accepted by organbuilders. Given the fact that Schnitger's organ in Bremen Dom still was tuned in meantone more than 80 years after Werckmeister's *Musicalische Temperatur*, it is very easy to imagine that Werckmeister himself was familiar with some organs (re)built around 1620, which had still not been retuned in meantone.

Chromatic compass and meantone temperament
[§202] That a compass like that of the manuals in Hamburg, St Nicolai (Schnitger, 1682, played by Vincent Lübeck) should indicate a well-tempered tuning[17] is not only unproven (as Ortgies correctly remarks[18]) but simply incorrect. Compasses including the E-flat, F# and G# were already common in late 16th century English instruments and these notes appear in virginalist works by composers as early as William Byrd which are entirely playable in meantone temperament.
[§203] That the pedal C# is of little use in meantone temperament may be correct in modal music, but this is certainly not the case in tonal compositions. Passages such as bars 119-123 in Buxtehude's *Praeludium* in g (BuWV 149) and bars 42-43 of Bach's *Fantasia* in g (BWV 542) are not necessarily unplayable in meantone temperament and bars 90-94 of Bruhns'

15 Cited in Harald Vogel. "Die Ästhetik der Mikrotöne. Die Doppelstimmung für die Woehl-Orgel in der Flensburger St. Nikolai-Kirche". Die große Orgel von St. Nikolai in Flensburg. Flensburg: Ev. Luth. Kirchengemeinde St.-Nikolai, 2009. 73-74.
16 Vogel 2009 [cf. note 15]. 74.
17 Wolfram Syré. Vincent Lübeck. Leben und Werk. Frankfurt am Main: Peter Lang, 2000. 316.
18 Ortgies 2007 [cf. note 1]. 71.

e minor *Praeludium* could also occur in a g major composition. That g minor might be "meantone-compatible" is proven by Lübeck's own *Praeludium* in that key. That the same is true for g major, is shown by Buxtehude's *Praeludium* in G (BuxWV 147; with one semiquaver d# in bar 21) and Lübeck's *Praeludium* in G (the d#s in bars 13, 71 and 72 hardly disturb the ear. One could even imagine that the last two pedal notes of bar 62 and the first two of bar 63 could have been an octave lower if composed specifically for the organ of St Nicolai.

The historical situation from the perspective of composition
[§204] Clearly, there is a discrepancy between the practice of organ tuning and composition in the second half of 17th, and, in Northern Germany, during at least the first half of 18th century. One has the impression that composers simply ignored the limitations of the vast majority of the organs, taking for granted that an unproblematic execution of their compositions was limited to the pedal clavichord. When playing the organ, one had either to transpose or to accept the bad intervals resulting from remote keys. That this second possibility has to be taken more seriously than modern listeners imagine, is suggested by more than one contemporary source. Some examples:

- In his *Propositiones mathematico-musicae* (1666) Otto Gibelius, a well known theorist still highly esteemed by Mattheson, complains about composers spoiling their compositions by composing them in remote keys: "Und die Wahrheit zu sagen/ so verderben offtmals die Autores durch diese übermässige Transpositiones ihre eigene Compositionen und Melodien, […] die sonst keines Weges zu verachten […]" ["To be honest, through these excessive transpositions, composers often spoil their own compositions and melodies […] that would otherwise be not at all disagreeable"].[19]

19 Franz Josef Ratte. *Die Temperatur der Clavierinstrumente. Quellenstudien zu den theoretischen Grundlagen und praktischen Anwendungen von der Antike bis ins 17. Jahrhundert*. Kassel: Bärenreiter, 1991. 300.

- In his *Cribum Musicum* (1700), Werckmeister criticises organists, who accept the bad Thirds inherent in meantone temperament as "good enough": "[…] Nun habe ich etliche Organisten gekannt, /denen diese falsche Tertia so angenehm gewesen / als die anderen reineren; wenn man sie hat corrigiren wollen / so haben sie gesagt / sie wäre gut genung / es wäre ihre Natur also / sie könnte nicht anders seyn. […]" ["[…] I have known several organists, who liked these bad Thirds as much as the other, purer ones. Should one want to correct these [bad Thirds], the organists said they were good enough, it is in their nature, that's how they are […]"].[20]
- As late as 1739 the Dutch musician Quirinus van Blankenburg provides, in his *Elementa Musica*, a tuning instruction for meantone temperament and criticises Werckmeister's and Neidhardt's "crying against the wolves". He continues: "[…] want deze klanken mogten zo huilen men zou ze niet gebruiken: maar wy bevinden dagelyks het tegendeel in 't nemen van quid pro quo op clavecimbelen die volgens 't bovenstaande temperament, (dat nu in 't gemeen gebruik is) gesteld zyn ["[…] because if these sounds / harmonies really did howl so much, one wouldn't use them: but we experience the contrary every day in the accepting of the quid pro quo [e.g. e flat being the same note as d#] on harpsichords, tuned according to the above temperament [= meantone] (which is general practice now) […]"].[21]

[§205] Although not necessarily representative of German practice, Van Blankenburg's opinion seems to be in line with what we know from Gibelius and Werckmeister. He seems to have been one of those organists criticised by Werckmeister and as a composer he repeatedly uses d# and a# even though in his time subsemitones had already disappeared from Dutch organs. Van

20 Andreas Werckmeister. *Cribum musicum oder musicalisches Sieb, darinnen einige Mängel eineshalb gelehrten Componisten vorgestellt*. Hildesheim: Georg Olms, 1970 (facs. of Quedlinburg/Leipzig: Calvisius, 1700). 32..

21 Quirinus van Blankenburg. *Elementa musica, of nieuw licht tot het welverstaan van de musiec en de bas continuo.* Amsterdam: Frits Knuf, 1972 (facs. of The Hague: Laurens Berkoske, 1739). 114.

Blankenburg's practice also demonstrates the methodologically dubious nature of trying to reconstruct the temperament of a composer's organ on the basis of the keys used in his compositions. It also demonstrates the disagreement among the organists about whom Gloger complains in 1710.[22] This impasse would have been one of the main factors permitting organ builders to resist certain tuning systems for so long.

[§206] The above-cited sources show that there was no sharp demarcation between works playable in meantone temperament and works that were not. Once one is aware of this,[23] it becomes clear that there seems not to have been any real discrepancy between the practice of organ builders and the requirements of written-down organ music, at least up to the generation of Tunder and Weckmann. This discrepancy arises on a large scale with the works of Dietrich Buxtehude. In the period relevant to the type of organ planned for the Orgelpark, therefore, the temperament of the vast majority of organs was no longer compatible with the requirements of composed music.

The temperament of the Orgelpark's new spring chest organ

[§207] In an ideal scenario, the temperament of the new instrument should meet the following criteria.

It should come suitably close to the temperament historically used in this organ type

[§208] If a new organ in a historic style is intended to give the best possible impression of the way the original instruments sounded and of the effect of music played on it, applying the temperament used in the original instruments is an important part of the copying process. In the case of a North German organ of about 1675 the temperament in question was usually meantone.

22 Ortgies 2007 [cf. note 1]. 72-73.

23 The ignoring of this fact seems to be one of the justifications for the theory of modified meantone temperaments in 17th and early 18th century organs.

It should meet the requirements imposed by the historic repertoire for which this organ will be constructed

[§209] As we have seen, from the point of view of the repertoire the situation is more complicated than it is from the perspective of the instrument. Whereas in the 17th century improvisation played a much more important role than the playing of composed music, in our time playing the notated repertoire is the main reason for building organs in historic styles. Many of the compositions we want to play require either a kind of well-tempered tuning or more than 12 notes in the octave.[24] If one also wants to play the works of J.S. Bach, which is one of the objectives stated by the Orgelpark for the new organ, the situation becomes even more complicated. Whereas the vast majority of North German repertoire would, theoretically, be playable in a circulating meantone temperament with 12 notes in the octave, many of Bach's compositions are, apparently, essentially designed for a well-tempered tuning. A temperament of this type would, therefore, represent the best option for the requirements of literature.

The tuning system should also fulfil the requirements of the organ's planned contemporary use

[§210] Essential to the new organ's intended use as a "modern" instrument, is the possibility of making all kinds of synthetic mutation combinations available[25] in a whole series of keys.[26] To blend well, the intervals between the component notes should not be too far out of tune[27] whilst, in order to

24 We have to be aware that from the historical point of view this possibility would have been anachronistic in the period around 1675. It is in precisely this period that sub-semitones were being removed from old organs.

25 The term "synthetic mutation combination" will be used for combinations composed of pipes drawn from unison and octave ranks.

26 E.g. if one has C-g0-e1-a flat1-b flat1-d2 on C, then one wants to have C#-g#0-e#1-a1-b1-d#2 on C# etc.

27 In order to obtain blending to the degree that one does not experience the constituents of the sound as separate components, the criteria for impurity in temperaments are not strict enough.

have a consistent colour on each adjacent note, the deviation from the pure intervals should not be too marked.

[§211] If one has only 12 notes in the octave, equal temperament would fulfil the second criterion perfectly and the first as far as the Fourths and Fifths are concerned. The Thirds are not optimal, producing the typical "Hammond-effect", but this can partly be solved by using pipes from the tierce ranks.[28] Good Seventh harmonics are also not possible.

[§212] Unequal well-tempered tunings fundamentally meet the second criterion less well than equal temperament does. The extent to which they meet the first criterion differs from note to note. In Werckmeister III for example, the major Third on c is very good whereas the Fifth is too impure to blend well. On c# the opposite is true, on f both are good and on b the Third is not very good and the Fifth worse still.

[§213] Regular open temperaments (such as 1/4, 1/5 and 1/6 Comma "meantone") meet the second criterion well as long as the Wolf Fifth and the bad Thirds are not involved. In spite of the perfect major Thirds, meantone fails to meet the first criterion very well because of the rather poor Fifths.[29] In this respect, 1/6 Comma meantone in particular is preferable because the impurity is rather well spread over the Fifths on the one side and the major Thirds on the other. However, with only eight good Thirds and eleven good Fifths in the octave, these tunings are not practical as long as there are only 12 notes in the octave.

[§214] From the above it will be clear that compromises are inevitable. The nature of these compromises depends on the number of keys in the octave.

[§215] If there are only the normal 12 keys in the octave, a truly satisfactory compromise is barely possible. A temperament like Barnes will be the best choice if the organ's use in baroque music takes priority. This temperament

28 For combinations with low synthetic tierce ranks in the lowest octaves, this solution will not be possible because the lowest tierce-rank is 1 3/5'.

29 This plays a particular role in building combinations of accumulated Fifths (like c-g-d1-a1), in which the use of pipes from Fifth-ranks is no longer a solution.

does not dull the characteristics of the different keys too much, but nevertheless still contains two pythagorean major and three pythagorean minor Thirds which fail to blend well in mutation combinations. For the organ's modern usage, a temperament like Neidhardt 1729 may be more preferable.[30] This tuning has no problematic intervals at all but is, as a result, rather colourless for baroque music, especially that of Buxtehude, Lübeck and Bruhns. In both cases earlier music would lose much of its tension and colour.

More than 12 pipes per octave

[§216] A much more satisfying result could be achieved if the organ were provided with more than 12 notes in the octave. Here one has the choice between a dual temperament system and the extension of a specific regular temperament. In practice, a dual temperament system requires at least 17 pipes in the octave to provide an acceptable modified meantone-like temperament on the one hand and a well-tempered tuning on the other. Whereas most of the older repertoire benefits from such a situation, the disadvantages for modern usage are comparable with those of a Barnes temperament.

[§217] Therefore, if one were to decide to extend the octave by five notes, an extended regular 1/6 Comma temperament with a spiral of Fifths from d flat to e# could be seriously considered. Instead of switching between two temperaments, it would then be possible to switch between the enharmonic pairs d flat/c#, a flat/g#, e flat/d#, b flat/a# and f/e# independently.[31] This would have the following advantages:

1 This temperament preserves in a reduced form all the characteristics typical for meantone. There is a clear and systematic difference between diatonic and chromatic semitones (better than in modified meantone). The good Thirds still have a positive effect on the organ's sound and the better Fifths partially compensate for the fact that the major Thirds are no longer pure. For tonal music this temperament has the advantage of considerably better dominant 7th chords.

2 For modern uses there are 16 notes with good Fifths, 16 notes with good Fourths, 13 notes with good major Thirds, 14 with good minor Thirds and seven with good harmonic Sevenths (the f# major scale). All good intervals of the same kind also enjoy the same degree of (im)purity.

3 Because of the regularly structured steps (chromatic tones and enharmonic steps), microtones can be used in a systematic way. In general this solution provides interesting possibilities in the context of microtonal music.

[§218] The disadvantages of this solution when compared to a dual temperament system are as follows:

1 Not every note has its enharmonic equivalent. As a consequence, and especially in certain works of Bach, one is sometimes obliged to accept bad Thirds (which are still considerably less annoying than in meantone temperament).

2 Some Bach works which were essentially conceived for a well-tempered tuning, especially those with a sad or dramatic affect, tend to become too "beautiful". In terms of intervallic purity, the same flattening of key characteristics occurs as experienced in equal temperament.

3 Certain passages, especially in works by Bach, demand rapid switching between enharmonic notes.

4 In tonal music, enharmonic modulations are theoretically not possible (in practice it depends entirely on the context[32]).

5 For modern usage, a true atonality is less practical. There is no neutral chromatic or whole tone scale. Theoretically there is also

30 With -1/6 Comma Fifths on c, d and g and -1/12 Comma Fifths on c#, d#, f#, a, b flat and b.

31 In switching from a flat to a sharp one could also manipulate the preceding pairs to switch at the same time (e.g. switching c#, f# and g# when switching from e flat to d#). This would be a practical solution, but would complicate the mechanism.

32 Even for the modulations in Bach's g minor Fantasia there is always a solution.

no perfectly static augmented triad, nor a completely neutral tritone (however, in practice, both are neutral enough).

6 A mechanical device for switching between the enharmonic notes is more complicated and takes more space than a device for switching between two temperaments.

[§219] The choice of an e# instead of a g flat is based on an analysis of the works of Buxtehude, Bruhns, Lübeck and J.S. Bach. In no work of Lübeck and Bruhns does a g flat occur, in BuxWV 149 only in a single dramatic moment and in BuxWV 159 only once as part of an incomplete diminished 7th chord. Even in the works of Bach, the rare occurrences of this note seldom cause problems. The only rather harsh exceptions are bars 429-432 of the *Toccata* in F (BWV 540) and bars 90-92 of the *Praeludium* in c (BWV 546).
[§220] On the other side of the spiral of Fifths there are remarkably few problems. Relatively frequent b#s are only found in Buxtehude's E major and f# minor praeludia and Bach's *Praeludium et Fuga* in E major (BWV 566). In both works of Buxtehude, the "bad" notes mostly pass by rather discreetly or are part of a "durezze" section. BWV 566, on the other hand, is unplayable in this tuning. Here, the only partial solution is to play the C major version BWV 566a.
[§221] The only important work of Bach which really suffers from a non well-tempered tuning, is the g minor *Fantasia* (BWV 542). Surprisingly, the main problem lies not in the enharmonic modulations, but in the successive g flat, c flat and f flat in bars 33-34. Here, limits are exceeded in a way which occurs nowhere else. However, being the only really problematic work, this seems acceptable to me for an instrument which is not conceived in the first instance as a "Bach organ".

Summary

[§222] The historically correct temperament of North German organs around 1675 (unmodified meantone) even then no longer reflected the requirements of contemporary organ compositions. Therefore, if the new organ were to have 12 notes in the octave, it must to be tuned in a well-tempered tuning. For reasons of blending in synthetic mutation combinations for modern use, this temperament should not contain Fifths which beat too strongly, nor too many pythagorean Thirds.

[§223] In the case of a tuning with 17 notes in the octave (the minimum for dual temperament systems) an extended regular 1/6 Comma temperature would make it possible to have a temperament with meantone-like properties which, at the same time, fulfils the requirements of literature up to the generation of Bruhns and Lübeck and, although not optimal, is also appropriate for playing almost all the works of J.S. Bach. For use as a modern instrument this tuning would offer additional possibilities in the context of microtonal music.

Abstract

The historically correct temperament of North German organs around 1675 is 1/4 Comma meantone. 17th and 18th century sources such as the treatises published by Preus and Werckmeister and temperament arguments like the one following the examination of the new organ in Bremen's Liebfrauenkirche, document how temperament was discussed in the days of Schnitger and his contemporaries. What we know, however, is that unmodified meantone even then no longer reflected the requirements of contemporary organ compositions. Therefore, if the new organ at the Orgelpark were to have 12 notes in the octave, it must to be tuned in a well-tempered tuning. For reasons of blending notes at will, which will be possible when playing the organ by the digital console, this temperament should not contain Fifths which beat too strongly, nor too many pythagorean Thirds.
In the case of a tuning with 17 notes in the octave (the minimum for dual temperament systems) an extended regular 1/6 Comma temperature would make it possible to have a temperament with meantone-like properties which, at the same time, fulfils the requirements of literature up to the generation of

Bruhns and Lübeck and, although not optimal, is also appropriate for playing almost all the works of J.S. Bach. For use as a modern instrument this tuning would offer additional possibilities in the context of microtonal music.

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VI

Ibo Ortgies - Johann Sebastian Bach and Temperament

Here, leading the way through every walk and cross walk, and scarcely allowing them an interval to utter the praises he asked for, every view was pointed out with a minuteness which left beauty entirely behind ~ Jane Austen (Pride and Prejudice, 1813)

[§224] The subject of temperament is boundless - not least in connection with Bach. The acoustical, and the mathematical backgrounds are basically not difficult to understand. Temperament is an area where history and music, instruments, acoustics, musical interpretation, theory and practice all meet and where one of these aspects cannot be considered meaningful separated from the others.

[§225] Descriptions of various historical tunings and temperaments are available in a plethora of publications and on the Internet today - often involving theoretical designs of which hardly anything accurate is known including whether they were applied in practice and to which degree of precision.

[§226] Besides pertinent articles of recent encyclopaedias,[1] a comprehensive article by Mark Lindley offers an unsurpassed overview of the theory and practice of tuning and temperament.[2] Numerous publications on tuning and

1 Wolfgang Auhagen. “Stimmung und Temperatur”. In Ludwig Finscher, ed., Die Musik in Geschichte und Gegenwart: Allgemeine Enzyklopädie der Musik VIII (Sachteil). Kassel: Bärenreiter, 1998. 1831-1847. Mark Lindley. “Temperaments.” Grove Music Online. Oxford Music Online. Oxford University Press. Website accessed April 25, 2014: http://www.oxfordmusiconline.com/subscriber/article/grove/music/27643. Mark Lindley. “Tuning.” Grove Music Online. Oxford Music Online. Oxford University Press. Website accessed February 23, 2014: http://www.oxfordmusiconline.com/subscriber/article/grove/music/28578.

