

Synergy of Form, Rhythm, and Orchestration in Three Microtonal Compositions

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## ABSTRACT

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Microtonal pitch systems have musical implications beyond the organization of pitch, suggesting the possibility of functioning symbiotically with orchestration, rhythm, and form in a musical work. This essay focuses on three compositions, each of which approaches tuning and microtonality in a unique way: *The Delusion of the Fury* (1969) by Harry Partch, *Limited Approximations* (2010) by Georg Friedrich Haas, and *Asking Ocean* (2016) by Marc Sabat. After a general analysis of the pitch materials in these three works, passages of music are examined and compared to illustrate how pitch systems, especially those in extended just intonation, inform orchestration, rhythm, and form, exploring how these composers balance the practical considerations of writing microtonal music with artistic intent. This essay argues that the success of these three works relates to a sensitivity toward the limitations and possibilities of their novel approaches to microtonal pitch organization.

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This dissertation is dedicated to my children, Thora and Victor.

## INTRODUCTION

“In the case of music that uses microtonal tunings and therefore a relatively unfamiliar set of pitch materials, the nature of the model or representation of the pitch space may significantly affect aspects of compositional thinking. The study of such models is thus not a sterile exercise in abstract theory but a necessary starting point for a detailed understanding of the music itself.”<sup>1</sup> —Bob Gilmore

After developing for more than a century, beginning as an experimental field and only gradually gaining widespread use, microtonality is now widely accepted by performers of contemporary music, taught widely in universities and conservatories, and commonly implemented by composers in a variety of ways. The various approaches to pitch developed by the seminal microtonal composers of the twentieth century have been thoroughly explored and analyzed, with a moderate to great amount of research on the music and theories of Antonio Alba, Gérard Grisey, Tristan Murail, Harry Partch, James Tenney, Ivan Wyschnegradsky, La Monte Young, and others. But how these approaches to pitch adjust compositional thinking, musical syntax, and the creation of new expressive and semiotic possibilities has been largely unexplored. Among the books and articles consulted for this dissertation there exists an abundance of pitch-system analysis but almost no investigation into the aesthetic ramifications of the pitch systems being discussed. In the quotation above, Gilmore claims that the organization of pitch influences all aspects of a composition, an idea that he has presented as a truism, but the question of *how* is left unanswered. This essay does not argue a historical imperative—that new principles of pitch organization *demand* new principles of orchestration, rhythm, and form. Indeed, traditional principles of organizing a musical work may be revitalized by novel approaches to pitch. Instead, this essay will demonstrate how microtonal pitch structures expand and enrich existing musical paradigms while simultaneously opening the possibility of new paradigms. A holistic conception

of a musical work, which includes considerations for the novel pitch materials, leads to aesthetically convincing microtonal music.

This essay considers microtonal pitch structure, largely focusing on extended just intonation, and its relationship to orchestration, rhythm, and form in the context of musical works. The goal is to analyze symbiotic relationships between musical elements arising from extended just intonation or other microtonal pitch systems, focusing on the following three compositions:

*The Delusion of the Fury*, Harry Partch (1969)

*Limited Approximations*, Georg Friedrich Haas (2010)

*Asking Ocean*, Marc Sabat (2015)

These three pieces share the common element of microtonality but each takes a unique approach. The Partch and Sabat pieces are conceived entirely in extended just intonation, whereas Haas draws upon a small set of approaches to microtonal pitch organization, not strictly just intonation. Nevertheless, I will rely on extended just intonation and an understanding of pitch that is based upon frequency ratios to analyze these works. The analysis will focus on sections of these three works that best demonstrate holistic connections between microtonal organization of pitch and the other musical elements. As a result of this focus, only select aspects of these extensive works will be discussed in detail.

*The Delusion of the Fury* by Harry Partch takes the form of two thematically related music theater works with an overture, entitled *Exordium*, and an interlude, the *Entr'acte* instrumental pieces. In the tradition of ancient Greek drama, tragedy is followed by comedy. Although the two acts contain two separate stories, both revolve around the theme of coming to terms with the nature and futility of anger. For this analysis of *The Delusion of the Fury*, the



*Exordium* will be the focus along with selected moments from throughout the remainder of the work. *The Delusion of the Fury* has the following form:

**Exordium** (instrumental)

**Act I:** Delusion of the Fury (based on *Atsumori*, a Noh play by Zeami Motokiyo)

**Entr'Acte** (instrumental)

**Act II:** Justice (based upon an Ethiopian folk story)

*Asking Ocean* by Marc Sabat is a large-scale piece that is approximately 50 minutes in duration, scored for solo string quartet with large ensemble. This work is in seven movements, mostly played without pauses between movements:

**I** - Prelude (tuning)

**II** - Pythagoras Drawing 1

**III** - Harmonium for Claude Vivier

**IV** - Interlude (intonation)

**V** - Harmonium for Ben Johnston

**VI** - Trill Flowers Fell

**VII** - Pythagoras Drawing II

*Limited Approximations* by Georg Friedrich Haas is a single-movement piece lasting approximately 30 minutes, scored for large orchestra and a solo ensemble of six pianos, each tuned down a twelfth of a tone to create a 72tet complement. *Limited Approximations* contains three internal sections.

## CHAPTER 1: SUMMARY OF PITCH ORGANIZATION

“I have always said that I’ve never found two microtonalists who have the same reason for using microtones, or who use the same method for composing with them.”<sup>2</sup>  
—Kyle Gann

If there is a tradition of just intonation, it is one that resists establishing or promoting any specific approach to pitch. Composers associated with just intonation each construct their own microtonal world, holding only the basic idea that intervals may be meaningfully expressed as whole-number ratios between their frequencies. The music of Partch, Johnston, Tenney, Young, and Sabat have few commonalities, in the way that Brahms, Boulez, and Hammersmith are all 12tet composers but the system of tuning is only a small part of their overall approach to composing music.

The lack of a consistent tradition in just intonation music derives from a belief that each composer should develop their own personal voice from the ground up, not taking anything for granted and questioning the most basic assumptions, including pitch organization and tuning. Indeed, while Ben Johnston lived in a pseudo-apprenticeship situation in Gualala, California, with Harry Partch, he was told by Partch that “If [he] or anyone else ever claimed to be a student of his, he would cheerfully strangle us.”<sup>3</sup> Partch did not shy away from discussing his own music and ideas around intonation, but he never took composition students and rejected the idea that other composers should write music like his. This hyper-individualism has had a lasting effect on just intonation composers, and indeed the same pressures of building a personal musical syntax is an ongoing theme for most composers from the postwar period onward.

Keeping in mind that each composer who desires to write microtones are encouraged to create their own approach, the first step toward a broader analysis of the three works is providing an overview of the pitch organization in each composition. The goal is to summarize and define

the pitch organization to develop a general understanding that may then be referred to in later chapters. This will not be an exhaustive analysis of the pitch systems at play, but it is a necessary first step toward the objective of discussing pitch in a wider context, opening a path toward the larger ideas presented by the music.

Regarding the notation of microtones, this essay will use a combination of cents and ratios to express pitch and interval. Each of the three composers uses their own system of notation and unique accidentals. To avoid confusion and help with readability, I will avoid these idiosyncratic accidentals and notational practices. The one exception is *Limited Approximations*, where the 72tet allows for a simpler system of accidentals showing quarter, sixth, and twelfth tones. The 72tet accidentals are provided in Appendix A, a brief glossary of microtonal and just intonation nomenclature.

### **1.1 - *THE DELUSION OF THE FURY*, HARRY PARTCH**

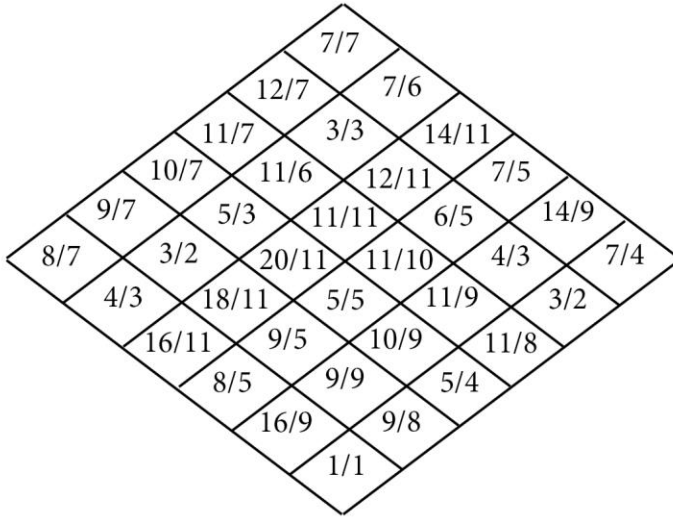
*The Delusion of the Fury* is written in tablature notation, almost always requiring transcription to first uncover the pitches in the score before any pitch-based analysis is possible. The musical figures that appear in this essay derived from *The Delusion of the Fury* have all been transcribed by the author. Additionally, appendix B is a complete transcription with some analytical annotations of the *Exordium*, also realized by the author.

The pitch organization in *The Delusion of the Fury* adheres to Partch's lifelong implementation of his uneven 43-notes-per-octave scale as a structural core. This scale is derived from a combination of 11-limit JI with various additional intervals from outside the 11-limit system to fill out the larger intervals between steps in the scale while maintaining overall symmetry around the tritone. The basic 11-limit JI produces 29 notes per octave, which Partch

then fills out with 14 additional intervals from outside the 11-limit collection. These additional intervals make the notes of the scale more evenly spaced and allow for enhanced tonicization of notes other than the 1/1 via secondary relationships. For example, one of the filler intervals from outside the 11-limit is 33/32, which is the 3/2 of the 11/8 interval and as such may be used to tonicize the 11/8 through this consonant relationship. For practical reasons, mainly regarding the design of his customized orchestra of original instruments, Partch uses a fixed-pitch system based on a G fundamental (1/1). The entire scale, with the filler intervals in bold, is provided in figure 2.