2 Mark Lindley. “Stimmung und Temperatur”. In Frieder Zaminer, ed., Geschichte der temperament or Bach and temperament are being collected in two excellent bibliographies on the Internet.[3]

[§227] It is not the aim of the present paper to repeat familiar details or merely to provide tables with mathematically exact values of individual, historical temperament designs. Instead, I am using some rather basic questions as a point of departure and will try to give answers, when the source situations allow for it:

- Which sources about musical temperament are relevant in regard to Bach's practice and what can be learned from them?
- How detailed, plausible or credible is the relevant information?
- Do we know whether Bach had any influence on the choice of temperament in organ projects? If so, to what extent and what was his advice?
- To what extent do extant contemporary reports, expert opinions and historical instruments allow us to reconstruct the temperament in organ building of Bach's age?
- What role did the temperament of instruments with fixed pitches (like keyboards) play in interaction with free-intonating instruments and singers?

Sources

[§228] The source situation with respect to Bach's relation to tuning and temperament is quite poor. No statements by Bach are known, that would allow tangible conclusions about the temperaments he preferred.

[§229] The report drawn up on the occasion of the examination of the newly-built, great organ of the Church of Our Lady (Marienkirche) in Halle (1716) is the only document from his lifetime and signed by Bach, in which a vague

Musiktheorie VI. Darmstadt: Wissenschaftliche Buchgesellschaft, 1987. 109-332.

3 Manuel Op de Coul, Brian McLaren, Franck Jedrzejewski et. al. Tuning & temperament bibliography. Website accessed February 23, 2014: http://www.huygens-fokker.org/docs/bibliography.html. Yo Tomita. Bach Bibliography. Website accessed on February 23, 2014: http://www.music.qub.ac.uk/tomita/bachbib/).

expression about a certain temperament occurs. The document is in the hand of Johann Kuhnau (1660-1722), while Bach acted together with Christian Friedrich Rolle (1681-1751) as co-signers. The report mentions a "still passable good temperament once shown to us by him [the organ builder Christoph Cuntius (1676-1722)]" which the organ builder had promised to set ("einzurichten").[4] The word "passabel" would be most likely understood to be "tolerable", or "acceptable", which is far from a welcoming or even enthusiastic praise of the temperament.[5] [§230] When considering historical organ examination reports, not least the comment above, one should assume that the instrument was ready to be examined in every respect, including voicing and temperament. Usually the temperament set by the organ builder was accepted, but the examiners demanded occasionally corrections.[6] Major changes in temperament were only requested if the organ builder had been unable to set the temperament reasonably correctly. If possible, however, one avoided a complete re-tempering and tried to manage with improvements because otherwise the organ would again not have been available to use for some time - perhaps even for several months.

[§231] In 1716, the three examiners Kuhnau, Bach, and Rolle found the organ of Our Lady in Halle "still to be quite impure" ("noch ziemlich unrein"). Whether the "still passable good temperament" refers to a correction or to a different, new temperament remains unclear. Firstly, the considerable amount of work associated with a complete new tuning would have been unusual, and secondly it should be noted that it was about a proposal by the

4 "von ihm [dem Orgelbauer Christoph Cuntius] uns einmahl gezeigten noch passablen guten Temperatur": Werner Neumann and Hans-Joachim Schultze, eds. *Schriftstücke von der Hand Johann Sebastian Bachs*. Leipzig: VEB Deutscher Verlag für Musik / Kassel: Bärenreiter, 1963. Bach-Dokumente I / nr. 85: 159.

5 A discussion of the term „passabel" is to be found in Johan Norrback. A passable and good temperament. A new methodology for studying tuning and temperament in organ music. Göteborg: Göteborg University, Department of Musicology 2002 (Skrifter från Musikvetenskapliga institutionen, Göteborgs universitet LXX; PhD Dissertation). 74-75.

6 See the last two paragraphs under the heading "Andreas Werckmeister".

organ builder, not by the examiners or even by Bach alone. The examiners judged the proposal (by the organ builder) only as "still passable", which is not exactly equivalent to a perfect agreement. Finally, nothing can be determined with safety, whether the wording resonates a jointly, consensual expression of all examiners or whether it was only the lowest common denominator of their possibly different views. Also hidden in the mist of history remains to what extent Bach exerted influence on this particular wording.

[§232] As a consequence, one cannot gain any knowledge about Bach's ideas on tuning from this document. Neither have Bach's family and his circle of colleagues and students left statements that allow an assessment of his temperament predilections with sufficient precision.

[§233] Only two years before Bach's death, Georg Andreas Sorge (1703-1778) wrote that Bach did not appreciate meantone diminished fourths, which were said to be unusable as major thirds, in organs: "In those four bad triads, however, a rough, wild, or, as Mr. Kapellmeister Bach in Leipzig says, a barbaric character is contained, which is unbearable to a good ear."[7] There is little doubt that Bach would have applied this statement to stringed keyboard instruments as well, and his aversion to this property of meantone temperament recurs to my knowledge without exception in descriptions of the temperament by professional organists and theorists of the German-speaking world in the 17th and 18th Century. Only an amateur like Friedrich Suppig (no later than 1690-after 1722) was apparently willing to allow the usage of meantone "wolf" intervals and chords.[8]

7 "In denen 4. schlimmen Triadibus aber ist ein rauhes, wildes, oder, wie Herr Capellmeister Bach in Leipzig redet, ein barbarisches Wesen enthalten, welches einem guten Gehör unerträglich fällt." Georg Andreas Sorge. *Gespräch zwischen einem Musico theoretico und einem Studioso musices von der Prätorianischen, Printz*zischen, Werckmeisterischen, Neidhardtischen und Silbermannischen Temperatur, wie auch [...] dem neuen Systemate [...] Telemanns zur Beförderung reiner Harmonie. Lobenstein: Sorge, 1748. 28 (= Werner Neumann and Hans-Joachim Schultze, eds. *Fremdschriftliche und gedruckte Dokumente zur Lebensgeschichte Johann Sebastian Bachs 1685-1750*. Kassel: Bärenreiter, 1969. Bach-Dokumente II / nr. 575: 450.

8 Friedrich Suppig. *Labyrinthus Musicus. Calculus Musicus*. Facsimile of the manuscripts: Paris,

[§234] It is, on the contrary, obvious why the proponents of new ways of tempering did not emphasize positive qualities of the old tone system that they rejected. Beyond this self-evident matter Sorge's statement does not allow further conclusions about Bach's preferences.

Stringed Keyboard Instruments

[§235] The information that relates directly or indirectly to Bach's way of tuning is more general and refers mainly to stringed keyboard instruments. In the first part of his instruction on playing the Clavier first published in 1753, Carl Philipp Emanuel Bach (1714-1788) speaks only in general terms about temperament, without any reference to his father. C. P. E. Bach's ambiguous wording leaves open whether he meant a close-to-equal or even an equal temperament.

[§236] On the one hand C.P.E. Bach requests, that from "most of the fifths should be taken [away] particularly so much of their greatest purity",[9] "that the ear hardly doesn't notice and one can play well in all twenty-four keys".[10] This would correspond to a well-tempered tuning on the basis of unequally tuned fifths (i.e. at least two different sizes of fifths). In the same section, on the other hand, a somewhat unclearly worded statement can be found, that can be interpreted as an indication of equal temperament: "On the Clavier one plays equally pure in all twenty-four keys and nota bene, multi-voice textures, albeit the harmony will at once uncover the slightest impurity because of the proportions. In this new way of tempering we have advanced further than before, although the old temperament was such that some keys were purer [than the others] as you even now encounter in many instruments." With some probability "old temperament" refers to meantone

Bibliothèque du Conservatoire, Rés. F 211-212 (Dated Dresden, 24 June 1722) (Tuning and Temperament Library 3), ed. by R. A. Rasch, Utrecht: Diapason Press, 1990. 170 and 173.

9 "meisten Quinten besonders so viel von ihrer größten Reinigkeit": Carl Philipp Emanuel Bach. Versuch über die wahre Art, das Clavier zu spielen. Berlin: "In Verlegung des Auctoris", 1753 (facs. ed. by L. Hoffmann-Erbrecht, Leipzig: Breitkopf & Härtel, 1982). ^{4}1978. 10.

10 "daß es das Gehör kaum mercket und man alle vier und zwantzig Ton-Arten gut brauchen kan." C.P.E. Bach 1753 [cf. note 9]. 10.

temperament, which was denoted by its opponents as "old" since the first releases of new, i.e. well-tempered proposals (beginning with Andreas Werckmeister's [1645-1706] publications in 1681). However, well into the 18th Century and beyond, the proponents of new temperaments had to admit that meantone temperament was still applied. Also it should be noted that C. P. E. Bach combines the "old temperament" with the more general term "instruments" and not with the organ as one might expect at first.[11]

[§237] In the obituary (1754) for J. S. Bach, written by C.P.E. Bach, Johann Friedrich Agricola (1720-1774), and others, the authors write, albeit delimiting the reference to Bach's tuning of harpsichords: "Concerning tuning he knew how to temper the harpsichords so purely and correctly that all keys sounded nice and pleasing. He knew of no tonalities, which should have been avoided due to impure tuning."[12] About twenty years later, in 1774, C.P.E. Bach broadened the wording to cover "instruments": "To tune his instruments as well as the entire orchestra was his main focus. No one could tune and quill his instruments to his satisfaction".[13]

[§238] In contrast to the organ, stringed keyboard instruments could be retuned much more easily, a fact that authors of the 17th and 18th Centuries sometimes mentioned as self-evident. Therefore, it is to be expected that tunings of such instruments as the unfretted clavichord, the

11 "Auf dem Claviere spielet man aus allen vier und zwantzig Ton-Arten gleich rein und welches wohl zu mercken vollstimmig, ohngeachtet die Harmonie wegen der Verhältnisse die geringste Unreinigkeit sogleich entdecket. Durch diese neue Art zu temperieren sind wir weiter gekommen als vor dem, obschon die alte Temperatur so beschaffen war, daß einige Ton-Arten reiner waren als man noch jetzo bey vielen Instrumenten antrift." C.P.E. Bach 1753 [cf. note 9]. 10.

12 "Die Clavicymbale wußte er, | in der Stimmung, so rein und richtig zu temperiren, daß alle Tonarten schön und gefällig klangen. Er wußte, von keinen Tonarten, die man, wegen unreiner Stimmung, hätte vermeiden müssen.": Hans-Joachim Schultze, ed. *Dokumente zum Nachwirken Johann Sebastian Bachs 1750-1800*. Kassel: Bärenreiter, 1972. Bach-Dokumente III / nr. 666: 88.

13 "Das reine stimmen seiner Instrumente so wohl, als des ganzen Orchestres war sein vornehmstes Augenmerck. Niemand konnte ihm seine Instrumente zu Dancke stimmen u. bekielen." Bach-Dokumente III [cf. note 12] /nr. 801: 285.

spinet, the harpsichords, and the fortepiano cannot be traced. But even fretted clavichords, in which the exact position of individual tangents is an essential factor of the temperament, allow only limited conclusions about their original temperament, because the temperament could be modified by subsequent manipulation of the tangents. The organ builder Johann Heinrich Gloger (ca. 1670-1732) compared the difficulty of setting the temperament of an organ with the easier tuning of clavichords: setting the temperament of an organ "requires more than if one tunes a string on a clavichord, which I can stretch as I want, or [manipulating] the tangents, which can be flexed [i.e. tuned] sometimes upwards and sometimes downwards."[14] Therefore, modern analysis of historical temperaments of fretted clavichords is meaningful only by including a certain margin for interpretation. But, conclusions about Bach's temperament choices cannot be drawn anyway, because there are no extant fretted clavichords from Bach's household.

[§239] Only in 1776, long after Bach's death, Friedrich Wilhelm Marpurg provided some detailed evidence about Bach's choice of temperament for stringed keyboard instruments:

> Do not come to me here with any expert from the previous centuries in which one made three keys ugly to gain one quite beautiful [key], or do not tell me, that this or that musician or amateur has approved a third, which is off by 81:80 [...] I can counter these dubious experts with a more substantial [expert], if it has to be argued with experts at all. Mr. [Johann Philipp] Kirnberger [1721-1783] himself has told me and others repeatedly how the famous Johann Sebastian Bach, during the time when he [Kirnberger] enjoyed the latter's [Bach's] musical education, obliged him to tune his Clavier, and that this master expressly requested of him to make [i. e. tune] all major thirds sharp. In a temperament in which all major thirds are sharp, i. e. in which they all are larger than

14 "[...] und da gehöret mehr zu, alß wen man eine saite auff einem Clavicordio Stimet, welche ich dehnen kan wie ich will, oder auch an denen Tangenten so bald auff bald niederwertz gebogen werden können." Liselotte Selle. "Die Orgelbauerfamilie Gloger (1)". Acta Organologica IV (1970). 59-118 / 92-94.

pure, a pure major third is not possible, and as soon as there is not one pure major third [in a temperament], a major third increased by 81:80 is impossible, too. Mr. Capellmeister Johann Sebastian Bach, who had not an ear blighted by an evil calculus, must thusly have felt that a major third increased by 81:80 is a heinous interval. Why do you think the same has titled his [set of] preludes and fugues composed in all 24 keys The Art of Temperament?[15]

[§240] This quote is often used as evidence that Bach used a temperament which met the conditions mentioned by Marpurg: All major thirds would have been larger than pure, the third C-E would be larger than pure, and the worst major thirds would be smaller than the Pythagorean major third. [§241] These conditions are met by a multitude of well-tempered tunings, but also by equal temperament. Marpurg's quotation, however, must be assessed in the light of the temperament history of the 18th Century. During this century very different well-tempered tunings were developed and proposed, but equal temperament was most often favoured by authors including Marpurg (and for example G. A. Sorge and Johann Mattheson before him).[16] Kirnberger, however, referred to by Marpurg, derived his temperament proposals (actually more like variations of Pythagorean tuning) from the ratios of pure intonation. Kirnberger studied with Bach between 1739 and 1741, and alluded in his composition treatise *Die Kunst des reinen Satzes in der Musik* (1774/1779) to Bach's authority – which does not necessarily mean that Kirnberger's temperament proposals go back to Bach himself. Probably it was welcome to Marpurg to counter Kirnberger's ideas about temperament with an argument that (according to Marpurg!) Kirnberger himself had conveyed as originating from Bach. But doubts remain: whether Marpurg really quoted Kirnberger correctly cannot be determined, and it remains unclear as well, whether Kirnberger would have agreed with Marpurg's presentation of the matter. But even if Marpurg's quote correctly reflects Bach's fundamental ideas about sharpened thirds, some degree of caution should still be applied:

- Strictly speaking the description must apply only to the period (1739-1741) in which Kirnberger studied with Bach. Before or after that period Bach might have generally favoured other principles of temperament than those provided by Marpurg. Bach might have applied a flexible tuning practice, which took various circumstances into account, for example: the particular instrument, the particular composition, the acoustics of the room, and other conditions of the performance.
- Marpurg's statement about which Pythagorean major thirds do not occur in temperaments where all thirds are larger than pure is wrong: on the contrary, temperaments by Andreas Werckmeister (1645-1706) and Johann Philipp Bendeler (1654-1709) prove that Pythagorean thirds can occur in such temperaments and that Marpurg could have known that.[17]

15 "Man komme mir hier mit keiner Auctorität aus den vorigen Jahrhunderten, wo man drey Tonarten häßlich machte, um eine einzige recht schöne zu erhalten; oder man erzähle mir nicht, daß dieser oder jener Musiker oder Liebhaber eine um 81:80 veränderte Terz approbiret hat [...] Ich kann diesen zweydeutigen Auctoritäten eine etwas gewichtigere entgegensetzen, wenn mit Auctoritäten gestritten werden soll. Der Hr. [Johann Philipp] Kirnberger selbst hat mir und andern mehrmal erzählet, wie der berühmte Joh. Seb. Bach ihm, währender Zeit seines von demselben genoßnen musikalischen Unterrichts, die Stimmung seines Claviers übertragen, und wie dieser Meister ausdrücklich von ihm verlanget, alle großen Terzen scharf zu machen. In einer Temperatur, wo alle großen Terzen scharf, d. i. wo sie alle über sich schweben sollen, kann unmöglich eine reine große Terz statt finden, und sobald keine reine große Terz statt findet, so ist auch keine um 81:80 erhöhte große Terz möglich. Der Hr. Capellmeister Joh. Seb. Bach, welcher nicht ein durch bösen Calcul verdorbnes Ohr hatte, mußte also empfunden haben, daß eine um 81:80 erhöhte große Terz ein abscheuliches Intervall ist. Warum hatte derselbe wohl seine aus allen 24 Tönen gesetzte Präludien und Fugen die Kunst der Temperatur betitelt?" Bach-Dokumente III [cf. note 12] /nr. 815: 304.

16 Franz-Josef Ratte. "Temperatur". In Michael Heinemann, ed., Das Bach-Lexikon. Laaber: Laaber Verlag, 2000. 506-514 / 513.

17 Werckmeister III, recommended by its author for use in remote keys and not infrequently in use today, is such a temperament: C-E, the best major third, is ca. 4 cents larger than pure. F#-

- Marpurg's aforementioned error raises doubts about his assumption that Bach "therefore" ("also") "must have" ("muß [...] haben") perceived a Pythagorean third as intolerable. Georg Andreas Sorge had indeed already in Bach's lifetime declared the Pythagorean third to be unsatisfactory. Sorge preferred that no major third be greater than pure by 5/12 of the (lesser) diesis. The lesser diesis is 41 cents, 5/12 of which result in 17.1 cents. This equates to a maximum size of the major third of 403,4 Cents. Sorge ruled out even more a major third of 406,8 Cents, i.e. larger than pure by half a diesis (= 20,5 cents).[18] In 1744 he had already called the even larger Pythagorean major third (407,8 Cents), which originates from the sequence of four pure fifths, "horribly sharp".[19] He emphasized: "Yes. Note! That no third can be off [i.e. sharper than pure by] a whole comma, because that would be a little too much, although Werckmeister and Bendeler have deemed it advisable."[20] These remarks, however, were not made in the context of Bach's ideas, and therefore these sources cannot provide sufficiently precise information about the latter's preferences (at any given time in his career) of the sizes of major thirds.
- Finally, a title of "Art of temperament" for the Wohltemperirte Clavier, ascribed to Bach himself by Marpurg, cannot be authenticated through any other source, neither through Bach-autographs, nor copies of the WTC, nor other sources from Bach's environment.

[§242] Although no concrete statements about temperament issues are known from Bach, other sources from his environment do not either permit an accurate determination of his temperament practice or wishes. That Bach was highly interested in the topic itself is amply demonstrated by the very title of the

C#, D flat-F, and A flat-C are all Pythagorean major thirds.

18 Sorge 1748 [cf. note 7]. 47.

19 "greulich scharf": Georg Andreas Sorge. Anweisung zur Stimmung und Temperatur sowohl der Orgelwerke, als auch anderer Instrumente, sonderlich aber des Claviers. Hamburg: Piscator, 1744. 27.

20 "Ja. Merke! daß keine Tertie ein ganzes comma schweben dürfte, denn das wäre ein wenig zu viel, ob es wohl Werckmeister und Bendeler vor thunlich erachtet haben." Sorge 1744 [cf. note 19]. 39.

Wohltemperirte Clavier. His interest in this matter, however, appears not to be unique if one sees the gradual raise of interest in the topic among musicians since the end of the 17th Century.

Bach partly newly composed the Preludes and Fugues for the Wohltemperirte Clavier, and partly assembled it using older compositions (where applicable after a revision). Some pieces were even transposed especially for this collection. It should be noted, that Bach did not provide any concrete indication about which type of temperament he regarded appropriate for the WTC. One possible explanation is that he wanted to leave that decision entirely to the discretion of the player. Arguments from history, palaeography, as well as tuning and temperament systematics have refuted modern hypotheses, which have been formulated with claims to absoluteness and according to which a concrete temperament favoured by Bach can be derived from graphical elements either from the ornaments on the autograph title page of the manuscript from 1722 or in his seal of the same year.[21]

[§243] It can be assumed that Bach favoured during the greater part of his life a temperament that allows the flexible use of all keys. The modulations in individual movements of early works already range so far that only well-

21 Herbert Anton Kellner's claim to derive Bach's temperament from Bach's seal (Herbert Anton Kellner. *Wie stimme ich selbst mein Cembalo?* Frankfurt am Main: Bochinsky/Das Musikinstrument, [3]1986) has been shown by Ulf Wellner's description of the original seal to rest on insufficient analysis. Kellner did not derive his ideas from the original seal, but from a modern, widely reproduced, simplified version (Ulf Wellner. "Ein unbekanntes Möbelstückaus dem Besitz Johann Sebastian Bachs". *Bach-Jahrbuch* 2009. 214–225 / 221-222). Bradley Lehman's more recent claim (Bradley Lehman. "Bach's extraordinary temperament: our Rosetta Stone". *Early Music* XXXIII (2005). XXXIII/1: 3-23 / XXXIII/2: 211-231), that the squiggles on the title page of the Wohltemperirte Clavier represent a specific temperament by Bach, is not corroborated by any evidence (Mark Lindley and Ibo Ortgies. "Bach-Style Keyboard Tuning". *Early Music* XXXIV (2006). 613-623). And even if Lehman were right, that the squiggles denote a temperament, the temperament cannot be specified as evidenced by numerous concurring and contradicting interpretations that have appeared since Lehman's article. In contrast to the famous Rosetta stone Bach's autograph does not carry along the "translation" for deciphering a specific temperament.

tempered tunings can be considered, and indeed, those which approach equal temperament are not ruled out. Let us recall here, for example, the *Toccata* in F sharp minor (BWV 910) and the *Fantasia* in A minor (BWV 922).

Andreas Werckmeister

[§244] It was probably Andreas Werckmeister, who in his *Orgel-Probe* (1681) defined the term "well-tempered" to denote the group of temperaments, which allow playing in all keys in the first place. Werckmeister regarded himself as the discoverer of such temperaments; at least he was the first to describe them. In this way he was seen in the 18th century as an innovator in the field of temperament, whose writings were widely received and to which one could refer if necessary. Leopold Mozart (1719-1787) wrote, for example, about the temperament of keyboard instruments in his violin treatise in 1756: "One must therefore temper, that is: one must take something from a consonance, but add something to the other; one has to divide them [the intervals] so [much] and let the tones beat relative to one another [so much], that they are all tolerable to the ear. And this is called the temperament. It would take too long to list all the mathematical efforts of many learned men here. One needs only to read Sauver [Sauveur], Bümler, Henfling, Werckmeister and Neidhardt."[22] Like almost all German-speaking authors until well into the second half of the 18th Century, Mozart strictly distinguishes the pure intonation of free intonating instruments from temperament.

[§245] During the 1670s Werckmeister apparently had the opportunity to test his temperaments (or at least one of them) in a short-lived project in an organ built by Zacharias Thayßner (? -1705). In his *Orgel-Probe* from 1681

22 "Man muß demnach temperiren, das ist: man muß einer Consonanze etwas nehmen, der andern aber etwas beylegen; man muß sie so eintheilen und die Töne so gegeneinander schweben lassen, daß sie alle dem Gehör erträglich werden. Und dieß heißt man die Temperatur. Es wäre zu weitläuftig alle die mathematischen Bemühungen vieler gelehrten Männer hier anzufuhren. Man lese nur den Sauver [Sauveur], den Bümler, Henfling, Werkmeister und Neidhardt." Leopold Mozart. *Versuch einer gründlichen Violinschule*. Augsburg: "In Verlag des Verfassers", 1756 (facs. ed. by G. Moens-Haenen. Kassel etc.: Bärenreiter, 1995). 47.

Werckmeister mentioned Thayßner's organ in Quedlinburg Cathedral, in which Werckmeister claimed one of his newly proposed temperaments had been implemented. An organ, at which an organist and other musicians could have heard for the first time a well-tempered tuning, would have been the best conceivable advertisement for Werckmeister's new ideas, but this is in all his writings the only reference to the existence of one of his temperaments in any organ; in the revised and extended reissue of the Orgel-Probe (1698) he did not publish this information again.[23] In his description of Christoph Cuntius's 1704 rebuilding of the organ in Gröningen (near Magdeburg) Werckmeister took note of the organ's retuning to a temperament that was no longer meantone temperament since it was designed so that "you can play all the pieces on it and make music according to today's way of transposing."[24] However, Werckmeister does not describe this new temperament in detail and does not refer to one of his proposed temperaments or his publications concerning this matter.

[§246] About the same time, in the 1670s, the organ builder Christoph Förner (1609/1610-ca 1678) ventured to modify meantone temperament which was ubiquitous:[25] There is a possible link to Werckmeister, again: according to a note in a funeral sermon, Trost's father, Johann Caspar Trost the Elder (before 1600-1676), is said to have even taught Andreas Werckmeister.[26] Werckmeister himself, however, had to admit that standard meantone temperament based on pure major thirds and fifths smaller by one-quarter of the syntonic comma was widespread.[27] In practice it will have been in many cases an

23 Ibo Ortgies. "A meeting of two temperaments: Andreas Werckmeister and Arp Schnitger". In Thomas Donahue, ed., *Music and ist questions: Essays in honor of Peter Williams*. Richmond (Va./USA): Organ Historical Society Press, 2007. 75-99 / 85-86.

24 "man nach heutiger Arth zu transponiren alle Stücke darauf spielen und musiciren kan." Andreas Werckmeister. *Organum Gruningense redivivum* […]. Quedlinburg/Aschersleben: Gottlob Ernst Struntz, 1705; reprint ed. by P. Smets, Mainz: Rheingold-Verlag, 1932. 22.

25 Felix Friedrich. "Christian Förner und die Orgel der Schloßkirche zu Weißenfels". Acta Organologica 27 (2001). 21-108.

26 Friedrich 2001 [cf. note 25]. 24.

27 Andreas Werckmeister. *Orgel-Probe*. Quedlinburg: Theodor Philipp Calvisius, 1681. 27.

approximation: there was enough work for organ builders, and inept, poorly educated or sloppy organ builders will have tuned standard meantone temperament, the "common" ("algemeine") temperament, insufficiently precisely. Accordingly, organ examiners regularly criticized until well into the 18th Century the temperament of organs, i.e. the execution of meantone temperament, which was not usually specified (not even in organ contracts), most likely because it was "common" ("algemein"). Information on a "new" or even "equal" temperament is seldom to be found, only very slowly increasing before the 1720s/1730s in Central and Northern Germany, while from the mid-18th Century, references to a "new" or "equal" temperament can be found in organ contracts in a conspicuously increasing number.[28]

The Trost organ in Altenburg

[§247] Despite these very early attempts, perhaps even the very first attempts in German organ building to introduce temperaments that increased the number of usable keys ultimately to the full range of modulation, meantone temperament remained the choice of the day in Northern and Central Germany up to ca. 1720 in both newly built and old organs – actually it took longer in Northern Germany than in Central Germany and that includes the big cities like Hamburg. Overall, the transition from meantone practice towards well-tempered tunings took place only gradually; one cannot speak of a big change towards well-tempered tunings in organ building.

Werckmeister. *Musicalische Temperatur, oder Deutlicher und warer mathematischer Unterricht, wie man durch Anweisung des Monochordi ein Clavier, sonderlich die Orgel-Werke, Positive, Regale, Spinetten und dergleichen wol temperirt stimmen könne*. Utrecht: Diapason Press, 1983 (facs. of Quedlinburg: Th.P. Calvisius 1691). VI. Werckmeister. *Erweiterte und verbesserte Orgel-Probe*. Quedlinburg: Th.P. Calvisius 1698 (Documenta Musicologica 1/XXX; facs. ed. by D.-R. Moser. Kassel etc.: Bärenreiter, 1970. 79.

28 Cf. Ibo Ortgies. *Die Praxis der Orgelstimmung in Norddeutschland im 17. und 18. Jahrhundert und ihr Verhältnis zur zeitgenössischen Musikpraxis*. Göteborg: Göteborgs universitet, Dept. of Musicology and Film Studies, 2004 (PhD dissertation). Online: http://ibo.ortgies.googlepages.com/phd-dissertationiboortgies (accessed on April 25, 2014). Chapter 4.

In Thuringia and Saxony, the trend gained momentum at the latest from the 1720s onwards, but by no means do all documents which are presented as supporting well-tempered tuning practice actually back up the claim. Among the dubious indications for a well-tempered tuning counts a remark about Bach playing daring modulations on the Altenburg Castle organ in 1739, initially suggesting an originally well-tempered tuning of the instrument. The organ had been completed only recently by Tobias Heinrich Gottfried Trost (approx. 1681-1759), a nephew of the aforementioned organist Johann Caspar Trost the Younger:

> It is better that the organist yield to the singing congregation than prevail over it. Few can direct the congregation as the old Bach, who once played the Credo on the great organ in Altenburg [first] in D minor, but for the second verse raised the congregation to E flat minor and for the third verse even to E minor. But only a Johann Sebastian Bach could do that and an organ like Altenburg, which we all neither are nor have.[29]

[§248] However, the original temperament of the Altenburg organ is not known, even if the extant papers from the time of the construction of the organ document an in-depth discussion of various alternative well-tempered schemes that even included equal temperament. The sparse concrete evidence of the temperament actually tuned by Trost seems to point most likely to modified meantone. Only a few decades after Bach's visit, in 1768, the temperament of the organ was described as "offensive" ("anstößig")

29 "Das Nachgeben des Organisten gegen die singende Gemeinde ist besser als sich durchsetzen [zu] wollen. Nur wenige vermögen die Gemeinde so zu lenken wie der alte Bach, der auf der großen Orgel in Altenburg einmal den Glauben aus D-moll spielte, beim zweiten Vers aber die Gemeinde ins Es-moll hob, und beim dritten gar ins E-moll. Das konnte aber auch nur ein Bach und eine Orgel in Altenburg. Das sind und haben wir nicht alle." Quoted from Felix Friedrich. "Johann Sebastian Bach und die Trost-Orgel zu Altenburg. Bemerkungen zur Problematik der 'Bach-Orgel' ". *Bach-Jahrbuch* 1983. 101-107 / 103. For Friedrich's sources see footnote 31.

and got changed into a "good and equal" ("gute und gleichschwebende") temperament![30] A retuning, however, would have been unnecessary if the organ had been tuned in 1739 according to one of the rather equalized temperaments (Johann Georg Neidhardt's [ca. 1680-1739] among them) discussed before the organ had been finished, or even to a practical approximation of equal temperament.

[§249] The quote about Bach's playing in Altenburg therefore does not allow the initially plausible conclusion that the Trost organ must have been in a well-tempered tuning. Furthermore, some 60 years had passed between the communication referred to above, and the report of the unknown author that was not published until 1798,[31] when equal temperament was no longer unusual, at least in the larger cities. If one considers that the image of Bach underwent an idealisation around 1800, the quote loses conclusiveness in relation to the actual conditions of the Altenburg organ in 1739. It remains unclear how a modified meantone temperament would have allowed even a Bach to play one of the Credo verses in E flat minor, without creating jarring discord. In this case, the statements of the sources are at least contradictory.

[§250] Considering the keyboard compasses of organs, often having a short octave (CDEFGA–) in manuals and pedal, and with the upper limit at c1 in the pedal, especially in Saxony and Thuringia,[32] the performance of many of Bach's keyboard works on many organs of his time would be impossible, or at best regions have been realized, not only in terms of temperament. The rendering of such works may in some cases have been possible by way of transposition (cf. *Praeludium et Fuga* in E major, BWV 566) or by serious interventions in the substance of the composition (such a practice is not reported in any source).

30 See Felix Friedrich's diligent analysis of the relevant documents and his historical account in Felix Friedrich. *Der Orgelbauer Heinrich Gottfried Trost. Leben, Werk, Leistung*. Leipzig: VEB Deutscher Verlag für Musik, 1989. 49–52.

31 "Etwas über Orgelspielen": published in *Dresdner Gelehrten Anzeigen auf das Jahr 1798* (no. 7) as well as in *Leipziger Intelligenz-Blatt* (1798), no. 23.

32 Not to mention much older organs, quite a few of which had not yet been rebuilt or enlarged even after Bach's death and some of which still possessed the manual compass FGA-g^2a^2, common until around 1600.

[§251] Documentation of organ temperaments either from archival material or by documentation of the organ in its present condition is itself an important task. As the example from Altenburg shows, the information from archival documentation may not match the information derived from other historical sources. And documentation of the present condition of an organ is inevitably difficult to interpret, since organs have consistently experienced significant changes in the course of their history, not only concerning the temperament but also pitch and voicing and other parameters, which may affect each other heavily.

[§252] As a rule of thumb for most instruments it can be considered that an original meantone or unequal temperament has been retuned to equal temperament at some time between about 1750 and about 1900, the pitch has been changed possibly later in the 19th or even in the early 20th Century close to modern concert pitch (a1 = ca. 440 Hz). In organs in *Chorton* for example pipes might have been moved up by a semitone, and the voicing adapted to later sound ideals.

[§253] But if the sources are scarce and descriptions of the work actually performed are lacking, it is impossible to exactly determine a once existing temperament. Other issues that play a significant role in the identification of the original temperament also remain open, for example, whether the original wind pressure can be determined at least approximately and correctly, and what exactly the status of pipe voicing originally might have been. Even in the rare, favourable cases, in which meticulous research and documentation of the pipework makes one think of having detected traces of a former temperament, the results are at best approximations to the status after the last documented change. If such a change is not documented, however, – and archival information is of course, more often than not, fragmentary – it must remain uncertain as to how an extant organ was originally tuned.

Organs in Leipzig in Bach's Time

[§254] One of the main tasks of organs in the service consisted of the accompaniment of polyphonic concerted music, i.e. mixed vocal-instrumental ensemble music. This task resulted in a constant problem because of the different pitches and temperaments: in Bach's time, organs in Northern and Central Germany, as well as brass and cornetti were tuned usually in the (common) *Chorton*, i.e. about a whole tone above (common) *Cammerton* (at ca. 415 Hz), which again was used mainly by singers and most instrumentalists. Occasionally organs could be found tuned in high Chorton, which was a semitone higher than the common Chorton. In contrast, the French woodwind instruments were sometimes in a low Cammerton tuned a semitone below the common Cammerton.[33]

[§255] In many of Bach's cantatas and passions, instruments were deployed that played in two or three different pitches (common Chorton, common Cammerton, and may be low Cammerton). Accordingly, individual instrumental parts were recorded in transposition, i.e. in different keys. Difficulties arose for the organist (playing in common Chorton): for example, a piece in C minor (as notated for singers and melodic instruments) had to be accompanied on the organ in B flat minor.

[§256] Regarding the organ in the church of Divi Blasii in Mühlhausen and its rebuild in 1691 by the organ builder Johann Friedrich Wender (1655-1729) Markus Rathey put forward a hypothesis that the rebuild in 1691 led to an unequal temperament according to one of Werckmeister's schemes, identified by Rathey as "Werckmeister III".[34] It must be noted, however, that, as Rathey himself states, evidence for Wender's tuning practice is lacking. Neither can an assumption be substantiated, that Wender no longer used meantone. Finally, Rathey emphasizes biographical and chronological relationships between Wender, Werckmeister and the Mühlhausen-organist Johann Georg Ahle (1651-1706), as well as relations between Werckmeister's and Ahle's writings. Rathey's observations are certainly valuable in themselves, but they do not allow a concrete conclusion as to the temperament of the Mühlhausen organ, and Ahle does not indicate anything about the organ's temperament in his writings. In this context it may be not without significance that even Bach's Mühlhausen-cantatas *Aus der Tiefen rufe ich, Herr, zu dir* (BWV 131), *Gott ist mein König* (BWV 71), and *Christ lag in Todesbanden* (BWV 4)[35] as well, all can be performed on an organ tuned in modified meantone temperament. Bach's proposal from early 1708,[36] however, to have the organ rebuilt by Wender again, was carried out only after he left Mühlhausen in mid 1708!

[§257] Yet, the fact that the organs in Arnstadt, Weimar, and Leipzig, which were used in performances of such music, still were tuned in meantone temperament appears less plausible in view of the range of keys Bach uses, even if one concedes that the continuo player could leave out a number of unusable notes here and there. Klaus Gernhardt found, however, that there is nothing known about the temperament of the organs in Leipzig, and those who were in charge of deciding on new temperaments were the church elders of the respective churches by way of the organists, not Bach as the Cantor and director musices (leader of the church music).[37] Bach could possibly express his professional opinion, but whether he really could impose his own ideas, remains uncertain. Whether he was involved in the planning of work on the Leipzig organs cannot be deduced from extant documents, and at best one might arrive at an educated guess.

33 Cf. Bruce Haynes. "Stimmton". In Ludwig Finscher, ed., *Die Musik in Geschichte und Gegenwart: Allgemeine Enzyklopädie der Musik* VIII (Sachteil). Kassel: Bärenreiter, 1998. 1813-1831. Haynes. "Western pitch standards". In Bruce Haynes and Peter Cooke, "Pitch." Grove Music Online. Oxford Music Online. Oxford University Press: http://www.oxfordmusiconline.com/subscriber/article/grove/music/40883. Website accessed April 25, 2014.

34 Markus Rathey. "Die Temperierung der Divi Blasii-Orgel in Mühlhausen". *Bach-Jahrbuch* 2001. 163-172.

35 BWV 4 is commonly assumed to have been composed in Mühlhausen.

36 Bach-Dokumente I [cf. note 4] 83: 152–155.

37 Klaus Gernhardt. "Über den Umgang mit den Quellen – unter besonderer Berücksichtigung der Stimmungsart bei Johann Sebastian Bach". In Martin Kares, ed., *Forschung und Dokumentation bei Orgelprojekten. Grundlage für Restaurierung und Stilkopie. Bericht über die Tagung der VOD vom 21.-24. Mai 2002 in Naumburg/Saale.* Karlsruhe: Vereinigung der Orgelsachverständigen Deutschlands, 2003. 16-19 / 18.