The core group of 29 intervals are arranged in the tonality diamond in figure 1, grouping the intervals by shared numerators and denominators in interconnecting diagonal rows. Partch describes the method of organizing intervals by shared numerators and denominators as over-tonalities and under-tonalities (O-tonalities and U-tonalities). Reading the tonality diamond (figure 1) from left to right, the upward-slanting rows provide the O-tonalities and the downward-slanting rows the U-tonalities. In other words, common denominators are grouped as O-tonalities and shared numerators are grouped as U-tonalities, with the minimum of two identities of each interval as shown visually in the grid. For example, the 12/7 interval has two identities as a member of the 12U-tonality and the 7O-tonality. Other intervals may belong to more than two of these O- and U-tonalities, the most obvious example being the 1/1, which is part of every possible O- and U-tonality, and the 4/3 intervals, which are part of the 3O-tonality, 1U-tonality, 3U-tonality (as 12/9), and 9O-tonality (as 12/9).

Figure 1: The 11-limit JI tonality diamond of 29 intervals



The nature of the type of just intonation system that only uses a single root note without secondary relationships (for example, the  $5/4$  of the  $5/4$  is not present nor the  $3/2$  of the  $9/8$ ), means that the more consonant the interval is, the larger the interval gap there is around it. This single-root JI formulation is known as a Farey system, which results in a perfectly symmetrical but very uneven scale. For example, the interval between  $1/1$  and the second scale degree,  $12/11$  is  $12/11$  (150.6c), whereas the following step between the second and third scale degrees from  $12/11$  to  $11/10$  is less than  $1/10$ th the size, a comma of  $121/120$  (14.4c). This was evidently problematic for Partch, so he filled in the larger gaps with intervals outside the strict 11-limit system. Figure 2 provides the “filler” intervals in bold font in a table. There are four intervals added between  $1/1$  and  $12/11$  and the inverse of  $11/6$  and  $2/1$ . There are single filler intervals added between the  $7/6$  and  $6/5$ ,  $9/7$  and  $4/3$ ,  $4/3$  and  $11/8$ ,  $16/11$  and  $3/2$ ,  $3/2$  and  $14/9$ , and  $5/3$  and  $12/7$ . Each of these filler intervals provides a secondary relationship to another interval in the scale; for example, the  $15/8$  interval is the  $3/2$  of the  $5/4$  and may be used to further harmonize or even tonicize the  $5/4$ .

Figure 2: Intervals in the Partch scale from outside 11-limit JI, new intervals in bold

Cents	0	<b>21.5</b>	<b>53.2</b>	<b>84.5</b>	<b>111.7</b>	150.6
Ratio	1/1	<b>81/80</b>	<b>33/32</b>	<b>21/20</b>	<b>16/15</b>	12/11

Cents	266.9	<b>294.1</b>	315.6
Ratios	7/6	<b>32/27</b>	6/5

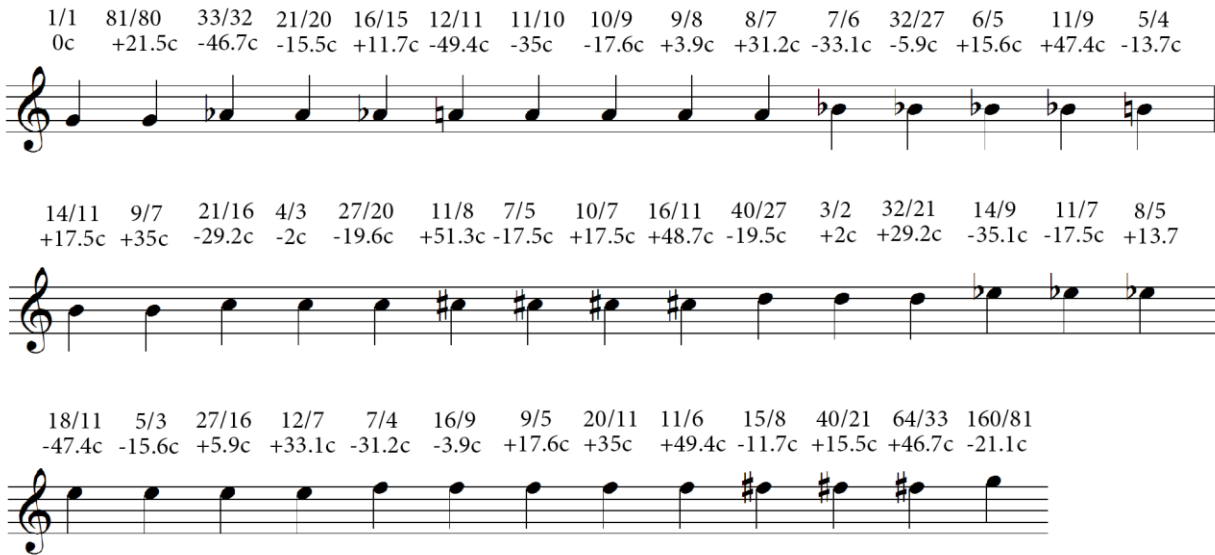
Cents	435.1	<b>470.8</b>	498.0	<b>519.2</b>	551.3
Ratio	9/7	<b>21/16</b>	4/3	<b>27/20</b>	11/8

cents	648.7	<b>680.5</b>	702.0	<b>829.2</b>	764.9
ratio	16/11	<b>40/27</b>	3/2	<b>23/21</b>	14/9

cents	884.4	<b>905.9</b>	933.1
ratio	5/3	<b>27/16</b>	12/7

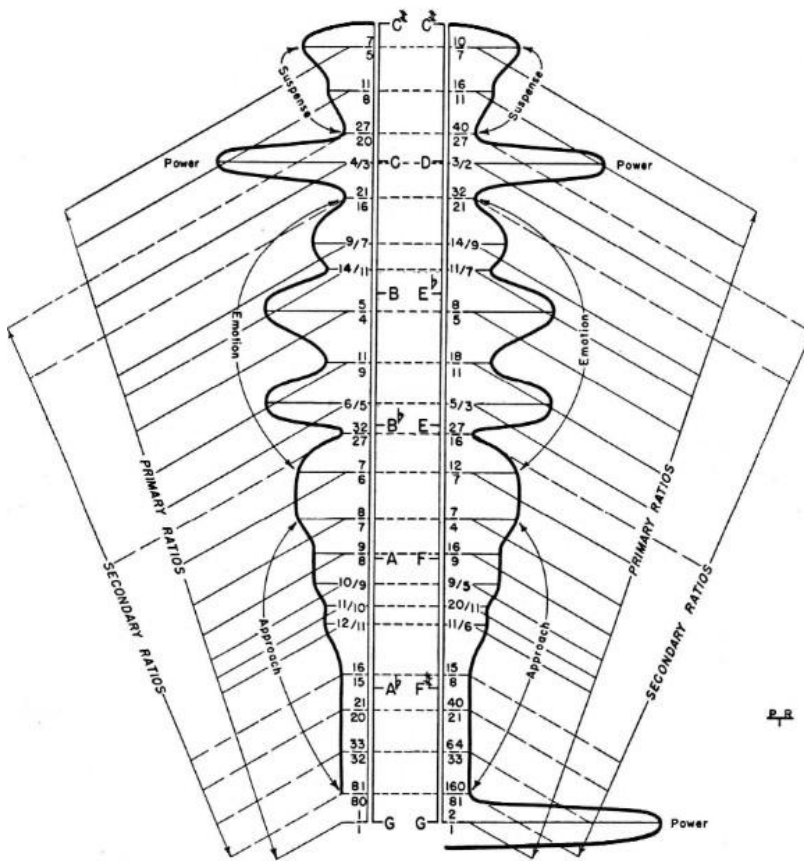
cents	1049.4	<b>1088.3</b>	<b>1115.5</b>	<b>1146.8</b>	<b>1178.5</b>	1200
ratio	11/6	<b>15/8</b>	<b>40/21</b>	<b>64/33</b>	<b>160/81</b>	2/1

Figure 3: The Partch scale of 43 notes per octave in traditional notation with cent deviations from 12tet



The resulting 43-notes-per-octave scale is rich enough to closely approximate just intervals in many keys, and indeed Partch more often tonicizes notes other than the 1/1 (G) in *The Delusion of the Fury*. The complete scale is shown in figure 3 as the nearest pitch in traditional notation with both the interval ration and deviation from 12tet in cents provided above each note. Partch also describes his scale according to expressive, extra-musical classification, in a graph he calls “The One-Footed Bride,<sup>4</sup>” shown in figure 4. The graph provides an interesting glimpse into Partch’s subjective understanding of interval as well as the primary and secondary connections between the intervals in the scale.

Figure 4: From Partch, “The One-Footed Bride,” a graph of comparative consonance



“The One-Footed Bride” also visualizes the symmetrical nature of Partch’s scale: when reading from bottom to top, the graphic provides an ascending scale on the left side and a descending scale on the right side. The subjective, expressive characteristics that Partch ascribes to interval regions is therefore also in parallel, the sixths and thirds appearing in the “emotion” region of the chart, for example. In Partch’s conception, diatonic scale degrees become regions with expressive qualities and various possible shadings of pitch beyond the minor and major variants of tonal music: seconds and sevenths represent “approach,” thirds and sixths are “emotion,” perfect intervals are “power,” and the tritone region between but not including the 4/3 and 3/2 is “suspense.” Partch fleshes out these ideas in greater detail in his treatise, *Genesis of a*



*Music*, but the brief introduction provided here will be sufficient for the purposes of this essay.

As Partch's music is always in service of a narrative text, the expressive content of these intervals form an essential part of the meaning he creates through his music.