[§258] Below follows an overview about the known work on organs of the main churches in Leipzig during Bach's tenure: [38]

- St Thomas, 1723, large organ, repair by David Apitsch.
- St Thomas, 1725, large organ, repair by Johann Scheibe (ca. 1675–1748).
- St Nicolai, 1725, large organ, renovation at a price of 600 Reichsthaler by Johann Scheibe. Thayßner had built the great organ of the Nicolai church only 30 years earlier, in 1693-1694. That Thayßner had temporarily worked jointly with Werckmeister in the field of temperament does not provide any clue about the possible temperament of the Leipzig organ. The subsequent dissociation of Werckmeister from Thayßner and in this case also the great renovation of Thayßner's rather recent Nicolai organ by Scheibe only three decades later speak rather against Thayßner whose qualities as an organ builder do not always appear in a favourable light. A new organ replaced Thayßner's organ in 1786.
- St Thomas, 1727 / 1728, small organ, overhaul by Zacharias Hildebrandt (1688–1757). The "small" organ had 21 stops on three (!) manuals and pedal. In 1740/1741 it was examined by Scheibe, its value assessed, and removed.
- St Thomas, 1730, large organ; Johann Scheibe cleans the organ, revoices it and reinforces the stop Posaunenbass.
- St Nicolai, 1737 and 1738, large organ, tuning and maintenance by Zacharias Hildebrandt.
- St Nicolai, 1739–1740, large organ, smaller repairs by Zacharias Hildebrandt.
- St Nicolai, 1740–1743, large organ, regular tuning and maintenance by Zacharias Hildebrandt.
- St Johannis, 1742–1743, new organ, II/22 by Johann Scheibe. Organ examination with participation of Bach in the autumn of 1743.

38 The following information on the Leipzig organs according to Ulrich Dähnert. *Historische Orgeln in Sachsen. Ein Orgelinventar.* Frankfurt am Main: Verlag Das Musikinstrument, 1980 (70. Veröffentlichung der Gesellschaft der Orgelfreunde, ed. by H. Henkel). 177–187.

- St Thomas, 1747, large organ, cleaning and overhaul by Johann Scheibe, supervised by Bach and the Thomas organist Johann Gottlieb Görner (1697–1778).
- St Nicolai, 1750–1751, large organ, overhaul by Zacharias Hildebrandt and his son Johann Gottfried Hildebrandt (1724/1725–1775).

[§259] Nothing is known today about any tuning-related work carried out before Bach began his tenure in Leipzig in 1723 or at the organs not listed above. The old organ of St Paul's Church had already been repaired, rebuilt, and extended in 1711-1716 by Johann Scheibe. The type of temperament is not mentioned in the examination report from December 17, 1717, signed by Bach in his capacity as a court music director in Köthen:[39]
[§260] Only Bach's signature is autograph. The examination took place in the presence of various dignitaries, including the current and the former Rector of the University and the organist of St John's church, Michael Steinert, and an organ builder Johann Christoph Lieberoth. The latter is probably identical with an organ builder with the first name Lorenz, who is mentioned in the Anderen Beylage zu dem Leipziger Jahrbuche, aufs Jahr 1718.[40] Both were witnesses on the part of Scheibe.
[§261] Neither is anything known concerning the tuning work of the old organ of St Paul's Church during Bach's tenure in Leipzig. In 1721/1722 Scheibe overhauled the New Church's Donat organ (1703-1704), which had to make way for a new organ in 1847 after various renovations.
[§262] All this information can be interpreted arbitrarily, and only with considerable reluctance might one conclude from Bach's extant concerted church music that the organs at St Nicholas, St Thomas and the New Church already had or were provided with non-meantone temperaments during his tenure. Examination reports or other evidence apparently do not exist. Concerning new organs or alterations of existing organs in the years before

39 Bach-Dokumente I [cf. note 4] 87: 163-168.

40 Cf. Bach-Dokumente I [cf. note 4] 87: 163-168 / commentary on p. 166. As an organ consultant acted the organ builder Adam Horatio Casparini (1676-1745) from Breslau (today Wrocław), Silesia.

Bach's taking office in Leipzig, Klaus Gernhardt referred to the well-known letter that Bach's predecessor, Johann Kuhnau, wrote in 1717 to Johann Mattheson (1681-1764): "But as much Neidhardt's temperament seems to be most appropriate according to reason, I still have not found any organ of a skilled instrument maker or organ builder, which is set up accordingly."[41]

[§263] Kuhnau's statement about not having heard any organ in Neidhardt's temperament is unlikely to refer only to a specific temperament proposal (possibly equal temperament), but might refer to realisations of other well-tempered tunings as well. It must remain an open question as to whether the occupational title "instrument maker" can be also interpreted meaningfully so that Kuhnau claims not to have encountered such well-tempered schemes in „instruments" as well, i.e. in stringed keyboard instruments (possibly and particularly fretted clavichords which could not quite as easily be retuned as unfretted clavichords or harpsichords)[42].

[§264] Scheibe's organ in St Paul's in Leipzig appears therefore not to have been tuned according to one of Neidhardt's schemes, perhaps not even in a different "still passable" (cf. §229-231) well-tempered tuning.

[§265] In 1746 Zacharias Hildebrandt completed the large rebuild of the organ at St Wenzel in Naumburg. Bach came to examine the organ together with Gottfried Silbermann (1683-1753). Bach had worked closely with Hildebrandt in Leipzig. It is conceivable that Bach was involved from the beginning in the planning of the Naumburg rebuild. In any case, even if Bach did not propose the temperament, he seems, after all, to have accepted the temperament during the examination. The factual and succinct but positive examination report, however, does not contain any note about temperament at all.[43] In 1753 the organist of the church, Bach's son-in-

41 "Sowohl aber des Neidhardts Temperatur der Vernunfft am gemässesten zu seyn scheinet, so habe ich doch noch kein Werck von einem habilen Instrument- oder Orgelmacher darnach eingerichtet angetroffen." J. Mattheson. *Critica Musica* II, Hamburg: Thomas Wierings Erben, 1725; quoted from Gernhardt 2003 [cf. note 37]. 18.

42 Cf., however, Gloger's quotation referring to manipulating tangents of fretted clavichords [§238].

43 Cf. Bach-Dokumente I [cf. note 4] nr. 90: 170–171. Ulrich Dähnert. *Der Orgel- und*

law Johann Christoph Altnickol (1719/1720-1759) referred in a detailed certificate to this instrument stating: "Concerning the temperament he [Z. Hildebrandt] is following Neidhardt, and one can very finely modulate in[to] all keys without the ear getting to hear anything repugnant, which is the most beautiful in today's taste of music [...]."[44] The wording "nach dem Neidhardt" (following the "Neidhardt") leaves open whether Hildebrandt followed Neidhardt's temperament proposals as exactly as possible or only followed Neidhardt's basic principle of a finer division of the commas. But only with great caution can it be interpreted as an indication that Bach might have taken to Neidhardtish principles at this time, i.e. in his later years. Since Neidhardt even suggested equal temperament (which he prescribed "for the court", even though that might not necessarily have been meant exclusively), it appears as one of the possibilities, that the Naumburg organ had an equal or close-to equal temperament in 1746. We don't know.

[§266] A look at two major music cities in the 1720s may illustrate that the evolution of the temperament in Bach's environment need not have been typical, and that most of the organs in Northern and Central Germany fell short of the temperamental demands derived from the interaction of the organ with ensemble music. In Hamburg, for example, all organs were still apparently tuned in meantone ("praetorianisch") at the end of the 1720s/ beginning of the 1730s. The Hamburg organist Georg Preus wrote in 1729:

> Now one would wish that we had in our organs a good temperament, because all our organs here [in Hamburg] are still tuned in the old Praetorian way, in which there are a lot of faults: that is, that one can not play in all keys because of the very hard [wide major] thirds, that is C sharp–F, D sharp [= E flat]–G [probably G sharp], F sharp–B flat, G sharp–C, B–D sharp [= E flat], also some minor thirds, and some fifths.

Instrumentenbauer Zacharias Hildebrandt. Sein Verhältnis zu Gottfried Silbermann und Johann Sebastian Bach. Leipzig: Breitkopf & Härtel, 1961. 108.

44 "In der Temperatur gehet er [Z. Hildebrandt] nach dem Neidhardt, und man kan aus allen Tonen gantz fein moduliren, ohne daß das Gehör etwas wiedriges zuhören bekomt, welches bey heutigen Gusto der Music das schönste ist [...]." Dähnert 1961 [cf. note 43]. 115.

> If only something would be taken from the one [interval] and added to the other, both concerning the fifths and some thirds, it would provide a better temperament, as to be found in other places.[45]

Preus's term "Praetorianisch" is unequivocal: it denotes meantone temperament with pure major thirds, without a modification which would have made possible to use the chords of B major, F minor etc.[46]
[§267] Preus's counterpart, J. Mattheson, indirectly confirmed this in 1731.[47] Still in 1748 Mattheson testified again as to the very slow introduction of new temperaments in organ building practice (apparently not only concerning the North German coastal region but in general) and he regretted that the organ was therefore hardly useful as a continuo instrument outside a very limited choice of keys.[48]

45 „Nun wäre zu wünschen, daß wir in unsern Orgeln eine gute Temperatur hätten, da alle unsere Orgeln alhier [in Hamburg] noch nach der alten Praetorianischen Arth gestimmet seyn, worinnen den noch viele Fehler stecken: so, daß man nicht aus allen Tonen spielen kan; wegen der sehr harten Tertien, als cis f. dis g. fis b. gis c. h dis [= es]. item einiger kleiner Tertien, und einige Quinten. Wan nun dem einen was genommen, so wohl die Quinten, als einige Tertien, und den andern wieder was gegeben würde, so würde man eine bessere Temperatur haben; wie, an andern Oertern zu finden." Georg Preus. *Grund-Regeln von der Structur und den Requisitis einer untadelhaften Orgel, worinnen hauptsächlich gezeiget wird, was bey Erbauung einer neuen und Renovirung einer alten Orgel zu beobachten sey, auch wie eine Orgel by der Ueberliefferung müsse probiret und examiniret werden / in einem Gespraech entworffen von Georg Preus, Organisten an der Heil. Geist-Kirche in Hamburg*. Hamburg: C.W. Brandt, 1729. 7. For a further discussion of the context see Ortgies 2004 [cf. note 28] (particularly chapters 4 and 8) and Ortgies 2007 [cf. note 23].

46 In the same way the term "praetorianisch" was used by others like Georg Andreas Sorge (Sorge 1748 [cf. note 7]. 43-46).

47 Johann Mattheson. *Grosse General-Baß-Schule Oder: Der exemplarischen Organisten=Probe Zweite / verbesserte und vermehrte Auflage*. Hamburg: J.C. Kißner, 1731 (facs. Hildesheim etc., Olms ²1994). 143–144 and 164–165.

48 Johann Mattheson. Aristoxeni iunior. Phthongologia systematica: Versuch einer systematischen Klang-Lehre. Hamburg: Johann Adolph Martini, 1748 (facs. Leipzig: Zentralantiquariat der DDR / Kassel: Bärenreiter 1981). 76.

[§268] In Dresden, the situation seems to have been similar in 1722. If one trusts Friedrich Suppig, apparently a musical amateur albeit with quite high music-theoretical ambitions, he described meantone temperament as the temperament, which was found on the "common Clavier[en]" ("gemeinen Clavier").[49] It is therefore hard to imagine that his remarks only referred to stringed keyboard instruments, which after all could be retuned easily.

Conclusion

[§269] We know little about Bach's actual temperament practice and are mostly dependent on theoretical writings, which – if they are proposing new temperaments – initially often do not present more than ideas that only slowly came into general use. The volumes of *Bach-Dokumente* provide us with a wealth of observations by Bach's descendants and students. It is quite likely that concrete knowledge about Bach's temperament practice would have been handed down to us, if he had regarded his own temperament principles as so important that they were worthy of formulating them in some more detail. Given the fact that this is not the case, everyone may draw their own conclusions; a definitive solution to the problem of Bach-temperament does not exist today.
[§270] Whatever the likings and predilections of a player might be in considering the use of one or another temperament scheme for the music of Bach, the argument that Bach used a particular temperament is based on (modern) taste and therefore a fallacy that can never replace proper "hard" evidence. Evidence that we unfortunately simply do not have. In the end, it remains a matter for the individual to decide which temperament seems to be musically apt for the performance of any of Bach's compositions.

49 Suppig 1722 [cf. note 8]. 171. Suppig's description of mathematically definable pitches on the "common Clavier" results in the "common" temperament, i.e. meantone temperament.

Abstract

During Bach's lifetime, the history of temperament in Western music took new turns, but his relationship to this development is far from well understood.
The article explores a number of relevant questions to help define what we actually can know about this matter:

- Which sources about musical temperament are relevant in regard to Bach's practice and what can be learned from them?
- How detailed, plausible or credible is the relevant information?
- Do we know whether Bach had any influence on the choice of temperament in organ projects? If so, to what extent and what was his advice?
- To what degree do extant contemporary reports, expert opinions and historical instruments allow us to reconstruct temperaments in the organ building of Bach's age?
- What role did the temperament of instruments with fixed pitches (like keyboards) play in interaction with free-intonating instruments and singers?

It appears that conclusive evidence for answering these question does not exist, which might be liberating: In the end, it remains a matter for the individual to decide which temperament seems to be musically apt for the performance of any of Bach's compositions.

Ibo Ortgies

Ibo Ortgies (*1960, Norden, Germany) is a musicologist and music historian at the University of Gothenburg, Sweden, where in 2004 he successfully defended his PhD-thesis on the tuning and temperament of seventeenth- and eighteenth-century organs and consequences for musical performance practice of the time.
He has conducted research and extensively published in the field of music- and organ building history in North Germany and the Netherlands. His research has contributed to new views on the keyboard music of the North German Baroque, especially Dieterich Buxtehude and his contemporaries but also Bach.

From 1992 to 1999 he was the co–initiator and consultant of the organ building project in Bremen-Walle, Germany: A newly built organ in early Baroque style in meantone temperament and with split keys (inauguration 2002).
When the organ research institute GOArt was founded in 1995 at the University of Gothenburg, he was already a close collaborator of GOArt's work as an external organ expert and researcher. 1999 he joined GOArt's staff, at first as a member of the reference group that advised the construction of the North German Baroque Organ in Örgryte New Church built in the University of Gothenburg's organ research workshop (inauguration 2000).

VII

Jacob Lekkerkerker - Am I an Organist or do I play the Organ?

[§271] “Am I a guitarist or do I play the guitar?” To be honest, I have forgotten where I read this question and who is supposed to have said it. Nevertheless, it pops into my head from time to time. “Am I an organist or do I play the organ?” “Being an organist” suggests a lifelong attachment to the instrument, “playing the organ” suggests that another sort of relationship is possible.
[§272] The reason this question has occupied my head is linked with the limitations of the organ which one sometimes encounters and which have already been extensively discussed elsewhere. The organ is a sluggish instrument, or at least some pipes speak more sluggishly than others. Ensemble playing with a large organ is difficult. As a player you are bound by the room in which the organ stands. You draw multiple stops and they all sound together, complete with all the note doublings. Dynamic expression is only possible when the pipes are located in a swell box, or if the organ has a general crescendo pedal or ‘walze’. Etc...
[§273] When I lamented to Hans Fidom recently that I wished I had played the piano he responded rather forcefully: there are already plenty of good pianists, keep playing the organ and keep doing what you do best.
[§274] Anyway. It is important for the reader to know that in this article, the perspective of the player is of central importance, and that the player in question is sometimes an unsatisfied one... My starting point is this: one instrument, one player. One could just as easily start from the perspective of the organ as a machine, or as an instrument which requires a whole team to be able to play it.

Funky Organs

[§275] A project on which I am working during 2014 is entitled FUNKY ORGANS, developed at the Oude Kerk in Amsterdam with support from the Amsterdams Fonds voor de Kunst (Amsterdam Art Fund). This is a project which seems to have been conceived in parallel with the developments surrounding the new organ in the Orgelpark. I have been working for around five years combining organs with live electronics and, whilst these activities have until now made use of a small continuo organ, FUNKY ORGANS investigates the possibilities of larger instruments and, most especially, the large Vater/Müller organ on the West wall of the Oude Kerk and the Ahrend organ in the transept, currently tuned in meantone temperament.

[§276] With FUNKY ORGANS, I want to discover whether the application of certain techniques can make large organs more flexible in terms of timing (when playing with others) and in terms of dynamics. The larger organ in the Oude Kerk is really beautiful. Nevertheless it remains true that rhythmic ensemble playing is not possible across the entire sound spectrum (the lowest notes in particular are always heard slightly late). In addition, dynamic expressivity is not possible other than through varying the number of stops or the nuances of touch.

[§277] The project in the Oude Kerk will occur in three phases. Firstly, a phase in which the technical infrastructure of the microphones to be used will be determined. Secondly, a phase in which sound effects are tried out and finally a phase in which the actual playing of the organ will become the centre of focus.

Phase 1: microphones

[§278] The first phase involves the creation of a set-up with various microphones both inside and directly in front of the organ. The signals from these microphones will be sent directly to a sound system. The goal of this test configuration is to create a mixed sound consisting of the acoustic sound of the organ on the one hand and the recorded sound of the organ on the other and then to investigate the relationship between the two elements in the room. The recorded organ sound is transmitted via a sound manipulation device so that an extra layer can be added, variable

both from the point of view of the organ registration and from the point of view of the equipment. I have little knowledge of microphones and so am working intensively with a sound engineer. I intend, however, to work with various different kinds, including the so-called Schaller pick-up microphone. Guitarists, for example, use the oyster model in order to amplify the body of an acoustic guitar. These work well with a continuo organ when a single wooden pipe is lifted out and its extra, peripheral sounds captured.

Phase 2: guest musicians

[§279] During the second phase of FUNKY ORGANS I will invite a number of guest musicians with considerable experience of such sound modulation devices, including electric guitarists. They stand in a long tradition and know their "tools" as an organist knows his stops. Moreover, many of the pieces of equipment they use have become "classics" due to the ease of their use and specific sound qualities. Examples include the Moogerfooger and the colourful pedals made by the firm Boss including the various pitch shifters and delays.

[§280] Whereas, during the first phase of the project, the test microphone and amplifier set-up will be determined, during the second phase I will play the organ in a number of practise sessions during which the guest musicians will provide live inspiration. A schematic overview of the process can be summarised as follows:

- microphones record organ sound produced by the organist
- sound in turn fed to the sound manipulation devices
- which in turn are controlled by the guest musicians
- the results then combine with the acoustic sound of the organ

[§281] The guest musicians are, generally speaking, a sound source in themselves whilst performing. One instrument, one player. In this transitional stage, I am the player, and they are the second player, the sound manipulator. This manipulation of the source sound is in fact a normal part of their daily musical activities; discovering the limits of their equipment during their rehearsal sessions.

Good buttons

[§282] The idea of progressing the initial phases of FUNKY ORGANS in this manner grew from a sense of dissatisfaction with an earlier project. A number of years ago, Jurriaan Berger and I reached the final of the Jur Naessens Music Prize with a project entitled music for portable organ and kaoss pads. Kaoss pads are small sound manipulation devices from the contemporary music industry, developed in such a way that the sounds can be altered using one's fingers on a touchscreen and the modulated result in turn sent to an amplifier. The kind of sounds which can be created in this way continue developments made in pop music culture. Jazz pianist and composer Jurriaan Berger and myself spent weeks in a small room with a continuo organ and various microphones located both within and outside the case. These recorded the live sounds from the instrument and sent them to two kaoss pads.

[§283] The result, I believe, was remarkable and we won the aforementioned prize. Nevertheless, I found working with the kaoss pads very disappointing and I found the whole set-up too complicated, certainly as far as cables, microphones and amplification were concerned, but, in particular, regarding the interaction with the touchscreens. A good button has some resistance but a touchscreen doesn't and this complicates the production of precise sound-effects. Therefore, when faced last year with the challenge of finding comparable sound-effects for a duet for continuo organ and singer, I went in search of new solutions. In the first instance I wanted to be in control of the apparatus myself as it was in any case to be a short duet. The solution had to be easily manageable therefore and every extra button is one more to be controlled. In addition, I wanted to ditch the touchscreen. In the same way that a player seeks contact with the sound source, the player of an electronic instrument searches for his buttons which in turn must provide the necessary resistance. There must, therefore, be a relationship between motoric memory and equipment. Companies such as Numark, Pioneer, Boss etc. enjoy a fine reputation for the manufacture of this sort of equipment. I don't know it especially well but I suspect that a whole lot of science is behind what you might describe as the touchability of electronic knobs.

As simple as possible

[§284] In any case, I sought out a basic set-up with a continuo organ, microphone and an amplifier. The goal was to keep the situation as simple as possible. Somewhere in a cupboard I located my first guitar amplifier, bought in 1990, and also my first studio microphone, dating from the same period (at the time I was playing in a rock band). These still worked well; not too sensitively, with the resulting limited danger of feedback. Then I invited a very experienced electric guitarist, Alfredo Genovesi, to bring a series of his effects pedals. He duly appeared at the Oude Kerk one afternoon with his suitcase-on-wheels and proceeded to unpack all manner of equipment; an amazing site for the passing tourist. We experimented for a few hours and I fell in love with a small effects box produced by Boss, the Pitch Shifter Delay, easily combinable with an expression pedal, controlled by the feet. Thereafter, I rehearsed for a number of weeks with this set-up:

- microphone in the organ
- Boss PS-3 Pitch Shifter Delay
- expression pedal
- guitar amplifier

[§285] A comprehensive combination, offering many sound possibilities without the danger that practical music-making could become hindered by technical complications. One of the four knobs allowed access to 15 different effects, one of which could be further manipulated via an expression pedal. The result was an organ sound somewhere between a Hammond, a pipe organ and a synthesizer; perfect for the duet taking shape in my head. Just as the afternoon with Alfredo had resulted in an inventory of possibilities, the second phase of FUNKY ORGANS is expected to function likewise. Guest musicians bring their equipment in order that we can evaluate the most effective sound possibilities.

Phase 3: finding answers to the lethargy of the organ

[§286] The third phase is where the research outcomes will be sought: finding answers to the lethargy of the organ in rhythmic ensemble playing and the creation of possibilities in the field of sound dynamics. This brings me back to the essential *raison d'etre* of the FUNKY ORGANS project. I have now been working for a number of years in a beautiful church in which are housed a number of remarkable organs. During this period I have perpetually sought the co-operation of musicians from other musical disciplines, in order to be able to improvise together in concerts and services. Two things have been continually problematic. It is sometimes difficult to unite sound-worlds, especially when one of the sound-worlds in question is a certain kind of very "plastic" electronic music, in particular sound clouds. The static sound of the organ functions in a much more direct way, with the result that the contrast is difficult to bridge. In addition I experimented a great deal with music in which ostinato pulses play the key role, leading to dissatisfaction from the other musicians. "The organ is late", is an oft-heard complaint. The test set-up of FUNKY ORGANS is intended to facilitate investigation into a possible solution to these two practical obstacles. I have high expectations that this can be achieved. The sound of the organ can, thanks to the sound modulation effects, be re-modelled into sound clouds which, dynamically and expressively, can be expanded, dependent on the acoustic sound of the organ which would continue simultaneously. In addition, a simple device such as a loop station can be used to establish a loop, based on the sound of the organ. This can function as an external rhythmic point of reference when playing with others. [A loop is a continually repeated motive.] The reason FUNKY ORGANS has come into being will, by now, be clear. I am not an organist, nor a guitarist, I just want to make music. Music, preferably, which is just a bit funky…

The New Organ at the Orgelpark

[§287] Thinking of the new baroque organ in the Orgelpark, I would like to grasp the opportunity to consider the ultimate implications of the project I am currently undertaking in the Oude Kerk. In the Oude Kerk, I am operating within pre-existing peripheral conditions. In the Orgelpark, on the other hand, the thought process begins with a blank canvas.

[§288] The most important point for me is one I have repeatedly highlighted, namely the relationship between playing technique and technical infrastructure. One of my organ teachers, Ewald Kooiman, used to quip when an organ had been restored, "does it have an adjustable

bench?" I share his practical viewpoint. In the Netherlands especially, it is commonplace to build organs which work against the player. Pedal keys which can't be reached, stop knobs likewise, hopeless music racks, a pitch which fails to conform with the 21st century standard, an unnecessarily heavy action etc. This is an organbuilding and restoration culture which has come about quite understandably. The Netherlands has so many extraordinary historic organs and the tendency to approach them with the attitude of a museum curator seems self-explanatory. Perhaps this is a "good thing". I don't know.

[§289] The building of a new baroque organ in the Orgelpark offers different perspectives. As I understand it, the sound-canvas will be focussed on the baroque period, but, in addition, a variable wind supply and electronics will be applied to the concept. There have already been various initiatives concerning new organs in, among other places, Germany and Sweden, which shall be intensively investigated. I do not know these organs well enough in order to offer an adequate assessment and shall therefore leave others to pass judgement.

Sketch

[§290] Allow me, however, to offer a sketch of the organ I would build, based on my own experience. That ideal organ is perfectly adapted to the room in as far as the sound is concerned, just like the already-extant Sauer organ in the Orgelpark. The touch is the same as the *Positif de Dos* of the French baroque organ in the VU University in Amsterdam and the organ has three manuals and pedals. It has both drawknobs and stop keys so that the player can choose which to use. The draw knobs for the "feel" and in order to offer the possibility of not drawing the stop entirely (slightly less than 100% can be fantastic…). The stop keys for instant changes. The combination system is easy to use with combinations which can be saved on a simple, incorporated "Setzer" with not too many possibilities. Too many possibilities for saving combinations gives the illusion that everything can be saved, eventually to be deleted because data memory can no longer be maintained. Endlessness creates illusion. So far my dream organ is based on existing models.

[§291] As an extra addition, I would like to see four feet pistons and five further expression pedals:

- Four feet pistons for making independent loops with three manuals and pedal.
- The first expression pedal would vary the wind supply. The pedal would be linked to four different knobs; one each for the three manuals and the pedal.
- The second and third expression pedal would be linked to microphones, permanently set up in the organ. These microphones would, in turn, be linked to sound modulation effects and amplifiers which could be switched on and off and controlled with turning knobs. The sound effects made possible by this equipment would include a standard selection of 20th century possibilities, such as pitch shifter, harmonist, superoctave, delays, etc. A comparison can be drawn with the engaging of traditional organ stops and then manipulation of their sound via the swell pedals. The sensitivity of the two expression pedals would also be altered via two knobs (a standard option with most expression pedals).
- The fourth pedal would determine the overall volume of the amplification and would be equipped with a good sound-limiter.
- The fifth expression pedal is a general crescendo. Using this pedal, four different crescendo options would be available, three of which could be programmed in advance, with a fourth programmable by the player.

[§292] The impression could easily be gained that an organ such as this might become a "machine" requiring more than one player. However it has not been conceived as such. The player would only be obliged to make two "new" choices. Which wind pressure and do I want to vary it? Shall I work only with the acoustic "basis" sound or shall I choose to add a flexibly amplified layer to the picture? The rest is standard organ equipment: a "Setzer" (programmable sequencer) and general crescendos (acoustic and amplified). The expression pedals are designed to work easily with the sound world chosen by the organist and, in any case, the use of expression pedals is a normal part of any organ technique.

Conclusion

[§293] I realise that the perspective presented in this article is a limited one. A new baroque organ at the Orgelpark should be thought of from three perspectives, I think. These are the perspectives of the traditional organist, the contemporary musician, and the composer. Mine is the perspective of the improviser seeking to mix the traditional sound of the pipe organ with that of 20th/21st century electronics. Nevertheless, I believe that this is a strong perspective with parallels from which to reason. Thinking back to the baroque, one observes organists who improvised on instruments that were outstandingly well suited to the task. Although many baroque organs were large and had many stop knobs, the experienced player could nevertheless play them alone, without the help of assistants. The latter have become required since the playing of printed music overtook improvisation as the common way of playing these instruments. This is especially true when organists perform music from different style-periods on different organs. But when I think of Johann Sebastian Bach, Dietrich Buxtehude and Jan Pieterszoon Sweelinck, I see solitary figures sitting at the console with rows of stop knobs to both left and right. My perspective for an improvisers console at the Orgelpark would be exactly that, together with some pistons and expression pedals, an undeniable 19th century invention.

Abstract

From the perspective of the musician, who wants to make music on organs, I develop the project FUNKY ORGANS. Its aim is to find answers to the question how to make large organs more flexible in terms of timing and dynamics. I consists of three phases: adding electronic devices to the organ (microphones, loudspeakers, effect tools); inviting guest musicians to play with me and inspire me as to how to use the additional equipment; discerning which of the undoubtedly many possibilities work best to free the organ of its

lethargy. Essential aspects will be ease of use and identifying gear that "talks back" - which, for example, excludes touch screens.
Regarding the new organ at the Orgelpark, I would, aside from normal equipment such as a programmable sequencer, suggest to have draw knobs for the stops (allowing to manipulate the wind consumption per stop) as well as stop keys (allowing immediate control). Furthermore, I would suggest to equip the organ with five extra expression pedals: one to vary the wind supply; two to control the sound effects produced by using the microphones in the organ; one to control the overall volume of the amplification; and one to control to addition of stops. When I think of Johann Sebastian Bach, Dietrich Buxtehude and Jan Pieterszoon Sweelinck, I see solitary figures sitting at the console with rows of stop knobs to both left and right. My perspective for an improvisers console at the Orgelpark would be exactly that, together with some pistons and expression pedals, an undeniable 19th century invention..

Jacob Lekkerkerker

Jacob Lekkerkerker has, during the last few years, developed a career 'headlined' by two key themes. On the one hand he has worked intensively to develop his art as an improviser and, on the other, he has become a pioneer in the manipulation of organ sound. In the context of the latter he has re-mixed organ samples live using DJ equipment and experimented with live sound-altering through the application of microphones and sound-modulation effect to acoustic organ sound.
Jacob Lekkerkerker prefers to work with musicians from all disciplines, dancers, actors and artists. For his experimental work his was awarded the Sweelinck-Muller Prize for innovative organ projects, the Jur Naessens Music Prize for musical adventurers, and the "Schnitgers Droom" Prize. Jacob Lekkerkerker is organist of the Oude Kerk in Amsterdam and an art historian.

VIII

Robert van Heumen - The New Baroque Organ as a Hybrid Electro-Acoustic Instrument

[§294] My name is Robert van Heumen. I am a composer, improvisor and laptop-instrumentalist. I use the laptop as a sound-generating device controlled in an instrumental and tactile way, connecting action to sound like an acoustic instrument. Live sampling is my main tool.

Introduction

[§295] I started working in the field of electro-acoustic music around the year 2000. My first entry in this field was at the Studio for Electro-Instrumental Music (STEIM) in Amsterdam, where after a year of odd jobs and volunteer work I was offered a position as a project advisor. At STEIM I assisted in a wide variety of projects by artists developing their electro-acoustic instruments. It was also at STEIM that I developed my own laptop-instrument and built my experience as an improvisor using this instrument. My experience with organs is of a more recent date: in 2012 I contacted Orgelpark with a plan for two compositions: *First Law of Kipple*, a composition for 4-channel soundtrack and MIDI-controlled Sauer organ and *Tubes in Chains*, a composition for various amplified and distorted organs, flute with electronics and laptop-instrument. The latter was commissioned by Orgelpark and performed by my band Shackle (with Anne La Berge) and Dominik Blum on November 3 2013 in a concert also featuring *First Law of Kipple* (*FLoK*) and two pieces by David Dramm. To explain the use of the organs in both compositions, I would like to go into details a bit. *FLoK* is a piece played back by the computer using Steinberg's Nuendo multi-track audio software, where audio sent to the 4 speakers and MIDI sent to the Sauer organ's digital interface is synchronized. The work is fully automated: once started, no human interference is necessary. Registers are changed during the piece by sending the appropriate MIDI control messages.

[§296] When I was working on this piece in 2012, the MIDI specifications were not fully documented yet, so I needed to research the response of the interface to MIDI messages sent from the computer. This gave me valuable insight in the MIDI-implementation of the interface and also made me aware of its flaws.
[§297] As opposed to the quite simple setup for *FLoK*, the configuration for Tubes was much more complex. It involved amplification and live sampling of the Sauer and Chest organs, using distortion pedals on both organs, adding the acoustic Molzer and Verschueren organs, live sampling of the flute, using a partly notated score with visual cues and three performers. On top of this dealing with the unusual acoustic space and the diametrically opposed characters of the very direct and dry electronic sound of Shackle and the slow and reverberant acoustic organs.
[§298] Relevant to this essay is mainly the amplification of the organs: the Sauer feed came from two dynamic microphones already present in the organ, usually sending a signal to the speakers in the original console below it to provide the organ player with more direct aural feedback. Theoretically a far from ideal situation, using dynamic microphones and only two of them, as some pipes would sound much louder than others and the sound quality would not be great. But for *Tubes* this turned out to be sufficient. The subtle amplification helped the acoustic organ sound to blend with the electronic sound from the speakers, and it gave me a quite direct signal for live sampling that matched the original sound of the organ. The Chest organ was amplified using two Neumann microphones inside the instrument. This also provided a direct signal for live sampling and helped the instrument to be more present in the electro-acoustic sound field. The "extra-musical" sounds of the mechanism and the blower of both organs added texture and more character to the piece and created a vibrant buzz in the speakers: a sound bed that strengthened the blend of the acoustic and electronic worlds. The original plan for *Tubes* also included a section where the organ player through the digital Sauer console would trigger and control flute samples on the laptop-instrument and simultaneously I would trigger notes on the Sauer organ with the joystick that is part of my laptop-instrument. After numerous experiments I decided to postpone the idea for a next piece, mainly due to a lack of musical necessity. I had not found a satisfactory method to map

the collection of continuous controllers that constitute a joystick to a series of on/off events to trigger organ notes. The essential difference between continuous and discrete seems to be the issue here, and I have not solved that yet. A secondary reason to drop the idea was the limitation of the MIDI implementation on the console: the organ would stop responding to MIDI if too much information was being sent. This is an issue that definitely should be addressed designing the new organ.

General remarks

[§299] This essay constitutes my ideas concerning the plans to build a Baroque organ incorporating 21st century technology. In my opinion these plans are a perfect excuse to build a hybrid electro-acoustic organ, incorporating acoustic and electronic sounds, merging the best of both worlds. But first of all the most important aspect that should govern all decisions: LIMITATION. In computer-based electronic music, if you do not limit your possibilities, you get nowhere. You play around with programs, with plugins, with effects, with toys, with hardware, but you only scratch the surface, you never go deeper. If you limit yourself, if you force yourself to work with what you have, then you have to go deeper. So: make choices, limit the possibilities in the acoustic design but more importantly in the electronic design. Most composers will not have much time anyways to work with the instrument, so they do not have the time to sculpt the instrument exactly as they like. Provide presets, but also provide the possibility to make one's own presets. Develop an instrument with character. An instrument that can not do everything, but that can do a limited number of things really well. Do not be afraid that the instrument will only fit a small number of composers and performers: everyone will find a way to make beautiful music with it. Limitation sparks creativity. The remainder of this essay consists of a collection of suggestions for the design of this hybrid electroacoustic organ. In itself these suggestions are very personal, I believe that there should be multiple discussions about these aspects, these limitations. Every outcome is acceptable to me, as long as clear decisions are made. One last remark: I do not know much about organ technology, so some aspects that I would like to see in this new organ might not be very feasible with respect to the mechanics of the organ.

Microphones

[§300] I understand the urge to have a very flexible microphone placement system, but limitation is important. Thinking about my preparation time for the pieces I created for Orgelpark, I am actually glad I did not (have to) go through the process of placing different microphones in different positions in the Sauer organ and figuring out what sounded best. This could have easily consumed all the time I had working with the organ, let alone the practical issue of working alone and having to walk up and down all the time repositioning the microphones. I actually worked a bit on amplifying the Molzer organ, placing microphones, but as soon as I realized that it would take a long time finding the right spots for a decent signal to sample I stopped and decided to not amplify the instrument at all. This may sound lame to you, me being just lazy not wanting to go through the trouble. But for me this is being practical. As much as I like technology, I rather spend my time making music.

[§301] So what then? I would opt for a number of fixed microphones and a smaller number of flexible ones, a combination of contact microphones on the mechanism and condenser and dynamic microphones placed in strategic places with a couple of patch-bays to limit cables running through the organ. This of course needs experimentation and is highly dependent on the space around the pipes. The goal should not be to cover all pipes in an equal way, that would be impossible (or would need one microphone for each pipe), so choices would have to be made, again. Some of the pipes and parts of the mechanism could be treated as special and have a dedicated microphone (these could be called "effect sounds"). Of course this would have to be documented, so composers can take advantage of those effect sounds. All the microphones signals would have to be accessible on the floor through a patch-bay. When working alone in the hall it is very useful to have access to the audio signals right next to the digital console. To further limit the multitude of options, some microphones with similar functionality could be combined within the patch-bays. For example a couple of "overhead" microphones or a couple of mechanism contact microphones combined into one stereo signal. These combinations can be seen as an example of the presets I talked about earlier. The best approach in my opinion would be to plan three phases in the process: building the acoustic organ while reserving

space for microphones, then experimenting with the placement and in the last phase mounting the microphones.

Speakers

[§302] There are multiple reasons why speakers should be included with the organ. First of all there is of course the amplification of the microphones inside the organ. Then there is the playback of electronically generated sound from a sound engine inside the organ (I would call this "internal sound"; more on this in the next section) and playback of sound from another source ("external sound"; for example sound from a computer to play back in one of the speakers inside the organ to resonate with a specific pipe). To achieve a good blend between the acoustic and electronic sound generated by the organ it is essential that there are speakers inside or very close to the organ. Having both would be ideal. Just like with microphones I think choices have to be made regarding placement of the speakers. Obvious positions are of course immediately left and right of the organ. More interesting options would be inside the organ and opposite of the organ on the other balcony to incorporate the room into the sound of the organ. Speakers inside the organ can be divided in "amplification" speakers to play internal or external sound to make it merge well with the acoustic sound of the pipes and "effect" speakers that are placed for example right above certain bigger pipes to create resonance of internal and external sound within the pipe. Whether this will be effective as a composition tool has to be researched. Last but not least, there should be a subwoofer inside the organ, for resonance and to playback internal and external sound in the lower frequency domain. Again I would opt to first build the acoustic organ and then experiment with speaker placement before mounting them. A couple of patch-bays would be necessary to route microphones and internal and external sound inputs to various speakers, both internal as specified above as external, for example PA speakers on the floor. The patch-bays would ideally be placed both right next to the organ and below on the floor.