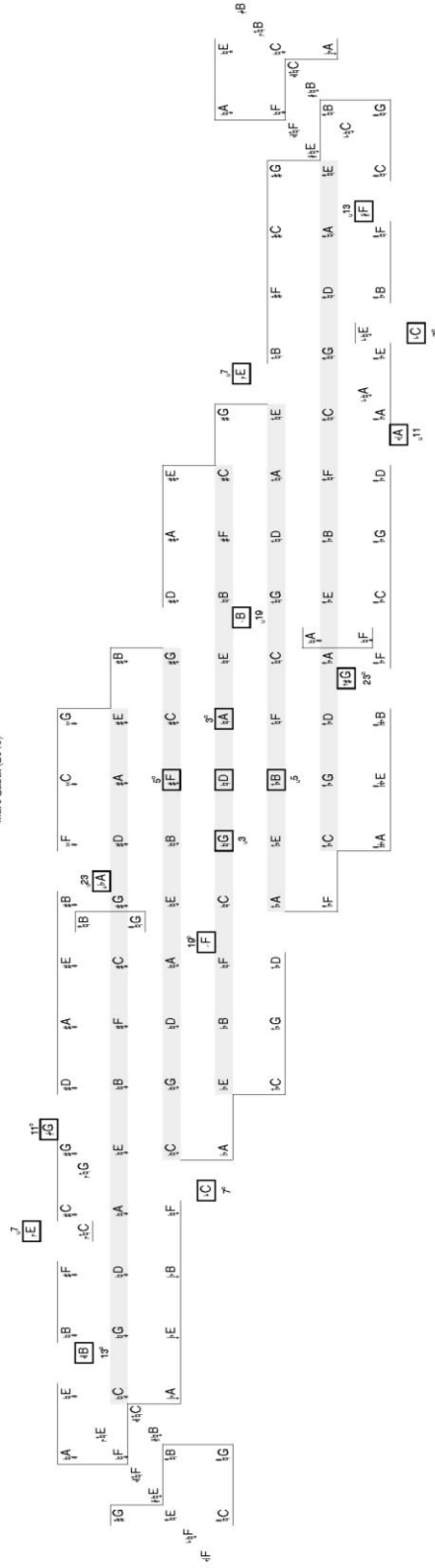
## **1.2 - ASKING OCEAN, MARC SABAT**

In *Asking Ocean*, Sabat draws upon a vast and rich microtonal system, nearly limitless in possibility and geared toward both a general flexibility as well as realizing his specific conceptions of tunable JI intervals and triadic JI harmony to their fullest potential. This pitch system derives intervals from a 53-tone 5-limit Euler lattice with additional 46 enharmonic border tones that complete major and minor triads of the 53 aforementioned tones as well as the 23-limit harmonics and subharmonics from D. Furthermore, the extremities of the Euler lattice are extended by a series of syntonic commas ( $81/80$ ) that further enhance pitch gradation and the variety of available just triads as well as forming near enharmonic equivalents to other pitches within the lattice and border tones. This extended Euler lattice is provided in figure 5.

Figure 5: The 5-limit Euler lattice with 23-limit harmonics<sup>5</sup> (from the *Asking Ocean* score)

53-TONE 5-LIMIT EULER LATTICE (SHADED) WITH 46 ENHARMONIC BORDER TONES & 23-LIMIT HARMONICS / SUBHARMONICS FROM D

Marc Sabat (2016)



The near-enharmonic equivalents included in this Euler lattice may then further harmonize notes within the system as well as pivot to distant regions of the lattice, shifting their harmonic function to another identity with virtually the same pitch. Sabat provides a summary of the intervals in this 23-limit extended JI system in the front matter of his scores and explains the rationale for his approach to pitch in a brief article, “Three Tables for Bob,”<sup>6</sup> which goes into greater detail regarding the principles behind his pitch system and the notation of his music using the accidentals of the extended Helmholtz-Ellis JI pitch notation.<sup>7</sup>

Each movement of *Asking Ocean* implements a unique collection of intervals or a basic harmonic idea that draws upon the expansive range of intervals within Sabat’s system. For example, the first movement, *Prelude (Intonation)*, focuses on a series of modulations beginning on A ( $3/2$ ) and descending by  $3/2$  intervals three times down to a C ( $16/9$ ). The sense of tonal center is created through a collection of 11-limit intervals that establishes the bass note as the root, fading in and out smoothly and transposing en masse as the bass note changes.

The inclusion of the enharmonic border tones ensures that each pitch in the Euler lattice may be harmonized with a variety of triads and every pitch may be the root of the just major triad (6:5:4). Indeed, an essential component of forming a scale using a Euler lattice is the high degree of acoustic consonance that can be formed around any pitch in the scale. Exactly what limit the JI composer sets is ultimately arbitrary. Partch, using an extended form of the 11-limit, came nowhere near exhausting the possibilities of his scale. Likewise, Sabat’s 23-limit harmonics and 5-limit Euler lattice represent a wealth of harmonic possibilities, virtually endless in number. More importantly, their scales should be understood as reference points rather than closed systems. For example, if Partch uses a slide on one of his stringed instruments, he will end up writing pitches that are outside the scale as an entire chord may be transposed uniformly;

however, these new pitches still exist within the logic behind the creation of the scale. Lastly, the 23-limit harmonics and subharmonics may function as pivot points to more remote areas of the Euler lattice, as noted by Marc Sabat: “The higher prime consonances may be considered as ways of more directly leaping to distant regions of the Euler lattice with slight enharmonic variations of intonation.”<sup>8</sup>

Sabat’s pitch system is powerful in its ability to create cycles of modulations by drawing upon near enharmonic equivalents (skisma). These minuscule shifts by skisma are a way Sabat explores the phenomenon of microtonal drift that is inherent to modulation in any JI system. Stacking a just interval will almost never return to the original pitch class, and this is the reason for the wolf tones in a Pythagorean scale or the many meantone solutions, eventually leading to the development of 12tet for complete modulation equivalency. The fifth movement of *Asking Ocean, Harmonium for Ben Johnston*, features a series of triads that modulates via common-tone relationships in a lengthy progression that cycles through the entire 53 central notes of the 5-limit Euler lattice and their 46 enharmonic peripheral neighbors, taking advantage of a near equivalency of the E raised by two syntonic commas with the F lowered by two syntonic commas at m. 100. The difference between these two pitches is 4.2 cents, a nearly imperceptible skisma, allowing Sabat to continue the series of modulations while remaining within his system of microtonal notation and avoiding microtonal drift. When one moves beyond theoretically ideal tunings to the playing of real instruments, there is always some leeway in terms of accuracy, generally referred to as the just noticeable difference, which is dependent on the context, but is usual placed at roughly 3 cents.<sup>9</sup>

### 1.3 - LIMITED APPROXIMATIONS, GEORG FRIEDRICH HAAS

In contrast to Partch and Sabat, Haas does not look to just intonation as a basis for harmony and ascribes no inherent importance to pure intervals, even describing the overtone series that informs so much of his musical language as a construction that is “as artificial as any other musical material.”<sup>10</sup> This statement is illuminating in the analysis of *Limited Approximations*, as Haas mixes several approaches to pitch fluidly and does not cohere to any systematic organizational principles in regards to microtonality. Although Haas may not have been considering his notes in terms of JI while composing, it is nonetheless a useful, though sometimes limited, tool for analysis. Indeed, one has a sense of a more improvised approach to pitch in *Limited Approximations* as compared to Sabat and Partch, perhaps stemming from his understanding of microtones after a lifetime of exploring microtonality through composition. Haas was certainly aware of the music and theories of Partch, Tenney, and other prominent JI composers, but his approach to pitch in general is purposely non-systematic.

In *Limited Approximations*, Haas doesn't set a static scale, instead working with various approaches to pitch within a 72tet system, often approximating just intervals. The title, *Limited Approximations*, refers to the 72tet tuning of the pianos and their ability to attain just intervals with a reasonable degree of accuracy. 72tet divides the semitone in six equal parts, or 16.7 cents, and can therefore play any desired pitch with a maximum deviation of 8.3 cents. More importantly, 72tet can approximate any interval in an 11-limit JI collection within 3 cents, a characteristic of 72tet that is outlined by James Tenney in his article on *Changes*, his piece for six harps in 72tet.<sup>11</sup> As a shift of 3 cents constitutes a skisma too minute to be heard as two discrete intervals in almost any context, 72tet is thus adept at realizing 11-limit JI while maintaining an ease of modulation and tonicization for any note in the 72tet collection. However,

the 13th partial, being 41 cents higher than a 12tet minor 6th, is impossible to approximate in a convincing way in 72tet as it is located almost equidistantly between the minor sixth plus a third of a tone and the minor sixth plus a quarter of a tone. This inability to produce the 13th partial in 72tet may enrich the meaning of the “limited” in the title of *Limited Approximations*.

As a final general characteristic of 72tet, there is a certain practicality in terms of instrumentation as 72 is a multiple of 12, which means that 72tet can be attained by a combination of uniformly transposed tempered instruments, as Haas does with the pianos in *Limited Approximations*. As a generalization, the 72tet system is more open and adaptable than the more precise and uneven JI systems of Partch and Sabat. With 72tet, one can approximate almost any interval and still retain an ability to change fundamental freely without altering how the new fundamental may be harmonized. Conversely, 72tet does not contain the variety of unique harmonic possibilities that arise as fundamentals shift to notes in the scale other than the 1/1, and this asymmetric array of pitches in the works by Sabat and Partch produces unique and interesting musical results.

Haas takes advantage of many of the possibilities presented by 72tet. Instead of a set scale or collection of intervals, Haas explores the following four elements or approaches to pitch:

1. Overtone chords, often with added notes
2. A 12tet chord made from alternating perfect fourths and tritones
3. Microtonal clusters
4. Quasi glissandi created from segments of consecutive 72tet notes

In *Limited Approximations*, the overtone chord, shown in figure 6, is usually structured with prime number partials 1-3-5-7-11, with an additional tone that is related to a secondary root note, the most prevalent being 13/9 and 10/7. A contrasting analysis would be to understand these additional notes as high partials, the 23<sup>rd</sup> overtone in particular, which is approximately an 8<sup>th</sup>-tone sharp from a 12tet tritone. Adding secondary 3/2 intervals to the partials of the overtone series is a recurring idea in *Limited Approximations* and shows some similarity to Sabat's approach using the Euler lattice, with chains of 3/2 and 5/4 intervals. The second approach to pitch is the use of a recurring 12tet chord, also shown in figure 6. This harmony is structured as a repeated pattern of a tritone followed by a perfect fourth, these intervals stacked to eventually contain the entire chromatic set of 12tet. Another way of understanding the 12tet chord is as a tritone interval that repeats at the major 7th, which complements the idea of stretching and shrinking the octave that plays a role in this piece and is a fundamental aspect of spectral thinking in general.