Sound engine

[§303] Orgelpark's Sauer organ is MIDI-controllable and has two microphones inside that can be used for amplification and live sampling.

Adding multiple microphones and speakers to the new MIDI-controllable Baroque organ is already very exciting. Going one step further by adding a sound engine inside the instrument and thus creating a true hybrid electro-acoustic organ would be mind-blowing. Imagine a perfect blend of great acoustic pipes and versatile electronic sound, being able to live-sample an acoustic register and play that back instantly with just a little change in pitch or timbre, merging that with other acoustic registers and strangely familiar organ-like sounds generated by the physical modeling module, then adding gesturally controlled extremely pitched-up and -down sampled material from the mechanism of the organ, grounded by an extremely low-pitched throbbing sine tone. Wow, that would definitely be amazing. Of course any electro-acoustic composer could bring his own tools and create electronic sounds in combination with the acoustic organ. But we can offer them new possibilities, open up new sound worlds, have composers and musicians think outside the box, create music that would be unthinkable without this instrument. And: if we arebuilding an organ anyway, consulting experts in various fields and limiting ourselves by making decisions on what to include and what to omit, why not add the electronic aspect? We have the knowledge and we have the means. Again, we could never satisfy every composer wanting to work with the organ, but compare it to presets in music software or on hardware synthesizers: it gives the less-experienced composer a selected choice of sounds to start with but at the same time allows the experienced composer to create his own sounds. We would also attract composers and players just because of the very special character of this instrument – people who might otherwise not think of writing for or playing a church organ. Widen the horizon.

[§304] The sound engine would ideally consist of three modules: virtual analog synthesis, sampling, and physical modeling synthesis. All three would reside on a computer inside de organ, to be configured from interfaces right next to the organ as well as next to the digital console on the floor. Both interfaces could be a computer or an iPad, depending on the complexity of the software interface, connected by ethernet using screensharing to connect. The computers would be running Mac OS X and the one inside the organ would be connected to a high quality audio interface. The electronic sounds would be triggered from the manuals of the organ, to be selected in a similar

vein as registers of the acoustic organ. A manual could be connected to one specific pitched sound but there should also be the possibility for every key to trigger a different sample. Combinations should also be allowed: for example a certain region of the manual playing different pitches of a sine-tone and another region triggering individual environmental samples.

Analog synthesis

[§305] For the analog synthesis module one could think of a hardware analog synth, but since we would like to have control of the processes in two places it would be more practical to have a virtual analog synth running on the computer inside the organ. This could be dedicated software or a custom program built in SuperCollider or any other sound programming environment. It would consist of the traditional analog synthesis components like oscillators, filters, envelopes, amplifiers and LFOs. Although you can create any complex sound as a combination of these components, I would imagine using this analog module for relatively basic sound material that blends very well especially with the pipes of the organ.

Sampling

The sampling module could also be either a dedicated commercial package or a custom program built in a programming environment like SuperCollider. The latter would give us more flexibility to customize the module, but would potentially be more costly to develop. Although customizing a commercial program could also be quite time-consuming and thus expensive. The choice would be mostly between the flexibility of a custom program and the support structure that comes with commercial software.

[§306] The sampling module can be divided in two parts: sample playback and live sampling. The sample playback part would have a library of samples to choose from and the option to include one's own samples and to save live sampled acoustic sound from the organ. The library could be allowed to grow as more people use it. Initially it could have a bank of samples from the organ itself, for example to be able to play the acoustic pipe and its electronic counterpart simultaneously where the latter could be processed. And like it was mentioned on the Orgelpark blog, it would allow for a comparison of both sounds, which could be an interesting study in itself.

[§307] We could include other samples that potentially would be of interest to many composers; one could think of banks of environmental sounds, factory sounds, mechanical sounds or speech. Of course banks of recordings of other organs would be interesting; this would again open up the possibility of research into the question whether acoustic pipes might become irrelevant as recording and playback technology progresses into the area where recorded and original sound becomes indistinguishable. Personally though I believe a recording could never replace the presence of a physically resonating object in a space; on the contrary I would be very interested in playing all kinds of samples through speakers projecting into the bigger pipes and hearing their resonance. To build up a sample library we could also consider publishing a call to sound artists to send in proposals.
[§308] The live sampling part of the sampling module can be seen as a dynamic sample bank. We could have a "dynamic register" (as discussed further on) consisting of "recording keys" that record from a specified microphone into a specific position in the sample bank and "playback keys" that playback recordings in that sample bank.

Physical modeling
[§309] The third module: physical modeling. This is a technique where sound is not built through additive or subtractive synthesis using sine waves, noise and filters, nor is the sound derived from processing samples. From Wikipedia:

> Physical modeling synthesis refers to methods in which the waveform of the sound to be generated is computed by using a mathematical model, being a set of equations and algorithms to simulate a physical source of sound, usually a musical instrument. Such a model consists of (possibly simplified) laws of physics that govern the sound production, and will typically have several parameters, some of which are constants that describe the physical materials and dimensions of the instrument, while others are time-dependent functions that describe the player's interaction with it, such as plucking a string, or covering tone holes.

My only experience with this synthesis technique is using Logic's Sculpture plugin in *First Law of Kipple* (as described in the introduction), but I see a great deal of potential in combining this with the acoustic organ.

MIDI support
[§310] Orgelpark is already building a lot of experience with MIDI-controllable organs through the presence of the Sauer organ. We should use this knowledge and consult composers who have worked with the Sauer for the MIDI implementation in the new organ. Since it seems already decided that the new Baroque organ will be MIDI-controllable I will not discuss the pros and cons but go into the details of the implementation immediately.
[§311] First of all there should be some thought about how to use MIDI channels. The MIDI communication protocol distinguishes 16 independent channels. Originally these channels were thought of representing different instruments; in MIDI studios the various digital instruments could be separated by controlling them on different channels. Just like with the Sauer organ, the digital console for the new organ should distinguish the three manuals and the pedals by having them send the MIDI on separate channels. Aside from musical information like triggering notes or changing the position of the swell pedal, MIDI can also transmit configuration information, like the selection of registers or controlling octave switches. On the Sauer organ this proved very effective: when controlling the Sauer from a computer one can engage registers during a piece without physically touching the register switches on the digital console.
[§312] Taking this a step further, MIDI can also be used to transmit meta-control data: selecting a registration preset on the digital console and even go into the console menu and change global settings. As powerful as this is, it is also dangerous and has to be thought through. There have been examples where the Sauer organ stopped responding to MIDI while pipes were sounding, and that of course is an undesirable effect. While this can never be completely avoided, we should make sure the MIDI implementation distinguishes clearly between the various types of data.
[§313] I would recommend transmitting configuration data and meta-control data on separate channels. It would be best to use channels 14 and 15 for this. Generally when adding tracks to MIDI software each track will

automatically be assigned a new MIDI channel to transmit from, starting from MIDI channel 1; so it is ill-adviced to use any of the lower numbered channels for non-musical data. Some MIDI software uses MIDI channel 16 for configuration data, so for that reason I would not use that channel on the new organ either. As a next step in MIDI control for organs, I would like to see MIDI continuous control of the valves for each pipe. This could help bridge the gap between the discrete character of the organ, where there is no way to add more expression to the sound of a pipe once triggered, and the continuous character of external controllers. Having continuous control over the opening of the valves could create an extra layer of expressiveness. Another aspect in MIDI control could be the speed of the wind motor. I have used the "motor ab" switch on the Sauer organ in the *Tubes* composition (as described in the introduction) to have tones glissandi down; it would be great to have more control on this aspect. Even better would be the possibility to control this independently for multiple groups of registers.
[§314] A note on register and assignment switches: on the Sauer digital console these can be controlled by sending their appropriate MIDI note number: a velocity of value 127 would switch that particular switch on if it was off and off if it was on. Meaning that if the organ player would switch them manually, there is no way the computer knows the correct state (on or off). It would be much more useful being able to set those switches to on and off by sending velocity 127 and 0 respectively.
[§315] Last but not least: a solution has to be found for the fact that too much MIDI information sent to the Sauer digital console makes it crash. It is disturbing that even a restart of the digital console doesn't always seem to reset the instrument.

Interface

[§316] The new organ as discussed above has the following components:

- A collection of acoustic pipes, including the electronics that controls the opening of the valves
- A sound engine computer
- Speakers and microphones inside and around the organ, including patch-bays

- An analog keyboard console (including register/assignment knobs) and digital screen interface on the balcony
- A digital keyboard console (including register/assignment knobs) and digital screen interface on the floor

[§317] To discuss the interface of this hybrid organ, I would like to introduce some terminology. The organ will consist of various traditional Baroque registers which are divided into traditional assignment groups. Let us call those registers "traditional" and their pipes "acoustic". The acoustic pipes have as their counterpart the electronic sounds from the sound engine; let us call those sounds "electronic pipes". The counterpart of traditional registers I will call "dynamic" registers: freely assignable registers consisting of combinations of acoustic and electronic pipes. With dynamic registers every manual can be a combination of every thinkable combination of electronic and acoustic pipes.
[§318] Let us now discuss screen-based control versus dedicated knobs. We have a great number of configuration and musical parameters to control: building electronic pipes in the sound engine, configuring dynamic registers, assigning traditional and dynamic registers to manuals, specifying microphone and speaker routings. Some of these actions should have dedicated hardware interface elements, others can be configured using a screen either using a mouse/computer keyboard combination or a touch screen. As a rule of thumb I would advise to have physical knobs for direct musical actions like selecting and assigning registers, and use a screen for more preparation-type actions like building dynamic registers. Next to register and assignment switches for the traditional registers, I would opt for a range of physical dynamic register switches. I would say that we could have 3 assignment groups of 5 registers each. Every one of those registers can combine acoustic and electronic pipes. These registers can be seen as presets to be programmed and assigned by the composer beforehand. Just like the swell and roll pedals, we could consider adding an array of pedals to control parameters of the electronic pipes. Some of these could be setup to control specific parameters like pitch or volume, others could be left open to assign by the composer.

Tuning

[§319] I do not have a specific preference for a tuning system. What would be an interesting idea though is to add pipes or objects that can be blown but have no determined pitch. These can be treated as "acoustic effect sounds", analogous to non-pitched electronic material like environmental sounds.

Conclusion

[§320] I would strongly recommend taking this opportunity to build a hybrid electro-acoustic Baroque organ consisting of acoustic and electronic pipes and traditional and dynamic registers. With respect to the electronic part of the organ I would advise to build it in three phases: first decide on the type and rough number of electronic components (speakers, microphones, sound engine, interface elements) and build the acoustic organ keeping in mind these components. Secondly experiment with various electronic components: microphone and speaker type and placement, various electronic sounds; then decide on their specifics and build this. Finally we can make an inventory of all the control parameters we need and design and build the digital console incorporating all the details.

Abstract

The plan to build a Baroque organ incorporating 21st century technology is a perfect excuse to build a hybrid electro-acoustic organ, incorporating acoustic and electronic sounds, merging the best of both worlds. The most important condition would be *limitation*: if we don't limit our possibilities, we get nowhere.

I would opt to first build the acoustic organ and then experiment with microphone and speaker placement. Patchbays would ideally be placed both right next to the organ and below on the floor. Going one step further by adding a sound engine inside the instrument and thus creating a true hybrid electro-acoustic organ would give the less-experienced composer a selected choice of sounds to start with, and would allow the experienced composer to create his own sounds. The sound engine would ideally consist of three modules: (virtual) analog synthesis, sampling, and physical modeling synthesis. The interface to the hybrid organ should contain both register and other dedicated knobs, but a digital screen interface as well. As a rule of thumb I would advise to have physical elements for direct musical actions like selecting and assigning registers, and use a screen for more preparation-type actions like building dynamic registers. My suggestion would be to first decide on the type and rough number of electronic components (speakers, microphones, sound engine, interface elements), then build the acoustic organ keeping in mind these components. Using the analog console of the organ experiments with these electronic components can be done (mic and speaker type and placement, various electronic sounds). That would be phase 2. Phase 3 would be building the system.

Robert van Heumen

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Van Heumen is performing regularly with his band Shackle and various other constellations. Van Heumen teaches music programming language SuperCollider at the Conservatory of Amsterdam and collaborates with Anne La Berge in teaching Converging Objects workshops on live electronics and structured improvisation at universities and other educational organizations, both in the Netherlands and internationally. Van Heumen worked for 10 years at the Studio for Electo-Instrumental Music (STEIM) in Amsterdam as project manager, curator of the Local Stop concert series and member of the artistic committee. In a previous life he was a trumpet player, mathematician and software programmer.

IX

Anne La Berge - Proximity and Communication with the New Baroque Organ at the Orgelpark

[§321] My performance experiences in the Orgelpark have been as a flutist and composer working with amplification and live electronics. I have performed works of my own and by others in ensembles that have included the Sauer organ, the Verschueren organ, the Elbertse chest organ, the Molzer organ and live electronics. I have also improvised with organists using the moveable console of the Sauer organ, the Verschueren organ and the Elbertse chest organ. The only organ that I have digitally processed in performance is the Elbertse chest organ.

[§322] It is very inspiring news that the Orgelpark is building a new baroque organ with the prospects of extending the timbre, the tuning, the independence of the pipes and the added advantage of a moveable digital console. These additions to the traditional organ will give composers and performers who use the instrument many opportunities to substantially contribute to new musical adventures both technically and musically.

[§323] This article will focus on:

- The use of live electronics with the new baroque organ including
    - > Sounds from the wind system and the pipes as audio signals
    - > The placement of microphones
    - > Mixing the audio from the organ and the placement of loudspeakers
    - > The MIDI console and the data communication system
- The structure of the organ and the placement of fellow musicians during performance
- The benefits of multiple temperaments for 21st century music

[§324] Composers and performers and sound technicians will potentially use amplification, recording, audio signal processing and digital communication systems with the new organ. Therefore, in this article, I will use the term "composer/performer" for this group of practitioners. The term "composer/performer" from here on refers to: composers who do not perform, composers who participate in the performances their works, performers who play only composed music and performers who play both composed and improvised music.

Live electronics

[§325] The use of amplification and audio signal processing gives composers and performers the tools to stretch their musical imaginations by giving them the opportunity to combine the organ sounds with non-organ sounds, process the organ sounds and amplify sounds inside the organ that are barely audible. These audio techniques are useful for both composers and performers in their search to find a timbral repertoire that suits their musical visions.
[§326] Amplification and audio processing can be used in many stages of music making, beginning with gathering sounds for playback during the performance of a composition and extending to live audio processing during an improvisation.
[§327] Amplification and audio processing are tools to augment an instrument. My personal experience with live electronics has been focused on augmenting the flute. The technique of producing a sound on the flute is very close to producing sounds on the organ pipes. I see my instrument as a kindred spirit to the organ and my discussions and proposals for the new organ are clearly related to my own experiences with the flute. However, I have the advantage of being able to play more than one pitch from the same pipe and I can walk around while doing that!

Microphones

[§328] The signal flow chain for amplification and processing begins with the microphone. Placement of microphones in the new organ is the first step to consider. To decouple the organ sound from the influence of the room will give the strongest and most clear signal. The Orgelpark has a natural

reverb that suits the acoustic sounds of the organs but the microphones for amplification and processing need to be placed where they will pick up as little signal as possible from the church reverb. This will depend on the type of microphones, the number of microphones and the positions of the microphones.
[§329] One microphone placement area would be on or as close as possible to different parts of the windchests outside and inside. Depending on the microphone and the construction of the windchests, it may or may not be possible to hear the action of the mechanical movements inside each windchest. The mechanical sounds from the windchests could be processed, recorded or even used as triggers in compositions and performances.
[§330] The range of audio signal quality from hi-end condenser microphones to inexpensive contact microphones is incredibly broad. Hi-end microphones are not always preferred because each microphone signal can be used for a specific musical function. Contact microphones would probably be the most appropriate for the outside walls of the windchests but this depends on what the composer/performer would like to do with the sounds. If they want to mic material where subtle timbral differences can be heard, then condenser microphones rigged inside the windchests would be the most appropriate. In the case of micing the windchests, systematic experiments would be useful to find out what the ideal positions of the microphones are to mic particular sounds. Therefore it would be advisable to have a range of microphones available for composers and performers to use on or inside the windchests.
[§331] It is important to know whether the mechanisms in the different windchests make different sounds or do they all sound exactly the same? And is it musically relevant to couple the sounds of the windchests with the corresponding pipes that are sounding? I would say yes.
[§332] I propose that the microphone positions on each pipe are moveable. The minimum would be: near the mouth and at the end of the open flue pipes; near the mouth of the closed flue pipes; and at the end of the reed pipes. That is not to say that all pipes should have multiple microphones installed on or in them at all times. The point is that composer/performers should have the choice to place microphones on each pipe where they will receive a signal suited to the sounds they want to either process, amplify or use for other input in their electronic set up.

[§333] The questions that this multi-microphone proposal brings are:

- Will there be access and enough space to place different kinds of microphones on the pipes and on the windchests?
- And if so, is it important to build specific microphone holders or should that be left up to each composer/performer to invent?
- Is it possible and useful to install microphones inside the windchests?

[§334] Rather than proposing that the new organ's microphone placement be set in stone, I suggest that we look at their placement in terms of areas on the pipes. For example, the mouth area, the end-of-the-pipe area, the inside-the-pipe area. This implies that the exact placement of the microphones is up to the composer/performer. It also invites further research to be done to figure out where the ideal and/or exact places should be for optimal use in specific musical situations.
[§335] Augmenting the organ by using digital audio signal processing pushes the boundary of traditional organ sounds into unknown territory. Because each pipe has its own tuning and timbre, it is crucial to place the microphones close to the sound source of each pipe. That way the sonic parameters of each pipe could be virtually isolated, the audio signal quality could be controlled and the composer/performer would be able to access the highest quality signal possible.
[§336] Once a strong signal is received, a composer/performer can amplify it, record it and process it. This isolation of pipe sounds will give composer/performers the opportunity to recombine the pure and processed pipe sounds in countless permutations and in ways that are unconventional to the traditional organ. New sounds give birth to new music!
[§337] This proposal, if taken literally, would include thousands of microphones. Needless to say it would not be practical or musically interesting to mic every pipe at the same time. One should have the choice to mic groups of pipes or single pipes depending on what they would like to musically achieve. I imagine that most musicians would like to mic each rank and then have a few pipes that have single microphones for close micing. Perhaps some musicians would like to mic 100 of the smallest pipes and all of the windchests for a completely different set of sounds. Or

maybe a composer/performer would like to mic 96 pipes to create a set of 8 timbrally distinct octaves. Personally I would be interested in having the option to mic all of the ranks separately, to individually mic at least 61 single pipes and to research micing the mechanical sounds of the windchests.
[§338] Microphone placement for optimal professional recording of performances and for commercial release is another issue to be decided. I will gladly leave those decisions to be made by the experts in the recording field.