Figure 6: JI chord and 12tet chord

The figure displays two musical staves. The left staff, representing the JI chord, has a treble clef and a key signature of one sharp (F#). It contains six notes with the following ratios: 7/4 (top), 13/9 or sharp 10/7 or outside harmony, 11/8, 5/4, 3/2, and 1/1 (bottom). The right staff, representing the 12tet chord, has a treble clef and a key signature of one flat (Bb). It contains six notes, each with a unique combination of accidentals, representing the 12 tones of the chromatic scale.

♭ - ♯ 1/4 tone flat or sharp

↓ - ↑ 1/6 tone flat or sharp

♭ - ♭ - ♭ - ♭ - ♯ - ♯ 1/12 tone flat or sharp

12tet and overtone-based approaches to tuning are not mutually exclusive and are often elided and superimposed in *Limited Approximations*. A combination of the overtone chord with 12tet harmonies reminiscent of the Second Viennese School constitutes an important feature of Haas's harmonic language, as can be heard in his violin concerto (1998), *in vain* (2000), *Blumenstück* (2000), and many other works. Haas discusses his interest in the clashing of different tuning systems within a single work, even mentioning the chord structure specifically used in *Limited Approximations*, stating “the contrast between temperament (in my case mostly tritone-fifth and tritone-fourth chords) and the overtone series was to exercise my mind in many of my compositions over the next thirty years.”<sup>12</sup>

The third pitch element, microtonal clusters, is defined as a group of at least two notes heard simultaneously where the intervals between adjacent notes are smaller than a semitone. The microtonal clusters in this work are mainly used to explore the perception of interval versus pitch bandwidth in different registers, which will be considered in depth in chapter 2.3 on orchestration.

The fourth and final approach to pitch is the multi-instrument glissandi, which are realized through shifts in pitch by 12th-tone increments. This technique involves dovetailing single pitches in a sequence where adjacent pitches are raised or lowered by a twelfth of a tone from one to the next. This technique provides the illusion of a glissando as a result of the slightness of the incremental changes in pitch. This technique can be heard in one of its most salient forms at m. 57 of *Limited Approximations*, shown in figure 7, where the pianos pass off octave tremolandi in rising twelfth-tone increments.



Figure 7: *Limited Approximations*, quasi glissandi at m. 57

The image displays a musical score for six pianos, labeled 1 through 6, arranged vertically. Each piano part is written on a grand staff (treble and bass clefs). The score shows a tremolandi cascade where each piano part enters with a tremolo and then moves upwards through the measures. The dynamics range from pianissimo (pp) to forte (f). The parts are retuned relative to each other, as indicated by the labels: 1. Klav. +1/6, 2. Klav. +1/12, 3. Klav. +/- 0, 4. Klav. -1/12, 5. Klav. -1/6, and 6. Klav. -1/4. The score is set in a key with two flats and a 3/4 time signature. The music features a series of tremolos that create a slowly rising cluster of tones across the six pianos.

As seen in figure 7, the tremolandi cascade upwards through the six retuned pianos, each fading in from pianissimo to a forte dynamic, creating the effect of a slowly rising cluster of tones. Similar passages occur throughout *Limited Approximations*, an excellent example of a musical idea that is only possible with the specific instrumentation and the 72tet tuning system that is being used.

## CHAPTER 2: ORCHESTRATION AND INSTRUMENTATION

Each of the three compositions discussed in this essay have contrasting instrumentations but share a number of key concepts and challenges in terms of orchestration. Most importantly, all three works are scored for acoustic instruments without the inclusion of electronic elements, and so each of the composers must deal with the physical limitations of pitch production on real instruments as opposed to the precision of a synthesizer. *The Delusion of the Fury* is scored for the full complement of Partch's custom-built orchestra of instruments requiring twenty-three performers. *Limited Approximations* is scored for six retuned pianos and large orchestra. *Asking Ocean* is scored for solo string quartet with a large ensemble of eighteen instruments. (*Asking Ocean* is an expanded version of Sabat's 2011 string quartet, *Euler Lattice Spirals*.)

Microtonal music presents a fundamental challenge regarding orchestration: Western instruments are typically designed to excel at playing in 12tet. Even when considering untempered instruments, like the violin or trombone, instrumentalists rarely study how to perform microtonal music within their conservatory or university training. A composer cannot simply write microtones freely and expect accurate results in performance but must address the practical challenges of realizing microtonal music in some way. In a sense, this is simply an intensification of the standard challenges of orchestration as one must be aware of the instruments and generally avoid writing things that are impossible for an instrument to play.

Partch, Haas, and Sabat each take a somewhat different approach to the problem of instrumentation. Partch's answer to the challenge is the most extreme, inventing new instruments and relying upon devoted, specialized performers who learn to play his inventions and read their novel tablature notation. In a related, but less extreme approach, Sabat physically alters the traditional Western instruments he writes for and expects a moderate understanding of just

intonation and just interval notation on the part of the performer. The expectation that a performer has studied just intonation would likely have been unrealistic when Partch began composing in the 1920s, but with a compositional practice spanning from the 1990s to today, Sabat has been able to work with a wide range of ensembles from around the world with considerable success. The way in which Haas extends 12tet, by creating six equally spaced divisions of the semitone, is perhaps the most approachable for traditionally trained performers. The 72tet system further divides the octave equally while maintaining 12tet as the structural backbone and point of reference, as 72 is a multiple of 12. Furthermore, Haas's use of pitch is generally simpler and more immediately comprehensible than Partch's or Sabat's, as Haas usually limits himself to the overtone series as opposed to a full array of JI intervals and presents his harmonies more sparsely. Haas's musical language favors a slower harmonic rhythm, with the music luxuriating on a single fundamental for longer than Sabat and Partch, which allows more time for performers to tune their microtonal intervals and audiences to perceive them. This chapter will detail these ideas further and demonstrate how each of these composers address the relationship between orchestration and pitch.

## **2.1 – CONFLUENCE OF THEORY AND INSTRUMENTATION IN PARTCH'S ORCHESTRA**

Unable to realize his musical ideas with traditional instruments, Partch built an orchestra of his own. The impetus is described by Philip Blackburn: "He gave voice the primary role and constructed the necessary instruments to support it."<sup>13</sup> Over the course of his lifetime, Partch built many types of tuned wooden, metal, and glass percussion instruments, reed organs, and altered fingerboards for guitars, violas, and cellos. Figure 8 provides an overview of these instruments, all of which are used in *The Delusion of the*

*Fury*. While some of Partch's compositions include traditional instruments, usually a clarinet and/or cello, *The Delusion of the Fury* uses only Partch's instruments along with several hand percussion instruments of South American and African origins.

Figure 8: An overview of Partch instruments

### Plucked String

Adapted Guitar 1  
 Adapted Guitar 2  
 Harmonic Canon 1  
 Harmonic Canon 2 (Castor and Pollux)  
 Kithara 1  
 Kithara 2 (bass kithara)

### Wood Percussion

Boo (Bamboo Marima)  
 Bass Marima  
 Marimba Eroica  
 Diamond Marima  
 Quadrangularis Reversum  
 Eucal Blossom  
 Gourd Tree  
 Cone Gongs  
 Xymo-Zyl (wood + glass)

### Glass and Metal Percussion

Cloud-Chamber Bowls  
 Xymo-Zyl (wood + glass)  
 Spoils of War (Glass and Metal)  
 Mazda Marimba

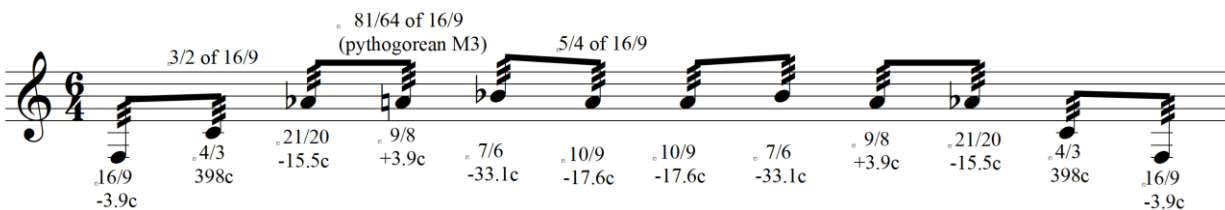
### Sustaining Instruments

Adapted Viola  
 Chromelodeon 1 (66-key Reed Organ)  
 Chromelodeon 2 (88-key Reed Organ)

Partch's instruments are not only able to play the pitches in his scale: the design of these instruments reflects his conception of harmony and the how he organizes pitch in a musical work. The clearest example of this confluence of theory and instrumental design is the diamond marimba, where the 11-limit tonality diamond that forms the backbone of Partch's scale is turned into a parallel arrangement of tuned wooden bars, as shown in figure 9. The instrument's design reflects the relationships between the



Figure 10: *The Delusion of the Fury*, strumming the harmonic canon at m. 1



This strumming motive not only begins and ends the *Exordium*, but also returns frequently throughout both acts of *The Delusion of the Fury*, functioning as a point of repose in the music and signaling a transition in the dramatic action. This motive tonicizes the 16/9 by placing this pitch in the bass and forming a just major triad above it along with three additional notes. It is a perfect example of the holistic application of Partch’s musical theories with instrumental design and the actual implementation of pitch in a work: the motive consists of simply strumming the open strings of the harmonic canon, so that the tuning and resonance of the instrument itself becomes the musical motive. The motive is the instrument, an arpeggio, and a harmony all at once.

Partch modified reed organs to create his chromelodeons I and II, retuning them to the notes from his scale. The chromelodeon I is tuned to Partch’s scale in sequence from low to high, with a color coding showing the O- and U-tonalities on the keys. Chromelodeon II, however, is tuned non-sequentially in a way that tells us something about pitch organization. The instrument has several stops, each tuned differently. The most fascinating of the stops is the “x-stop,” which when playing an ascending chromatic line creates the melody shown in figure 11. In figure 11, the lower staff provides the notes as if they are being played on a standard keyboard while the upper staff and ratio notation between the staves show the resultant pitches. Furthermore, when certain stops

are combined one will hear chords rather than a unison or octave doubling of the pitch, a practical and easy way for Partch to draw upon specific harmonies, the use of stops rendering them simple to perform in rapid sequence by depressing single keys.