Loudspeakers

[§339] Mixing the pure, dry organ sounds with the amplified and processed sounds is another musical decision that should be looked at. Before discussing audio mixing options I will discuss the placement of the loudspeakers.
[§340] I propose, for general use, a set of 2 to 8 loudspeakers placed at either side and above the organ case where the organist and the other performing musicians are engulfed in the extended instrument's sound. When the loudspeakers are arranged around the organ, other musicians playing with the organ will not need monitors and the ensemble and audience would experience relatively the same sonic results. There are advantages and disadvantages to placing the loudspeakers behind the performers rather than in front of the performers. I have, in my own experience, found this to be the most musical set up because all participating musicians hear the composite sound of the ensemble which includes the acoustic organ plus the other musicians and their amplified and/or processed sounds.
[§341] The disadvantage of this set up is that some microphones will feed back. This can usually be solved with microphone placement in proximity to the loudspeakers. If moving the microphones does not solve the problem, I would recommend repositioning the loudspeakers by hanging them or experimenting with their placement. The priority above all is to create an ensemble sound that integrates the ensemble including the organ and the live electronics. The danger of determining a fixed position for the loudspeakers far away from the performers is that the music coming out of the loudspeakers and the music coming from the acoustic instruments loose their sonic relationship. They don't blend. They decouple and the musical

reasons why the live electronics and the amplification should be used at all become confused and unclear.

[§342] There are many musical scenarios that will need attention with regards to loudspeaker placement in the Orgelpark besides the one I propose where all the musicians are sitting close to one another in the balcony. One that I assume will be common is that the ensemble, including the organist, and the audience will all be sitting on the main floor. For this set up, I would propose that loudspeakers in the balcony still surround the new organ and that the ensemble be flanked at the rear by stereo loudspeakers on the main floor. The organ sounds should also be included in the total mix on the main floor. That way the acoustic and the processed organ sounds will still be coming from one area in the balcony and be mixed into the ensemble sound in the hall. I anticipate that composer/performers and sound technicians will enjoy hours of experimenting with speaker placement to realize their musical needs. The questions that are important to consider are:

- How many loudspeakers need to surround the new organ case to create a satisfactory mix between the pure organ sounds, the amplified organ sounds and the processed organ sounds?
- Will these same speakers that surround the organ case also work when the ensemble is placed in the balcony close to the organ?
- What is the ideal loudspeaker placement when the ensemble and the organist are performing on the main floor?
- How many loudspeakers are necessary to create a mix between the acoustic organ sounds, the amplified organ sounds, the ensemble sounds plus the processed sounds?

[§343] The decisions as to where the loudspeakers should be placed and how the mix will determine what sounds are coming out of which specific loudspeakers should be made by the composer/performers and the technicians working with them. There are, however, many composer/performers who will appear at the doorstep of the Orgelpark with either a lack of interest in audio dispersion, little understanding of audio mixing or a small amount of rehearsal time. Therefore a set of presets for mixing acoustic and processed sounds would save time for many artists who come to work with their live electronics in the Orgelpark.

Mixing

[§344] I have proposed a microphone system that would include separate microphones for at least 40 ranks, individual microphones for at least 61 single pipes and the possibility for microphones to be built into the windchests. Mixing so many audio signals at one time could be a nightmare! The inputs for the microphones need to be systematically organized where the choices for using or not using them are arranged in hardware and software presets with options, for the more ambitious, to bypass them.

[§345] I have been working with the Roland REAC system that uses a CAT5 network to communicate digital audio from one location to another. This system is installed in Splendor Amsterdam. Using a digital audio transfer system similar to the REAC would streamline the wiring from the audio inputs from the microphones for the instrumentalists and the microphones in the organ. It would also cut down on the hardwiring from the microphone and processed audio mix to the various loudspeakers distributed in the balcony and on the main floor.[1]

[§346] Once the number of flexible and stationary microphone positions have been established, a digital snake system needs to be set up where stage boxes are strategically placed inside the organ case. These stage boxes should have easy access for plugging and replugging the microphones. The combinations of microphones that can be plugged into the stage boxes should be as flexible as possible. Ideally the audio would be transferred digitally to a submixer that is located next to the new organ and/or another mixer on the main

1 Information on the REAC system: http://www.roland.com/products/en/exp/REAC.html. REAC (Roland Ethernet Audio Communication) is Roland's original technology for low latency, high quality digital audio transfer. REAC transfers 24-bit uncompressed multi channel audio with very low latency. REAC technology eliminates the typical problems found in analog transfer such as signal quality degradation or hums and buzzes. In addition, since REAC transfer happens over lightweight cable and is immune to externally induced noise, designers and integrators have more freedom for cable placement resulting in lower cost installations. Heavy analog multi core cable requires large, expensive conduit for installations, and suffers from high frequency losses and potential for induced hums and buzzes. REAC's transfer protocol provides digital audio in a lightweight, inexpensive and easy to install cable format.

floor. The location of the mixers will depend on who is mixing the sound. In many cases, a submixer will be needed in the balcony while another mixer is located on the main floor. A mixer in the balcony seems unavoidable. It would be terribly inconvenient if a composer/performer was experimenting with mic placement and he or she would have to run up and down between the balcony and the main floor for every adjustment. Likewise, if the entire ensemble is in the balcony and the composer/performer is managing the submix, a mixer should be accessible to them in the balcony. In other cases, where the ensemble is performing on the main floor, the mixer on the main floor would be sufficient and the digital snake(s) should run directly from the new organ in the balcony to the main floor.
[§347] The flexible placement of the microphones and the mixer(s) is necessary because it gives the ultimate mixing control during the experimental process to the composer/performer/technician and it gives them the choice to place the submixer and the main mixer where they need to be during performances. The working/creative places and the performance places are potentially different and those places may even change during the process of creating the piece.
[§348] As an extra, I would like to propose experiments placing small loudspeakers inside the larger pipes and playing sounds through these loudspeakers, using the pipes as natural filters while playing the organ at the same time. This combination of speakers-in-pipes could produce some lovely sonic results. That would mean that a person would need to access the tops of the larger pipes and lower loudspeakers into the pipes. Or, depending on the size of the mouth of the pipe and the size of the loudspeaker, one could place the loudspeaker inside the pipe near the mouth. I have used this "loudspeaker inside the tube" principle by placing a Monacor SP-45/4[2] inside a tenor saxophone. The sounds played through the loudspeaker were filtered and processed by the fingerings and the sounds the saxophone player played. This rendered some lovely sonic results!

2 More information: http://www.monacor.de/index.php?id=128&artikelid=2108&L=1.

[§349] I have also been working with the composer Hugo Morales where audio is played into the flute through a plastic tube that is inserted into the end of the flute while I play the flute at the same time. Our experiments have led to some surprising and inspiring results so far.
[§350] These two experiences where someone is playing an acoustic "tube" while audio is played into the tube at the same time interest me very much. It would be handy to have 12 - 24 extra output channels in stage boxes in the organ case to manage the audio being played into the organ pipes.

Communicating with the organ digitally

[§351] The capability to communicate with the new organ digitally from various remote locations gives the Orgelpark a leadership role as a modern-day live-electronic instrument. These locations include digital consoles on the main floor and the balcony. The digital communication is not limited to the consoles, it can be via computers or controllers from anywhere in the world.
[§352] The digital organ console for the Orgelpark Sauer organ has proven to be a great resource for composer/performers in recent years. Some of the advantages are: that it can be positioned anywhere on the main floor; it has more registration combinations than most organs; it has a computer memory to store and recall not only settings but also music played on it; and it can receive and send MIDI to an external digital device including a computer.
[§353] I propose coupling this existing digital organ console to the new organ in addition to building a new one that can be easily transported to the main floor, the balcony and to the foyer on the lower floor of the building. That way the organ could be played from anywhere in the building.
Most important, is that the console can be in close proximity to the actual instrument. The benefits of performing close to the organ are:

- The organist needs to use the digital functions of the console but would like to be close to the organ to hear it more clearly.
- An ensemble is performing in the balcony with the organist who is using the digital functions of the console and they prefer to be close to one another for more intimate contact for their ensemble playing.

- A composer/performer is experimenting with microphone placement and audio processing and would like to be close to the organ while testing the various stages of his or her research. The advantages here are that the digital console can save the settings whereas the traditional console cannot and the digital console can execute more registration combinations than the traditional console. And who knows? Maybe the digital console will have places to put various iPad, iPhone, Arduino and Android devices on it where the wireless connections are part of the console's own communication system!

[§354] Organizing the communication between computers, controllers, the organ console and the organ itself should be done using a combination of a wireless and a CAT5 or CAT6 ethernet network. Current literature recommends CAT6 because it will become the standard in the future.
[§355] The advantages of communicating with the organ console and the organ via CAT6 ethernet is that a patchbay could be built in a central location and the devices that will need to be communicating can be patched into the patch bay. This patchbay would include:

- A network router for wireless controllers and international remote communication
- Any number of computers that communicate with the console, the organ and among one another
- One or more digital organ consoles
- And the organ itself

[§356] Following this line of thought regarding wireless and ethernet connections among the various devices and to the new organ, part of the communication hardware design would include ethernet connections on the organ, on the console and in other points in the Orgelpark where the console, computers and wireless routers could be connected.This may sound like a network circus, but it is similar to many live electronic setups. And remember, not all the possibilities for the digital communication would be used at one time. Too many devices communicating all at once is an example of over-ambitious-information-overload rather than an artful and creative musical event.

[§357] One scenario would be that a small acoustic chamber ensemble is performing with the new organ. They are sitting in the balcony with the organist who is playing the digital console. Two of the other players have laptops that are sending data to the organ console that switches registrations on the organ during the performance.
[§358] Another scenario is that there is one digital console in the foyer of the Orgelpark and one on the main floor of the hall. Two organists are playing the organ, one on each console. The organist in the foyer is hearing the organ in the hall via loudspeakers. A computer or an external digital signal processor is processing the organ sounds and the processed sounds are mixed into the performance heard both in the hall and in the foyer. In addition, a computer located in the foyer is sending registration change information directly to the new organ.
[§359] The composer/performers/technicians that will use the communication system vary from beginners to expert computer programmers. Therefore the range of how the interfaces are built and programmed should reflect this range of know-how and capability.
The hardware and software should be clear enough that the console programming is plug-and-play intuitive for organists that simply want to save their registration patches. On the other side, it should be flexible and powerful enough to create complex remote performances that involve multiple performers in and outside of the building.

MIDI vs. OSC vs. a combination

[§360] The advantages and disadvantages of MIDI have been under scrutiny for at least a decade if not more. The music community is still debating whether MIDI will retain its position as the primary communication protocol in commercial audio devices. So far, it has proven to be an incredibly useful communication standard and I suspect it will be with us for a while longer. However, Open Sound Control (OSC), another protocol for communication among computers, sound and other multimedia devices is optimized for modern network technology and would be appropriate for parts of the CAT6 ethernet communication system that I propose. My recommendation would be to use MIDI for the pitches and registrations for the new organ and use OSC for the communication between the organ, the console and other digital devices such as computers, iPads, Arduinos and other digital controllers. Devising the most streamlined and robust system using a combination of MIDI, OSC and other data communication protocols should be a major priority for the new organ.

Interface programs

[§361] When one looks at the programming languages that are often used by composer/performers using technology, Supercollider, Max and Ableton Live come to mind. These three programming languages have enormous users' groups where musicians are actively exchanging patches and constantly involved in mutual development and troubleshooting projects all over the world. If basic interface programs in all three languages were provided for the digital communication with the new organ this would offer composers a jump-start to interact with it.

[§362] The interface patches would include basic OSC communication examples for sending and receiving data between other devices in the Orgelpark. In other words, the new organ, the digital consoles and other devices on the network. The programmed patches would also include a simple setup for playing the new organ using MIDI and receiving and recording MIDI that is sent from either the consoles or from the new organ.

The Manual

[§363] Another point to be considered is the user manual for the new organ. I propose that the Orgelpark invests in a team of experts that create a manual that it can be used by composer/performers at all levels.

- The manual would explain how to use of the software and hardware.
- It would explain the organ mechanism and the digital and analog paths to produce sound from the pipes.
- It would describe how the new organ produces a sound including the mechanical mechanism, where the microphones are fixed and the flexible areas where other microphones can be placed.
- It would show the audio signal path from the microphones, through the digital stage boxes to the mixer(s) and then how the signal is transferred out through the loudspeakers or to digital signal processors, computers or analog audio processors.
- It would show the network communication system of the building that includes audio and video and how the patchbay works.
- It would explain the OSC and MIDI communication between the organ, the console and computers with Supercollider, Max and Ableton and give examples for basic operations including sending and receiving pitch and registration data.

Placement of fellow musicians

[§364] Designing the balcony space to feature a small ensemble where the musicians have close contact with the organist is a priority. The audience is a major consideration in this configuration. The seats in front of the organ that offer room for a choir is a place that could easily be converted into space for an ensemble or in some cases, the audience.

[§365] A place for a small ensemble near the new organ is critical since many acoustic and electronic performers base their ensemble interaction on visual and aural response. There is a significant difference between hearing the attack, the timbre and the release of a musical sound close by as opposed to far away. Also, most musicians react to one another using a range between subtle and grotesquely large physical movements. Organists have their own special movements that they use for communicating with other players and the closer the musicians are to one another, the more means they have for communication, especially since the mechanism of the organ is such that the actual sound speaks considerably later than when the keys are pressed. I prefer close physical contact with the musicians I play with and I feel much more involved when I can see the arms or even hands of the organist I am playing with.

Temperament

[§366] The main concern with the tuning of the new organ is that it can play baroque music in the most authentic tuning possible with options for extended temperaments such as Kirnberger, Vallotti, Werkmeister. I would like a combination of temperaments where, if combined, there are as many pure fifths, fourths and thirds as possible.

[§367] The composition and improvisation benefit of working with an organ with unequal temperaments is enormous, especially if one can set different ranks to different tunings simultaneously. The consequent availability of virtually infinite timbres will inspire not only use of unique microtonalities but it will hopefully enable limited but pristine just-intonation possibilities. The benefit of unequal temperaments is that there will be a gamut of pure intervals. Thus providing composer/performers the chance to use micro-pitch combinations. To use these pitch combinations where subtle "critical band" deviations can be used and juxtaposed with pure intervals is a gift.

Abstract

It is very inspiring news that the Orgelpark is building a new baroque organ with the prospects of extending the timbre, the tuning, the independence of the pipes and the added advantage of a moveable digital console. These additions to the traditional organ will give composers and performers who use the instrument many opportunities to substantially contribute to new musical adventures both technically and musically.

The use of live electronics with the new baroque organ should provide possibilities to work with sounds from the wind system and the pipes as audio signals, which requires facilities to place microphones in/on/near the pipes and the wind system. I propose a set of 2 to 8 loudspeakers placed at either side and above the organ case where the organist and the other performing musicians, who should preferably be able to work near the organ, are engulfed in the extended instrument's sound. The digital interface should be transportable or multiple, so that the organist can play the organ in close proximity to the instrument. My recommendation would be to use MIDI for the pitches and registrations for the new organ and use OSC for the communication between the organ, the console and other digital devices such as computers, iPads, Arduinos and other digital controllers. Furthermore, the system would benefit from applying CAT6 ethernet, as it allows to build a patchbay in a central location, in which the devices that will need to be communicating, including the digital console of the new organ, can be patched into. A manual that can be used by composer/performers at all levels is of utmost importance.

Anne La Berge

Anne La Berge's career as flutist/improviser/composer stretches across international and stylistic boundaries. Her performances bring together the elements on which her international reputation is based: a ferocious virtuosity, a penchant for improvising delicate textures and melodies, and her wholly unique array of powerfully percussive flute effects, all combined with electronic processing. Her compositions usually involve guided improvisation and text. In addition to creating her own work she regularly performs in other artists' projects in a range of settings from modern chamber music to improvised electronic music. She can be heard on labels which include recordings as a soloist and with Ensemble Modern, United Noise Toys, Fonville/La Berge duo, Rasp/Hasp, Bievre/La Berge duo, Apricot My Lady, Big Zoom, the Corkestra, La Berge and Williamson duo, Shackle and MAZE. She is an active artist in the musicians' collective Splendor Amsterdam and she is the co-director of the VOLSAP Foundation that supports innovative projects for composed and improvised music.

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Ernst Oosterveld - Baroque Organ Additions at the Orgelpark

[§368] In the New Baroque Organ at the Orgelpark, every pipe will have its own pallet. As a result each pipe can be manipulated via electromagnets entirely independent of the the stops to which they belong.
[§369] In the example featured in the magazine *Timbres* (issue 15), this model is explained using the analogy of a chess board. The letters A till H are the keys and numbers I to VIII are the stops. In the context of a slider chest, entire rows are activated by a single number. Spring chests allow individual cells to be activated by means of a mouse click in the software interface on a computer. Thus, the possibility to create a dynamic organ presents itself. The touch sensitivity of the keys can be used to apply a set of stops to each note.

The road to dynamic organ playing

[§370] The majority of MIDI keyboards send, in addition to a number related to the chosen note, a second number (1..127) relating to the speed at which the key is depressed. This is known as the velocity and is a means of measuring the strength of the attack. This value can be used to supply a louder volume to a digital note.
[§371] How might we use the manipulation of individual pipes as a means of making organ playing more dynamic? Let's take the chessboard model, with just eight keys and eight stops, as an example. The velocity (the speed of attack of a key from "off" to "on") is recorded as a value relating to a maximum of 128 steps. If the note sounds then the value = 0 is not applicable and the range of values attached to sounding notes is, therefore, 1 to 127. The value 127 is the maximum attack (the fastest).
[§372] We can now make use of the Graphic User Interface (GUI) in the first instance to decide whether or not we want to make use of the touch

sensitivity of the keys. If Velocity is switched on, various options present themselves as to how the velocity will be used.

Option: dynamic stop selections per key by Velocity values (on/off; default on)
[§373] If you choose this option, a standard list will appear corresponding Velocity areas with numbers of stops. For example:

Velocity range	I	II	III	IV	V	VI	VII	VIII
01 ... 16	1	0	0	0	0	0	0	0
17 ... 32	1	1	0	0	0	0	0	0
33 ... 48	1	1	1	0	0	0	0	0
49 ... 64	1	1	1	1	0	0	0	0
65 ... 80	1	1	1	1	1	0	0	0
81 ... 96	1	1	1	1	1	1	0	0
97 ... 112	1	1	1	1	1	1	1	0
113 ... 127	1	1	1	1	1	1	1	1

[§374] It will be obvious from this that the table can be filled in different ways. This occurs via updates from the GUI. In this example we can control, as a result of the touch sensitivity of a key, more or fewer stops (pipes). If you repeat a note, gradually striking it harder and harder, you will hear that each time more pipes are heard. If you play two different notes, here for example A and B, with A very soft and B very hard, the note A would trigger just a single stop and the note B many more pipes. The result is an entirely new way of playing the organ for which I have great expectations.

Option: switching Velocity for playing off
[§375] If you choose not to use Velocity (in other words, the traditional way of playing), you can nevertheless assemble a correspondence list for each key.