Figure 11: Chromelodeon II x-stop, upper line resultant pitch

Ratio	Cent Deviation
12/11	-49.4c
8/7	+31.2c
9/8	+3.9c
14/9	-35.1c
9/5	+17.6c
11/10	-35c
7/6	-33.1c
5/4	-13.7c
4/3	-2c
32/27	-5.9c
5/4	-13.7c
40/21	+15.5c
10/9	-17.6c
11/8	+51.3c
1/1	0c
14/11	+17.5c
10/7	+17.5c
27/20	-19.6c
3/2	+2c
7/5	-17.5c
16/15	+11.7c
6/5	+15.6c
11/8	+51.3c
10/7	+17.5c

Each one of Partch's instruments could be analyzed in this way, but the basic principle always remains the same: instruments are designed not just to play single pitches but to realize various approaches to pitch organization and reflects Partch's desire to link theory and practice.

## 2.2 – INSTRUMENT ALTERATION AND RETUNING

Sabat's approach to orchestration is similar to Partch's insofar as the tuning and construction of the instruments have a reciprocal relationship with the organization of pitch. In *Asking Ocean*, Sabat retunes and alters nearly all the instruments in the ensemble: the bowed stringed instruments, harp, and harpsichord are all retuned and the tubing of the brass instruments is

altered to access a wide range of microtonal pitches. Instead of inventing new instruments like Partch, Sabat alters and extends the possibilities of existing ones. How these instruments are retuned then influences orchestration, where instrumental combinations are devised to explore a harmonic idea that is built into the instrumental alterations. The clearest example of this technique is found in the fourth movement, *Interlude (Intonation)*, where the ensemble matches and harmonizes the pitches provided by the harpsichord, viola da gamba, and harp, the tuning of these three instruments constituting the harmonic world throughout. Sabat reflects on the issue of instrumentation and how the retuning and considerations of tempered versus untempered instruments influence pitch organization and form:

[T]he use of just intonation resulting in many different pitches in my music requires a different kind of sound production, different techniques of preparing/tuning the instruments, different sorts of rhythmic approaches depending on the extent to which readily available fixed pitches are composed as opposed to pitches found by ear. Another element is the composition of phrases and materials, which articulate a particular pitch. The desire to optimize the playability invites me to consider how best to realize certain pitches from available fixed pitches, constructing melodies or progressions deriving from harmonics, open strings, reliable brass partials, etc.<sup>14</sup>

Analogous to Partch's instrumental designs, the alterations of instruments in *Asking Ocean* reflect a reorientation toward not only the pitch material but the organizational principles of pitch. The retuned strings allow access to many microtones in Sabat's system while preserving a high degree of acoustic consonance between the strings to avoid dampening the resonance of the instruments. Maintaining highly consonant harmonies is integral to Sabat's harmonic language, an idea further reinforced by the retuning of the harp, which provides the possibility of a wide range of JI triads as shown in figure 12, a chart of triadic possibilities presented in the front matter of the *Asking Ocean* score.



Figure 12: *Asking Ocean*, triadic possibilities of the retuned harp from the front matter of the score<sup>15</sup>

The first movement is similar to the fourth and bears a similar title: *Prelude (Intonation)*. In this opening prelude, the suggested tonal center shifts through the open strings of the cello from A down to C in a series of descending 3/2 modulations. This bass movement sounds familiar—a parallel to the V-I bass resolution of a perfect cadence in common practice tonality. The first movement establishes the general sense of harmony used in the piece with acoustically consonant relationships between the open strings of the solo quartet and the open strings of the scordatura ensemble strings and natural trumpet. A practical consideration to beginning the work in this way is that by having the tonal centers played by open strings, they are certain to be in tune and form the underpinning for the harmonizing intervals, which remain fairly simple and relatively easy to tune. This movement amounts to a way of *tuning up* the ensemble, allowing the performers to both perfect the tuning of their instruments as well as orient their ears to the pitch language that Sabat employs. Sabat comments on these intonation/tuning movements from *Asking Ocean*: “In a number of pieces, I integrate the process of tuning, of finding the sound production needed to clarify the just intervals, directly into my music, and really like how this shapes the listening and playing.”<sup>16</sup> The instruments used in this section are inextricably linked

with the harmonies written in the score and so the retuning of the instruments becomes an essential part of realizing harmonic ideas.

Haas's response to the challenge of orchestration in microtonal music in *Limited Approximations* is the least drastic. He leaves the entire orchestra in a traditional tuning, but he alters the pianos by tuning each of them down a 12th tone in turn. Piano 1 is tuned at +33c, which means that piano 3 is in standard tuning. Each piano is thus in a transposed 12tet that is then multiplied by 6, resulting in a 72tet conglomeration. These six pianos are treated as a soloist ensemble in a version of a concerto grosso form. Much of this composition is focused on the ideas that are made possible by these pianos allowing for a precise and reliable 72tet scale.

### **2.3 - TEMPERED AND UNTEMPERED INSTRUMENTS**

While Sabat focuses on what he calls “tunable intervals,” intervals that can be tuned by ear, Haas uses the opportunity presented by the instrumentation including the 72tet piano amalgamation to explore ideas that are effectively impossible on untempered instruments. The first example of this comes from the quasi-glissandi passages, as described in section 1.3 and shown in figure 7. Another idea that demands the precision of the retuned pianos is the juxtaposition of the same interval in contrasting registers, which Haas realizes with both the neutral second interval (150c or exactly halfway between the major and minor second in 12tet) as well as 12th-tone clusters. The experience of hearing the same interval in contrasting registers creates an interesting perceptual effect as the expression of the interval changes. Haas describes this perceptual effect as well as some of the other opportunities presented by the retuned pianos:

The twelfth-tone interval is so small that it is no longer heard as an interval, but rather as the shading of a single note. A single tone played by a Romantic orchestra has a wider frequency. The aural effect of a scale in twelfth-tone

intervals is thus similar to a glissando. The effect of a cluster of twelfth-tones depends on the register: higher up, it is sharp, abrasive, biting; lower down it is soft, melting, rich. Of course it is also possible to build raw, dissonant chords with twelve-tone intervals—much more differentiated (also in the degree of acuteness) than with the traditional 12 tones per octave. But it is also possible to build much more “consonant” chords than in the traditional twelve-note scale: a close approximation of the twelve-tone scale can be produced in the overtone scale, accurate up to a twelfth of a tone.<sup>17</sup>

As suggested by Haas in the quote above, the instrumentation of *Limited Approximations* provides opportunities to explore microtonality in a precise and reliable way. One of the clearest examples of this can be found at mm. 391–404, which consists of rapid chord changes through 36 different overtone chords, beginning with the same chords as m. 196 and then moving beyond to many other new roots. Figure 13 provides a score excerpt from m. 323 where Haas explores sparsely placed notes from the low to high register, seemingly considering how these microtonal 72tet intervals are heard in a variety of registers

Figure 13: Experimentation of interval in contrasting registers in *Limited Approximations*

**accel.**

The score is divided into four positions (1. Pos. to 4. Pos.) and six keyboard parts (1. Klav. to 6. Klav.).

- 1. Pos.:** Treble clef, 3/4 time. Starts at measure 323. Features a melodic line with slurs and accents.
- 2. Pos.:** Bass clef, 3/4 time. Mirrors the melodic structure of the first position.
- 3. Pos.:** Bass clef, 3/4 time. Includes the instruction "con sordino straight (= 1 Pos.)" and a dynamic marking of *pp*.
- 4. Pos.:** Bass clef, 3/4 time. Includes the instruction "con sordino straight (= 2 Pos.)" and a dynamic marking of *pp*.
- 1. Klav. +1/6:** Treble and Bass clefs, 3/4 time. Dynamics range from *p* to *mp*.
- 2. Klav. +1/12:** Treble and Bass clefs, 3/4 time. Dynamics range from *p* to *mp*.
- 3. Klav. +/- 0:** Treble and Bass clefs, 3/4 time. Dynamics range from *p* to *mp*.
- 4. Klav. -1/12:** Treble and Bass clefs, 3/4 time. Dynamics range from *p* to *mp*.
- 5. Klav. -1/6:** Treble and Bass clefs, 3/4 time. Dynamics range from *p* to *mp*.
- 6. Klav. -1/4:** Treble and Bass clefs, 3/4 time. Dynamics range from *p* to *mp*.

The 72tet pianos allow Haas to realize rapid changes in harmony that would be practically impossible for untempered instruments. Figure 14 provides the progression of the root notes from a series of overtone chords from mm. 391–494 with notable pitch relationships between roots bracketed. The overall tendency of these chord changes seems to be their unrelatedness: a lack of common tones or shared consonances. Even for the most specialized microtonal performer, this progression would be impossible to play with accuracy on untempered instruments like strings. The orchestra is added to the pianos at m. 402, and as a result the intervals and roots become much more easily tuned by ear with precision, strongly suggesting a root of A. As in the layout of Partch’s percussion instruments and the use of open strings and tuning sections in Sabat’s *Asking Ocean*, we find another example of the microtonal composer being sensitive to practical concerns of playability and orchestration.

Figure 14: *Limited Approximations*, mm. 391–404 root progression



Any solo piano passages in *Limited Approximations* are effectively in 12tet at various transpositions; 72tet only exists as a combination, a meta-piano made up of all six pianos

together. Haas treats this facet of the orchestration as an opportunity, at times doubling a part between two or more pianos to create an unusual parallel motion by microtonal intervals. Similarly, a soloistic line in one piano may be echoed by another piano, creating a microtonally transposed imitation of the initial line. Both of these techniques give the aural impression of an electronic processing of the sound, the thickening of a part in perfectly parallel clusters sounds like a wide chorus effect, and the echoing technique sounds like a detuned delay line with various levels of feedback depending on the number of pianos involved. The ascending piano lines at m. 19 of the score are an excellent example of this detuned delay effect.

By relying on the mallet percussion instruments and reed organs he developed, Partch, like Haas, was able to bypass the practical concern of tunability when moving between chords without a clear harmonic relationship. However, Partch's aesthetic priority of connecting music with the voice and speech led to the primacy of more obvious pitch relationships and harmonic simplicity, and indeed this is the case for the majority of *The Delusion of the Fury*, especially the sections involving chorus or solo voices. Conversely, during the *Exordium* section, which is purely instrumental and relies heavily upon mallet percussion instruments, Partch moves between more distantly related harmonies. Figure 15 is a transcription of mm. 116–117 from the *Exordium*, where both measures begin with a rapid exchange of harmonies, as shown below the excerpt in terms of Partch's O- and U-tonalities. While not technically impossible, this music would be extremely difficult to perform with precision on untempered instruments, especially when taking into consideration that this music was written in 1966 when just intonation in contemporary music was still in a nascent state.

Figure 15: *The Delusion of the Fury*, m. 116, transcription

The musical score for m. 116 is divided into two systems. The first system includes parts for Bass Marimba, Marimba Eroica, and Quadrangularis. The second system includes Eucal Blossom. Intervals and cents values are indicated above the notes. A sequence of tuning boxes is located at the bottom of the page.

**Intervals and Cents:**

- Bass Marimba:** 16/9 (-3.9c), 3/2 (-2c), 5/3 (-15.6c), 8/5 (+13.7c), 8/7 (+31.2c), 8/5 (+13.7c), 9/8 (+3.9c), 8/7 (+31.2c), 4/3 (-2c)
- Marimba Eroica:** 8/7 (+31.2c), 12/7 (+33.1c), 11/8 (+51.3c), 9/5 (+17.6c)
- Quadrangularis:** 10/7 (+17.5c), 16/9 (-3.9c), 15/8 (-11.7c), 10/9 (-17.6c), 6/5 (+15.6c), 4/3 (-2c), 8/7 (+31.2c), 8/5 (+13.7c), 9/5 (+17.6c), 40/21 (+15.5c)
- Eucal Blossom:** 16/9 (-3.9c), 15/8 (-11.7c), 10/9 (-17.6c), 6/5 (+15.6c), 8/5 (+13.7c), 9/5 (+17.6c), 40/21 (+15.5c), 8/7 (+31.2c)

**Tuning Boxes:**

1UT 1OT 5UT 5OT 1OT 1UT 5UT 5OT 1OT 1UT      5OT 9UT 7OT      9UT 5OT 7OT      9UT 5OT

Voice is the single purely untempered element among Partch’s orchestration and presents challenges in terms of performability, which influences how Partch orchestrates and organizes pitch in sections with singers. In *Chorus of Shadows*, the first scene in Act I of *The Delusion of the Fury*, a singing processional performs a melodic line with extremely small interval changes that are all in proximity to F3. This melodic line reads as 9/5 – 20/11 – 11/6 – 20/11 – 11/6 – 20/11 – 9/5, forming a symmetrical pattern of intervals that barely change in pitch. The interval between the 9/5 and 20/11 interval is 99/100 (approximately 18 cents) and the interval between 20/11 and 11/6 is 120/121 (approximately 15 cents), both essentially impossible to tune by ear even in the context of the 1/1 fundamental, which Partch does not provide. Partch accomplishes this pitch precision through pitch matching with the chromelodeon, which doubles all the sung pitches. Additionally, the kithara and the chromelodeon harmonize this chorus part with alternating O- and U-tonalities as shown in figure 16. The 9/5 interval is harmonized with the 9O-tonality, 20/11 the 11U-tonality, 11/6 the 11O-tonality, and so on. The kitharas are designed

in such a way to promote this method of harmonization, where sets of six strings (hexads) are tuned to various O- and U-tonality chords. Through this technique of pitch matching and harmonization, Partch achieves an incredible level of pitch precision in the chorus, and we once again have this interplay between the practicality of orchestration and pitch organization, now extended to the untempered voices, accessing the subtle expressive shadings of irrational, comma-like, minuscule intervals.

Figure 16: *The Delusion of the Fury, Chorus of Shadows*, page 47, system 3, transcription

The musical score for Figure 16 consists of three staves: Chorus (bass clef), Kithara (bass clef), and Chromelodeon (treble clef). The Chorus part is a single line of notes with intervals and cents values: 9/5 +17.6c, 20/11 +35c, 11/6 +49.4c, 20/11 +35c, 11/6 +49.4c, 20/11 +35c, 9/5 +17.6c. The Kithara part is a complex texture of chords with intervals and cents values: 9/5 +17.6c, 3/2 -2c, 15/8 -11.7c, 20/11 +35c, 11/10 -35c, 11/7 -17.5c, 11/8 +51.3c, 15/8 -11.7c, 20/11 +35c, 11/10 -35c, 11/7 -17.5c, 11/8 +51.3c, 15/8 -11.7c, 20/11 +35c, 11/10 -35c, 11/7 -17.5c, 11/8 +51.3c, 16/11 +48.7c, 11/6 +49.4c, 11/8 +51.3c, 16/11 +48.7c, 11/6 +49.4c, 11/8 +51.3c, 15/8 -11.7c, 20/11 +35c, 3/2 +17.6c, 9/5 +17.6c. The Chromelodeon part is a single line of notes with intervals and cents values: 9/5 +17.6c, 1/1 0c, 9/7 +35c, 3/2 -2c, 12/11 +48.7c, 16/11 +48.7c, 11/6 +49.4c, 11/8 +51.3c, 12/11 +48.7c, 16/11 +48.7c, 11/6 +49.4c, 11/8 +51.3c, 12/11 +48.7c, 16/11 +48.7c, 11/6 +49.4c, 11/8 +51.3c, 12/11 +48.7c, 16/11 +48.7c, 9/5 +17.6c, 1/1 0c, 9/8 +3.9c, 9/5 +17.6c, 20/11 +35c, 11/6 +49.4c, 20/11 +35c, 11/6 +49.4c, 20/11 +35c, 11/6 +49.4c, 20/11 +35c, 9/5 +17.6c.

Even when utilizing pitch matching, Partch takes a safe approach to pitch when writing music for untempered instruments and voices at a faster tempo. The music discussed above from the *Chorus of Shadows* is performed in a very slow tempo, and one does not find anything nearly as demanding in terms of pitch precision in medium or fast tempi in this piece. Partch's text setting is generally speech-like, almost entirely monosyllabic and at a rate and rhythm that makes it easily comprehensible to the listener. Figure 17 provides a typical example of this setting in the chorus part of *The Lost Kid* from Act II. In this section, the chorus sings in parallel thirds with no



fraction interval notation provided; instead, they are expected to once again tune to the chromelodeon, which supports the 5-limit diatonic JI collection that provides the foundation of Partch's music. In this way, the custom-built instruments and how they interact with the chorus is made to be a productive limitation, creating new possibilities in orchestration and the realization of Partch's conception of pitch with both tempered and untempered instruments. The vocal lines are almost always doubled in the chromelodeon to the point where it is no longer an artistic choice of orchestration as much as a practical necessity that detracts from the expressive range of the music. If Partch were to write this piece today, he would likely not feel the need to double every vocal line with the chromelodeon. Regardless, the chromelodeon doubling becomes a feature of the music, another practical consideration transformed into an audible musical element.

Figure 17: *The Delusion of the Fury, The Lost Kid*, score excerpt, page 165, system 2, facsimile

The image shows a handwritten musical score for a piece titled "The Delusion of the Fury, The Lost Kid". The score is on a single system and includes several parts:

- Chorus (Cho):** The top staff contains the vocal line with lyrics: "Why - doesn't she just go a-way?". The tempo/mood is marked "Thumb piano" and "10 flanges". A handwritten note above the staff reads: "2 5/8 to 3 3/4 inches long. Notated, L. to R." with a double bar line and a diagonal line through it.
- Keyboard II (KII):** The second staff is for a keyboard instrument, with markings for "up (P)" and "down (P)".
- Chamber Ensemble (Ch En):** The third staff is for a chamber ensemble, with various rhythmic markings and notes.
- Maracas (M):** The fourth staff is for maracas, with rhythmic patterns and markings like "Cas" and "VR".
- Membranophone (MM):** The fifth staff is for a membranophone, with rhythmic patterns and markings like "3 3", "0 2", "3 3", "2 3", "2", "2 2", "1 3", "2".
- Drum (DM):** The sixth staff is for a drum, with rhythmic patterns and markings like "12", "3-4-5-4".
- Boo (Boo):** The seventh staff is for a boo instrument, with rhythmic patterns and markings like "4 10-3", "1-01-01-23-45-65-4".

## 2.4 – TIMBRE

A thorough investigation of the perception of pitch and timbre is beyond the scope of this essay. Instead, some generalizations about the relationship between pitch and timbre in the three works will be considered. The relationship between timbre and pitch is perhaps most problematic in *The Delusion of the Fury* and Partch's work in general, where the percussive instruments outnumber sustaining instruments many to one. Ronald Rasch addresses this paradox:

A problem when studying Partch, is the relationship between theory and practice. *Genesis of a Music* presents a well-formed, unitary theory of music and intonation. But the majority of Partch's instruments are percussion (which have sounds of inharmonic overtone structure), or plucked or struck strings (which have a rapid decay). Neither category is very well suited to illustrate or make manifest subtle differences in tuning and intonation. Listening to Partch's music,

one is, of course, aware of certain “intonational color” but it is difficult, if not impossible, to grasp the intonational details of the monophony from the arpeggios and ruffles.<sup>18</sup>

Indeed, the timbre of many of his instruments makes a clear perception of his tuning system imperceptible. However, one must not ignore the two chromelodeon instruments, which as reed organs are able to play powerful sustained notes with excellent pitch accuracy. It is these instruments that Partch used in presentations and recordings to demonstrate his tuning system, and for good reason. Moreover, as discussed in section 2.3, the chromelodeons are used to provide the vocal parts with their notes for pitch matching.

Returning to the issue of pitch perception with the struck and plucked instruments that make up the majority of Partch’s orchestra, we are confronted with the question of why Partch would create such a precise JI system and then realize it in a way that is difficult to perceive. This assertion, however, is predicated on an assumption that the precise pitches should be clearly heard at all moments. Partch sought to create a wholly original musical expression and the extended JI scale was his answer to dealing with pitch when he considered 12tet an artificial construct, but this does not require his music to constantly be expository of this novel pitch system. As Rasch puts it, a certain “intonational color” is produced, which may be the desired effect for Partch.