Option: Follow Stops
[§376] With this option, the stops can be activated via MIDI by controllers. For example, from controller 65 onwards (controller 64 is normally used to control the sustaining pedal of the piano), imagine that stop no 1 is activated via midi or via the GUI using controller 65. The midi channel can be made to correspond with the manual midi channel. In the GUI, the channel can be chosen freely. Should the “follow stops” option be chosen, then stop no 2 would send controller 66 with a velocity value of 127 to the midi out via the manual channel. In this case all stops would be activated on all notes on the manual. In our example (changing from 0 to 1: pallet opens / changing from 1 to 0: pallet closes):

Keys/stops	I	II	III	IV	V	VI	VII	VIII
A	0	1	0	0	0	0	0	0
B	0	1	0	0	0	0	0	0
C	0	1	0	0	0	0	0	0
D	0	1	0	0	0	0	0	0
E	0	1	0	0	0	0	0	0
F	0	1	0	0	0	0	0	0
G	0	1	0	0	0	0	0	0
H	0	1	0	0	0	0	0	0

Option: Manual Selection

[§377] In this option, the list can be manually populated. It will be clear that you must also be able to save combinations in the GUI for later use. Example:

Key/stops	I	II	III	IV	V	VI	VII	VIII
A	1	0	0	0	0	0	0	0
B	1	1	1	1	1	0	0	0
C	0	1	0	0	0	0	0	0
D	1	0	0	0	0	0	0	0
E	1	1	1	0	0	0	0	0
F	0	0	1	0	0	0	0	0
G	1	1	1	1	1	1	0	1
H	1	0	1	0	1	0	1	0

[§378] The musical use of this last option could be to accent certain notes or series of notes. For this, one could imagine that a number of combinations could be saved in order to switch quickly to alternative series of notes. For improvisations based on tone-rows, this could be especially interesting. In this context, one could also think of tone-rows which a tessitura of less or more than an octave. One would also be able to keep notes entirely unassigned: all stops would be inactive on that key (for improvisations along the lines of: ''find the sounding notes (or tone row)". Another use could be the construction of rhythmic structures with the sounding notes through the additional use of the non-sounding notes.

Midi channels

[§379] As a consequence of the fact that the organ has multiple manuals and a pedalboard, it is common sense to assign a Midi channel to each. The addition of an additional midi channel to control external midi devices might also be considered. This would only work via Midi out.

[§380] All stops belonging to each manual/pedal would be assigned a controller number. In order to save the whole organ in a certain setting, an additional midi channel might be considered in which a "program change" midi message can be sent or saved. The organ has an IN connector to which other midi keyboards can be connected. This allows the playing of the organ by two or more players. The GUI would allow one to determine whether a manual would send Midi (or not in the event that you would rather use midi in to play the organ from a keyboard). Player A would play the organ's first manual via MIDI, therefore, while the organist would play the rest of the organ from the console.

Local on/off

[§381] The organ should also feature a Local on/off option (which would default to on). If Local Off is engaged, the midi codes from the manuals (notes either on or off) would not be sent to the organ but only to midi OUT. As a result the organist would hear nothing but the midi data would, nevertheless, be sent. Using a computer would then allow the information to be manipulated and the revised data sent back to the Midi In connector on the organ thus playing the organ "externally". Examples of the required software would include MultiVoicer and Serializer programmes. MultiVoicer can create chords per midi channel from single played notes. Serializer allows played notes to be arranged in tone rows or chords in a midi channel. When using this last option, it is useful not to be able to hear the notes because these can come into conflict with the composition of the tone row. An example of the use of Serializer could be as follows: You play the pedal note C (let's assign it to midi channel = 3). Local on/off = off. You do not hear this note when you play it. The midi note is sent via midi out to a laptop (via the laptop's midi in connector) and is there processed as a note from a 12-tone row. For example, the note C# could become Midi channel = 1. If you then send this note via the laptop's midi out connector to the organ's midi in connector, you would hear the note C# on the manual. If you then repeat this 12 times with the same C on the pedal you will hear a 12-tone row on the manual.

Recording with MIDI

[§382] Through the use of midi, it is possible to make a complete recording of an organ recital. The organ send the data to a midi recorder. By reversing the process, in other words by letting the midi recorder play the organ, you would hear back precisely what was played by the organist. This is of course a better recording process than simply using microphones and an extra advantage of using MIDI is that editing becomes possible. If you play a wrong note, this can be corrected before being played back by the organ. Playing back via MIDI can also be used to facilitate playing with other organs or instruments. You can also overdub a recording, in other words play something over the recording and record this too. Midi manipulation offer a rich variety of musical possibilities in which the authentic sound of the organ is used.

External midi Mode

[§383] Regarding controlling extra midi equipment, one could imagine the following possibilities:

- The use of microphones inside the organ
- Controlling speakers (volume, on/off and routing)
- Use and control of cameras inside the organ
- Audio Effect equipment with midi control and other midi synthesisers
- Playing of midi synthesisers via an assigned midi channel
- Using this midi channel (or channels), tools such as program change, memory select, volume, send on load and soft thru for the control of synthesisers and other external equipment
- Permanent control, via midi control numbers and values, of a set of microphones inside the organ
- A number of faders/joysticks in order to direct, move and generally control video cameras inside the organ
- A number of faders with midi control for general use can be handy in order to influence equipment in realtime (acoustic effects, synthesisers etc). If a fixed combination of microphones is chosen, the control of these can be assimilated into the global midi channel

in the general settings of the organ by using a Program Change (patch setting). This has the advantage that use can be made of perpetually reproducible microphone settings. Separate faders with their own controller numbers and values would have to be available

[§384] General proposals:

- Microphone applications for recording and sound processing
- Contact-microphone applications on pipes and wind-chests for sound processing.
- Video cameras for recording, live coverage, observation of microphone placement within the organ
- Speakers for acoustic spatial reproduction

[§385] Through the use of (1) microphones, placed at the organ and/or hanging in the organ which can be moved automatically with help from cameras and controlled via the digital keyboard, and (2) contact microphones applied to certain stops, audio signals produced by parts of the organ can be sent using separate (3) microphone amplifiers to an (4) audio interface which would collect the information from each microphone separately in order to be able to mix it further via the computer. The outputs of the audio interface make it possible to place multiple speakers round the organ for acoustic reproduction.[1]

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1 RME make good digital equipment for multi-channel audio. For studio microphones (1) an 8-channel Octamic XTC with a MADI connection is an appropriate solution. For the contact microphones, various options are available. The M32 AD converter has 32 channels and a MADI connection. A cheaper option is the partner Ferrofish produced by RME. These have 16 channels AD and a MADI connection. The Octamic XTC (eight microphones) send signals via a MADI cable to (5) the MADIface XT. Two M32 AD converters can send signals from 64 (contact)-microphones via two MADI cables to (5) the MADIface XT. In addition, there is the option of using three MIDI I/O via MADI. The Madiface XT has three MADI in and out connectors and a USB 3.0 interface as well as a PCI express connector to which a Thunderbolt adapter can be attached. Using USB 2.0, it is possible to mix up to 70 channels. The MADI cables simplify the cabling to the computer. The advantage is that these cables can be very long without causing any faults. The MADIface XT (5)

[§386] The advantage of contact microphones in contrast to other microphones is the absence of crosstalk. The sound information from each pipe arrives separately in the mixer. For contact microphones, I have discovered the Measurements Specialities SDT Shielded Piezo Sensor SDT1-028K. This is a Piezo film sensor with a very large frequency response. The frequency response is often a problem with many contact microphones. These new film sensors offer better possibilities. Of course, it must be agreed with the organbuilders where on the pipe these elements could be attached.[2] An example of what you might do with the microphone signals. The channel after-touch midi information comes from the digital keyboard after the attack of a chord or note, when the key(s) remain depressed. In Midi, this provides the channel after-touch data. The degree of depression of the key determines the level of volume to the speakers. This makes it possible to introduce gradual changes in volume whilst playing. In the area of audio manipulation both live and offline, there are so many software possibilities that this can be left to the taste and insights of the composer or instrumentalist.

Additional proposal: placing the harmonic series under the keys of a midi keyboard

[§387] In the seventies of the last century the first commercial analog synthesizers appear on the market like the Mini Moog, ARP Odyssey and Oberheim. These synthesizers were all analog. They had a number of oscillators, filters and VCA's etc. There was no way to save your own sounds. Tuning the oscillators was always necessary and often needed while playing, because the oscillators started to drift in pitch when warming up.

comes with the TotalMix software (for Mac and PC) which has been produced to work with all RME audio interfaces. You now have a maximum of 196 inputs and 198 outputs. This mixing software makes it very easy to make all kinds of mixes (presets) in order to route microphones to speakers. In addition, the microphones being mixed on the computer can be sent to different speakers. Via midi it is also possible to change the mixing live.

2 Cf. http://www.liutaiomottola.com/electronics/bassducer.htm where this element is used on a double bass.

Several new designs and new sound synthesis methods were implemented after this period: in 1983 the first digital synthesizer the DX-7 by Yamaha with FM synthesis, sampling in 1985 on the Ensoniq Mirage. The PPG wave 2 was half digital (wave tables) and half analog (filters and so on) with a sequencer on board. The MIDI specification in 1983 made it possible for synthesizers and computers to communicate with each other. This is still the standard on most synthesizers.

[§388] Clavia came in 1995 with the Nord Lead, a digital "virtual analog" synthesizer. A synthesizer with all knobs sending and receiving midi data. For this synthesizer, I made special real time morphing software for PC. The knobs can be changed and recorded, but for every knob I made a timer and waveforms in software as well (midiMorph). All these midi changes create audio changes in real time. After the Nord Lead more generations of synthesizers followed with more polyphony and more synthesis methods in one keyboard. In the digital domain more and more virtual analog synthesizers and other equipment have become available in software. This process is still going on.

The importance of this historical development for musicians

[§389] The development of sound synthesis methods is enormous. More and more methods become available for the home studio and laptop and with very high quality. Multi track recording, effect sections, synthesizers, score writing, new instruments, plug-ins, the list is endless. Through all this, understanding of the construction of sounds and knowledge about sound synthesis is growing among musicians, producers, composers and dj's. Also special exclusive audio techniques are becoming mainstream. Like spectral synthesis in real time and manipulation of overtones.

The significance of having an option to play the harmonic series on a midi keyboard

[§390] The organ-, piano keyboard has been and still is the standard. Over many years pianists, organists and composers have been educated and trained in its use. The keyboard generates the equal tempered tuning with the A mostly 440 Hz. The Central C is key 60 in the Midi specification. The grand piano has 88 keys from a low A (key 21) till the high C (key 108). On the other hand the overtone series is very important in music experience and music playing. For instance, brass players explore these series by over-blowing (around 16 overtones). By using valves or sliding on a trombone the fundamental can be changed. String players know the partials by playing so called (artificial) harmonics. The double bass is well known for its rich range of overtone production. With my group ZEQ-Attack in collaboration with the double bass player Quirijn van Regteren Altena we expanded this instrument with midi on every string. With support from the Royal Conservatory of the Hague we are developing new software for this instrument.

[§391] On the other hand the harmonic series itself is not exactly playable on a midi keyboard. To find out these possibilities on a midi instrument it would be very convenient to have a method to play the harmonic series chromatically on the keyboard. In this manner the keyboard player could explore the rich palette of the harmonics and find new ways of playing. Overtone chords can be explored on the midi keyboard.

[§392] In general you can say that this is not only important in music theory lessons at conservatories and music schools, but it is also challenging for musicians and composers to experiment. The expansion of music by micro tones derived from harmonics, promises to become a very intriguing development.

[§393] For the new baroque organ I suggest one new harmonic register with 61 (4th-64th harmonic) pipes connected chromatically to the midi keyboard built on the fundamental C. If you want all fundamentals in one octave twelve registers had to be build, one for every fundamental. Here is a layout showing the placing of the harmonics under the midi keyboard with all midi notes rounded in cents. One is for the organ another is for a grand piano midi keyboard with option to choose the fundamental by a key (yellow part):

Mapping harmonics onto a midi keyboard

By Ernst Oosterveld. Proposal Colloquium Baroque Organ 2014-05-17, location Orgelpark, Amsterdam

Definitions in midi note nrs (mnn = Cents/100):

Harmonic(fundamental, 1) = fundamental

Harmonic(fundamental, n) = fundamental + Offset(n)

Offset(n) = 12 * ^{2}log(n)

Select fundamental :	Keyboard	MidiKey
9	A	21
10		22
11	B	23
12	C	**24**
13		25
14	D	26
15		27
16	E	28
17	F	29
18		30
19	G	31
20		32
21	A	33
22		34
23	B	35
24	C	**36**
25		37
26	D	38
27		39
28	E	40
29	F	41
30		42
31	G	43
32		44
33	A	45
34		46
35	B	47
	C	**48**
		49
	D	50
		51
	E	52
	F	53
		54
	G	55
		56
	A	57
		58
	B	59
	C	**60**
		61
	D	62
		63
	E	64
	F	65
		66
	G	67
		68
	A	**69**
		70
	B	71
	C	**72**
		73
	D	74
		75
	E	76
	F	77
		78
	G	79
		80
	A	81
		82
	B	83
	C	**84**
		85
	D	86
		87
	E	88
	F	89
		90
	G	91
		92
	A	93
		94
	B	95
	C	**96**
		97
	D	98
		99
	E	100
	F	101
		102
	G	103
		104
	A	105
		106
	B	107
	C	**108**

Preferred mapping of harmonic offsets:
put nr. 16 (offset is 4 octaves) at
midi key 60 (central C in normal use),
as the offset increases approximately
chromatically around nr. 16
(harmonics 1-3 not implemented for lack of space)

(choose fundamental for this sheet) 12 (input)

Harmonic nr. n	(mmn)	Offset
1	12	0
2	24	12
3	31,02	19,02
4	36	24
5	39,86	27,86
6	43,02	31,02
7	45,69	33,69
8	48	36
9	50,04	38,04
10	51,86	39,86
11	53,51	41,51
12	55,02	43,02
13	56,41	44,41
14	57,69	45,69
15	58,88	46,88
16	60	48
17	61,05	49,05
18	62,04	50,04
19	62,98	50,98
20	63,86	51,86
21	64,71	52,71
22	65,51	53,51
23	66,28	54,28
24	67,02	55,02
25	67,73	55,73
26	68,41	56,41
27	69,06	57,06
28	69,69	57,69
29	70,3	58,3
30	70,88	58,88
31	71,45	59,45
32	72	60
33	72,53	60,53
34	73,05	61,05
35	73,55	61,55
36	74,04	62,04
37	74,51	62,51
38	74,98	62,98
39	75,42	63,42
40	75,86	63,86
41	76,29	64,29
42	76,71	64,71
43	77,12	65,12
44	77,51	65,51
45	77,9	65,9
46	78,28	66,28
47	78,66	66,66
48	79,02	67,02
49	79,38	67,38
50	79,73	67,73
51	80,07	68,07
52	80,41	68,41
53	80,74	68,74
54	81,06	69,06
55	81,38	69,38
56	81,69	69,69
57	81,99	69,99
58	82,3	70,3
59	82,59	70,59
60	82,88	70,88
61	83,17	71,17
62	83,45	71,45
63	83,73	71,73
64	84	72

Preferred mapping of harmonic offsets:
for a 5 octave midi keyboard [range 36..96]
(harmonics 1-3 not implemented
for lack of space)

(mmn)	Offset	Harmonic nr. n
12	0	1
24	12	2
31,02	19,02	3
36	24	4
39,86	27,86	5
43,02	31,02	6
45,69	33,69	7
48	36	8
50,04	38,04	9
51,86	39,86	10
53,51	41,51	11
55,02	43,02	12
56,41	44,41	13
57,69	45,69	14
58,88	46,88	15
60	48	**16**
61,05	49,05	17
62,04	50,04	18
62,98	50,98	19
63,86	51,86	20
64,71	52,71	21
65,51	53,51	22
66,28	54,28	23
67,02	55,02	24
67,73	55,73	25
68,41	56,41	26
69,06	57,06	27
69,69	57,69	28
70,3	58,3	29
70,88	58,88	30
71,45	59,45	31
72	60	32
72,53	60,53	33
73,05	61,05	34
73,55	61,55	35
74,04	62,04	36
74,51	62,51	37
74,98	62,98	38
75,42	63,42	39
75,86	63,86	40
76,29	64,29	41
76,71	64,71	42
77,12	65,12	43
77,51	65,51	44
77,9	65,9	45
78,28	66,28	46
78,66	66,66	47
79,02	67,02	48
79,38	67,38	49
79,73	67,73	50
80,07	68,07	51
80,41	68,41	52
80,74	68,74	53
81,06	69,06	54
81,38	69,38	55
81,69	69,69	56
81,99	69,99	57
82,3	70,3	58
82,59	70,59	59
82,88	70,88	60
83,17	71,17	61
83,45	71,45	62
83,73	71,73	63
84	72	64

Abstract

Regarding the digital features the new baroque organ at the Orgelpark may provide, I would propose to look into the MIDI options of the digital console. An idea might be to work with the touch sensitivity of the keys. It allows, for example, to control the number of pipes sounding per key. It would be possible as well to combine stops per key in such a way that some of the keys are sounding stronger than others. It would, furthermore, be possible to program the keys in such a way that nothing sounds in the first instance, but have the data produced by the keys processed by a computer nonetheless, which then sends data to the organ, making it sound yet. This may, for example, allow to play chords with only one key or to apply seriality one way or another. I developed for both ways of making music the applications multiVoicer and Serializer respectively. External MIDI control might as well be organized by using microphones, cameras in the organ, synthesizers, speakers etc. Being able to save and recall complete set-ups would be a welcome feature. It would be useful to equip the organ with a ‘harmonic stop’: a set of 61 pipes that produce the fourth to the 64th harmonic. These pipes would allow to play ‘overtone chords’, which might be a challenging feature for improvisers.

Ernst Oosterveld

Ernst Oosterveld is composer (he studied with Theo Loevendie and Klaas de Vries at the Rotterdam Conservatory) and multi-instrumentalist. He studied as well with Gottfried M. Koenig and Paul Berg at the “Instituut voor Sonologie” at Utrecht University. Ever since the introduction of the Apple II, he has been exploring the the ways computers might be used in art. He developed, for example, wireless tap dance shoes with MIDI control and graphics; projecting letters (poems) via a MIDI-vibraphone; a hybrid double-bass; several music software applications such as multiVoicer, Serializer and midiMorph. midiMorph refers to both music morphing and algorithmic music; the application is a work in progress. The latest addition is generate WaveMusic, which is a module that allows to control musical parameters by manipulating

wave forms. As a composer, Ernst Oosterveld wrote both post serial and aleatoric pieces, assigned by ensembles such as ASKO | Schönberg. Reacting to the music by Webern, Boulez, Messiaen, Penderecki and Xenakis, Oosterveld wrote Exchanges, a composition for two pianos and large orchestra, including a cluster of 85 tones. With Quirijn Regteren Altena, Ernst Oosterveld forms the basis of the ensemble ZEQ-Attack. It researches new ways of making music with guest musicians, including free improvisation, pattern music morphing, wave music, hybrid instruments etc.; yet, the musician and musicality remain the main focus in Ernst Oosterveld’s music.