Haas and Sabat take a similar approach to timbre, both composers favoring sustaining instruments with a clear expression of pitch in their music. Indeed, there is a notable lack of unpitched percussion in both *Asking Ocean* and *Limited Approximations*, and the harmonies are presented in a clear way, without extended techniques that produce noise-like air sounds, key clicks, scratch tones, or overpressure. In *Limited Approximations*, the focus is on the pianos as a soloist ensemble. As a struck stringed instrument, the piano creates harmonies that are slightly

less clear than on sustaining instruments like bowed strings, but the sustain of the piano is still enough to clearly present the pitches in a precise and audible way. However, the quasi-glissandi played by the pianos are often performed as octave tremolandi passed between the pianos, an effect that turns the piano into a sustaining instrument capable of creating a dynamic arc. Using tremolandi in this way displays Haas's sensitivity to orchestration while creating the impression of a glissando with the timbre of the pianos.

### CHAPTER 3: RHYTHM AND PULSE

The relationship between rhythm and pitch in these three works once again involves the limitations, challenges, and possibilities of acoustic instruments performing microtonal music. The rhythmic profile of each of these pieces differs, but all three treat the rhythmic and metrical aspect of music with a sensitivity toward pitch organization. The performers in *Asking Ocean* are often given the opportunity to extend time to perfect their tuning at various moments in the piece; in *Limited Approximations* the orchestral instruments are provided ample time to realize the harmony when the intervals become more complex; in *The Delusion of the Fury*, Partch turns toward the ensemble of tempered instruments to create more rapid passages and harmonic rhythm. This chapter is divided into a general discussion of slow music, fast music, and the idea of proportionality, transferred from interval ratios in the pitch domain to the time domain.

#### 3.1 – PITCH PRECISION AND SLOW MUSIC

Boulez famously describes two opposing types of time, *temps strié* (striated time) and *temps lisse* (smooth time), stating that “In smooth time, we occupy time without counting it; in striated time, we count the time to occupy it.”<sup>19</sup> The concept of occupying time, immersing oneself in the music and luxuriating in a glacial movement of microtonal harmony is a common theme in JJ composition. The importance of smooth time—of writing music that focuses on slowly shifting sound masses without clear meter or pulse—is part of both *Asking Ocean* and *Limited Approximations*, whereas *The Delusion of the Fury* consistently evokes a striated sense of time.

The tempo indication for the first movement of *Asking Ocean* reads “*Tempo ad libitum*, take time necessary to sound a precise, stable intonation. Within each bar, repeat and move through the patterns freely as required, going back if and when needed.”<sup>20</sup> The title of this

movement is *Prelude (Intonation)*, and constitutes a method of working the process of tuning up into the piece itself. For untempered instruments, performing in extended just intonation requires significant reorientation in how the performer approaches their instrument. While there are now many instrumentalists who are well versed in JI performance, historically it has been very difficult to perform JI music that goes beyond the 5-limit with accuracy. This has resulted in a tendency for microtonal music to be generally slow and drone-like, allowing the time for performers to feel out the unfamiliar intervals in the harmonies. The glacial speed of the music is also necessary for the performers to feel the acoustic beating or lack thereof that results from small whole number just intervals.

The tendency toward slow music is reflected in sections of all three works but features most prominently in *Asking Ocean*. Conversely, the tendency to write slow microtonal music is also subverted by all three works, something made possible by the invented and retuned instruments as described in sections 2.1 and 2.2. Sabat reflects upon the relationship between rhythm, tempo, and pitch in his February 2013 correspondence with the author: “When working the tuning phenomena, it seems that the phrasing, the flow of time, becomes more important than precise hierarchies of rhythm: the phrasing which emerges from calibrating and coordinating dynamics, timbre, and pacing allows the sonority of the tuning, its most unique quality, to emerge and color the music, and becomes the most exciting thing about working with harmony.”<sup>21</sup>

In the fourth movement, Sabat returns to the same idea and presents a second “intonation” movement. Both of these movements function as extremely slow, drone-like sections where the performers can perfect the tuning and reorient themselves toward the harmonic world of the composition. Indeed, the intervals in the first movement are reasonably

simple to tune, whereas the intervals in the fourth movement are considerably more complex as if the tuning is being further refined as one travels deeper into the work. As is made clear in the tempo indication quoted above, pitch precision is privileged over all other elements of the music, and no rhythms or metrical structures are perceivable. The neutralizing of rhythm, pulse, and meter in these sections pushes the focus of the listener toward pitch and timbre.

Throughout the first movement of *Asking Ocean* the ensemble string quartet feeds the pitches of their retuned strings to the other instruments of the ensemble as the solo cello provides the bass note and chord root as open strings. The tuning process is reflected in the choice of intervals used, with a gradual exposition of the core area of the 23-limit JI collection, tonicizing notes in a descending fifths (4/3) pattern starting on A (1/1), moving through D, G, and C in turn. Except for the third movement, *Harmonium for Claude Vivier*, and to a lesser extent the final movement, *Pythagoras Drawing II*, the music of *Asking Ocean* maintains a slow harmonic rhythm and a drone-like quality with the vast temporal spacing that allows for the instrumentalists to hear and refine their intervals. Both of the two movements that contain the more rapid pulsation are brief in total duration, together accounting for less than 5 percent of the total length of *Asking Ocean*.

Although *Asking Ocean* tends toward a slow, drone-like quality most consistently, the Haas and Partch pieces both contain similarly slow sections that allow for the focus of the performers and audience to shift toward greater complexity in the pitch domain. As La Monte Young states about his own music: “One of the aspects of form that I have been very interested in is stasis—the concept of form which is not so directional in time, not so much climactic form, but rather form which allows time... to stand still.”<sup>22</sup> This applies to many JI compositions. An excellent example in *The Delusion of the Fury* was discussed in section 2.3, at the opening

section of Act I, *Chorus of Shadows*, where the chorus and the chromelodeon perform extremely minuscule intervals, harmonized by the O- and U-tonalities played by the kithara in a very slow tempo. On the whole, Partch's music tends away from a droning quality, drawing inspiration from Native American song and Chinese opera rather than the classical music traditions of India—in particular, the slow improvised section of the Indian raga (the alap) and the tambura accompaniment drone—which greatly influenced Sabat and many other microtonal composers.

A notable moment in *Limited Approximations* that relies on an extremely slow tempo is found in mm. 119–166. The harmonies move gradually from microtonal clusters to an F-quartertone-sharp JI chord and then a final C JI, with elisions and recontextualization of pitches from one chord to the next. The relationship between an F-quartertone-sharp and a C constitutes a just tritone (11/8), which means that when the overtone series of these two fundamental notes are combined, a complex and highly interconnected relationship is results. Figure 18 shows how the pitches of the F-quartertone-sharp JI chord may be recontextualized by the addition of a C bass note. In mm. 138–166 these two JI chords interpenetrate and crossfade back and forth repeatedly until finally the F-quartertone-sharp is reduced to a single F-quartertone-sharp pitch played by the violin. At various points in this passage the brass play the 12tet chord in a second, quieter layer. Additionally, a microtonal doubling on the high C5 appears and disappears in mm. 141–143. These elements provide a heightened level of activity and density that eventually clears to the pure JI chord on C at m. 166. This overtone chord is then expanded upon in m. 169, doubling each note of the chord at the 3/2 (perfect fifth) to create a much more complex and dense harmony. These microtonal harmonies, further complicated by layering of the 12tet chord, necessitate the slower tempo both in terms of playability for the performers as well as comprehensibility on the part of the listener



Figure 18: *Limited Approximations*, recontextualization of two JI chords

The figure shows a musical score with three staves (Soprano, Alto, Bass) and two systems. The first system is labeled 'm.138' and the second 'm.143'. Arrows indicate pitch class recontextualization: 7/4 to 6/5, 11/8 to 9/8, 7/4 to 7/4, and 3/2 to 3/2/11. Pitch classes are also labeled as 1/1, 3/2, 11/8, 9/8, 7/4, 6/5, and 3/2/11.

Figure 18 shows the two harmonies from the section of music describes in the previous paragraph. The arrows in this figure indicate the recontextualization of the first harmony into the second harmony. The first harmony, based on f-quartertone-sharp, contains only three pitch classes splayed out over a huge register through octave doublings. The second chord, with a C fundamental, is another typical chord from *Limited Approximations* where an overtone chord is combined with a more dissonant additional note, in this case the C-quartertone-sharp held over from the previous harmony, the 3/2 of the 11/8, forming a quartertone interval with the 1/1.

### 3.2 – PITCH PRECISION AND FAST MUSIC

Many of Haas's compositions are saturated with the overtone chord, structured as the pitches in the overtone series, usually up to and including the 11th partial. Examples of where the overtone chord is presented in an extended, drone-like context are abundant throughout Haas's body of work. In *Limited Approximations*, the retuned pianos present the possibility for more rapid

figurations and harmonic changes without sacrificing precise tuning. With this opportunity to be free from the practical concerns of performing microtones, Haas's musical language expands, and *Limited Approximations* becomes something unique from his large ensemble and orchestral output.

The section featuring rapidly shifting overtone chords on distantly related roots discussed in section 2.1, mm. 391–404, is an excellent example of a passage that is unique in Haas's output. This passage, if orchestrated without the six retuned pianos, would be essentially impossible to perform in the moderately fast tempo in which it is written. Despite the insurmountable difficulty in performance, the perceptual result is not as complex—an easily perceived musical idea as a single harmony is shifted between various roots. Indeed, the moderate rate of harmonic changes creates an expressive effect that would be lost at a slower rate.

Other examples of fast music in *Limited Approximations* are found in the passage from mm. 186–195 and the *intermezzo* at m. 358. The music at mm. 186–195 features the six pianos performing sixteenth-note repetitions of open fifths with ascending octave leaps. These repeated open fifths are hocketed between the pianos to give the effect of a downward glissando as discussed previously. This section features a long accelerando to quarter = 90bpm in a continued toccata feel provided by the continuous sixteenth notes. As this passage ends and the orchestration shifts from the pianos to the orchestra, the music returns to a slower, gradually shifting rhythmic profile as the untempered instruments of the orchestra are not capable of performing these fast-paced phrases. In the *Intermezzo* beginning at m. 358, the pianos perform rapidly shifting harmonies against a static chord in the strings, highlighting this relationship of fast versus slow music as a facet of the instrumental limitations. The pianos shift chords with

each eighth note in a series of changing meters in a way that would be nearly impossible to perform on untempered instruments with any degree of accuracy.

The last excerpt from *Limited Approximations* that will be discussed in terms of fast music is found at m. 285, a section featuring rapid piano flourishes that together form a consolidated harmony. Figure 19 shows this passage as a score excerpt as well as a reduction of the pitches into the resultant chord. Once more, this type of rapid figuration would be very similar to many passages from Haas's body of work if played at a slow tempo, but in this case the freedom from the difficulty of tuning these intervals allows for a unique musical expression. Indeed, the harmony that results from the combined flourishes of the pianos is quite complex, mixing an overtone chord based on a B quarter-tone flat with a microtonal cluster in the upper register in a way that is similar to the emergence of a high cluster in the opening phrase of the work following the compressed overtone series played by the pianos.

Figure 19: *Limited Approximations* m. 283, excerpt and reduction

The image displays a musical score for six piano parts (Klav.) and a reduction. The parts are labeled as follows:

- 1. Klav. +1/6
- 2. Klav. +1/12
- 3. Klav. +/- 0
- 4. Klav. -1/12
- 5. Klav. -1/6
- 6. Klav. -1/4

Annotations include "Teiltonreihe auf D" and "Teiltonreihe auf tief-H" above various passages. Dynamic markings such as *ff* are present. Fingering numbers (5, 6) are indicated below notes. The reduction on the right shows a simplified chord structure in treble and bass clefs.

In *Limited Approximations*, the chorus effects through microtonal clusters, the pseudo glissandi, and the complex chord progressions are all relatively understandable in terms of their musical syntax—their quicker pacing rendering these effects clearer than if they were realized at a glacial speed where the connections between pitches would be too widely spaced over time for their relationship to be clear.

Harry Partch's orchestra is essentially a percussion ensemble, and as a result *The Delusion of the Fury* does not depend on slowly establishing the tuning of precise intervals on untempered instruments. The majority of the *Exordium* as well as many scenes from the two acts feature faster tempo, and the consideration of tempo and rhythm are not as closely linked to pitch as in the Sabat and Haas works, the only exception being that a high level of pitch accuracy demanded from the vocal parts is reserved for slow sections, as shown in the discussion of Act I, scene I: *Chorus of Shadows*.

As previously discussed, *Asking Ocean* is dominated by slow pacing. One notable exception is the third movement, *Harmonium for Claude Vivier*, which becomes untethered from the concerns of needing ample time for the performers to tune their harmonics as the entire movement uses only the solo string quartet playing natural harmonics. This movement will be discussed in detail in the following section.

### **3.3 – PITCH RATIOS, POLYRHYTHM, POLYMETER, AND PROPORTION**

In *New Musical Resources*, Henry Cowell suggests a potentially meaningful relationship between interval ratio and rhythm.<sup>23</sup> Indeed, the perceptual borders between pitch, rhythm, and timbre were a fruitful source of musical ideas for many composers throughout the second half of the twentieth century. A notable phrase from the second half of Stockhausen's *Kontakte* renders the relationship between pitch and rhythm audible with the help of a pulse generator gradually slowing down past the barrier between rhythm and pitch at around 20hz. This idea can then be translated to intervals and cross-rhythms: if pulse generators tuned to a 3/2 interval at 60 hz and 40 hz respectively are slowed down to 1/20th of the speed, they produce a 3/2 polyrhythm. Combining or drawing a connection between a 3/2 rhythm and a 3/2 interval is an alluring idea

and provides a glimpse into an expansive world of mathematically self-similar musical materials. This idea of a synthesis of polymeter and interval has had a lasting effect on composers such as Johnston, Nancarrow, and Tenney, the latter two exploring the piano roll to realize complex polyrhythmic combinations. The second implication of this idea is a more general attitude toward tempo proportionality without necessarily marrying the temporal proportions with interval ratio in any precise way.

Partch rejects a dogmatic coupling of interval ratio with rhythmic proportions, but the conception of interval as ratio appears to have influenced his rhythmic language, where polymeter and steady repetitions are often employed. The origin of Partch's rhythmic language may be found in the popular and folk music traditions that interested him; Partch describes the banal yet inviting inclusion of a steady beat when discussing his rhythmic language.<sup>24</sup> With this in mind, we can conceive Partch's rhythmic structures as a kind of hybridization between popular and Classical forms, where steady beats are featured but change often or are varied with some regularity. Partch attempts to put subtlety and nuance into the repetitive rhythms in popular music, and these ideas manifest in many sections of the score. For example, the entire *Exordium*, except for the A sections and a few other very brief moments, features insistent and repeated 16th-note rhythms. The injected nuance that Partch refers to may be found in the patterns of accents, the groupings of 5s and 7s, unusual meters, polyrhythm, and polymeter. In the same way that Partch extended the 5-limit to the 11-limit in terms of pitch, he also expanded the metric limitations of popular music to include meters and groupings of 5, 7, 9, and 11. A polyrhythmic section in the final measure of the 19th system (m. 81 in the transcription), contains a 12/8 meter in the gourd tree and chamber bowls juxtaposed with the 28/16 meter in the diamond marimba and quadrangularis, a relationship that could be simplified to 7/6.

In *The Delusion of the Fury* we find some rhythmic similarities with gamelan insofar as there is often a web of interrelating rhythmic figures that together form a continuous 16th-note pulse with accent patterns. Like gamelan, new phrases are often signaled by a change in instrumentation and large-scale forms are reinforced with more extreme timbral shifts. Chinese opera is also a clear inspiration for certain sections: the action sequences in Act I are accompanied by relentless 16th notes on unpitched metal percussion while the spoken parts are accompanied by sparse, ambient textures, a general feature typical of many forms of Chinese opera, which Partch was exposed to while living in San Francisco in the 1920s.<sup>25</sup> The polyrhythmic moments were likely inspired by musical traditions from the Central African Republic, although Partch's music does not explore polyrhythm and polymeter as complex as one finds in Central African music, where asymmetrical rhythmic figurations create hierarchies within the rhythmic cycle as in the music of the Ippy-Banda or Aka Pygmy traditions.<sup>26</sup> It is likely that these influences are based upon Partch's personal impression of these musical traditions rather than extensive study or desire to create any type of fusion of traditions.

As discussed in section 3.1, the rhythmic profile in *Asking Ocean* is largely free of steady pulse and any clear articulation of rhythm or meter. The exception to this is the third movement, *Harmonium for Claude Vivier*, where Sabat organizes musical phrases in terms of additive rhythms. The musical phrases are organized in a type of continuous variation, where each recurring musical phrase is varied and developed in terms of both pitch and rhythm, producing phrases with proportional durations through a combination of additive rhythms. As seen in figure 20, the repeated low C is used to demarcate the phrases throughout this movement. The first three phrases of *Harmonium for Claude Vivier*, mm. 1–28 are shown below where the numbers refer to the number of eighth notes in the additive rhythms:





phrase is made up of progressively larger subphrases, and when considered as a whole, becomes part of a Fibonacci sequence with the exception of an interruption in a 16-beat phrase. In contrast, the third phrase contains two different approaches to symmetrical phrase groupings, the palindromic 6-4-2-4-6 as well as the grouped symmetry of 23 (10+13) – 8 – 23 (10+13). While these proportional additive rhythms hold no analog in the pitch domain, they share a similar logic in the organization of musical materials according to small whole-number relationships.

Sabat also explores metrical proportionality in the fourth movement, *Harmonium for Ben Johnston*, but in this case it is through layering polymeter and polyrhythm, all parts moving at a relatively slow rate to create the hypnotic and drone-like quality. This combination of rhythmic and metrical layers occurs throughout the entire movement; to take an example, at mm. 25–28 of *Harmonium for Ben Johnston*, the ensemble violin plays in rhythms suggestive of 6/8, the viola is suggestive 4/4, the harp reinforces the written meters of 4/2 – 3/2 – 5/4 – 5/4, and the solo string quartet performs in rhythms that do not suggest any meter. Furthermore, m. 27 contains a slow 6:5 polyrhythm. There appear to be no regular patterns in this type of rhythmic and metrical layering, which occurs throughout the movement, but the organizing principle has a clear effect and could be compared to some of the more complex arrangements of JI pitch.

In *Limited Approximations*, Haas also includes sections with proportional rhythms, in the form of polyrhythms, additive rhythms, and changing rates of pulsations. Once more, the connection with pitch structure is tenuous, and the rhythmic profile of this work is likely more influenced by the minimalist structures of Steve Reich and the cloud-like rhythmic conglomerations of György Ligeti. In this way, there is a shared root with Partch of Central African music, mediated by Reich and Ligeti in the case of Haas. All three of the works often treat rhythm in terms of proportion. The connection with just intonation is indirect, but the

impetus to organize musical materials of any kind using simple proportions of small whole-number ratios presents an analogy with just intervals.

## CHAPTER 4: FORM

In Partch's treatise expounding the theoretical basis of his music, *Genesis of a Music*, he focuses his musical aesthetic around the two central concepts of monophony and corporeality, music that connects to the voice and the body. Corporeality is contrasted with abstractionism, described as *music for music's sake*, and he pointed to J.S. Bach as the most notable example of an abstract composer. Partch associates traditional forms like theme and variations and the sonata with abstractionism and calls for a more open and fluid approach to musical form.<sup>27</sup> While this demand for a rethinking of musical form could apply to any music irrespective of pitch organization, we have already explored links between pitch and both rhythm and orchestration that suggest limitations and opportunities in structuring both the small and large-scale forms in the works discussed and this chapter will build upon these ideas further. In some regards, these three pieces take a traditional approach to phrase structure and pitch, with harmonic ideas or tonal centers providing formal delineation. Traditional modes of organizing the flow of a piece are recontextualized through their relationships with novel approaches to pitch; predictable and familiar formal organization aids in the comprehensibility of less predictable and unfamiliar pitch structures.

### 4.1 - PHRASE STRUCTURE

The vocal writing in *Delusion of the Fury* is borne from the same impulse felt by the humanists of the Florentine Camerata when they invented opera in the early seventeenth century: they sought a return to the ideals of ancient Greek art with a focus on monody and the centrality of drama. Instead of the Italian language of early opera, Partch looked to American English, and to a limited extent the Yaqui language, as a basis for his music, both in terms of spoken word and



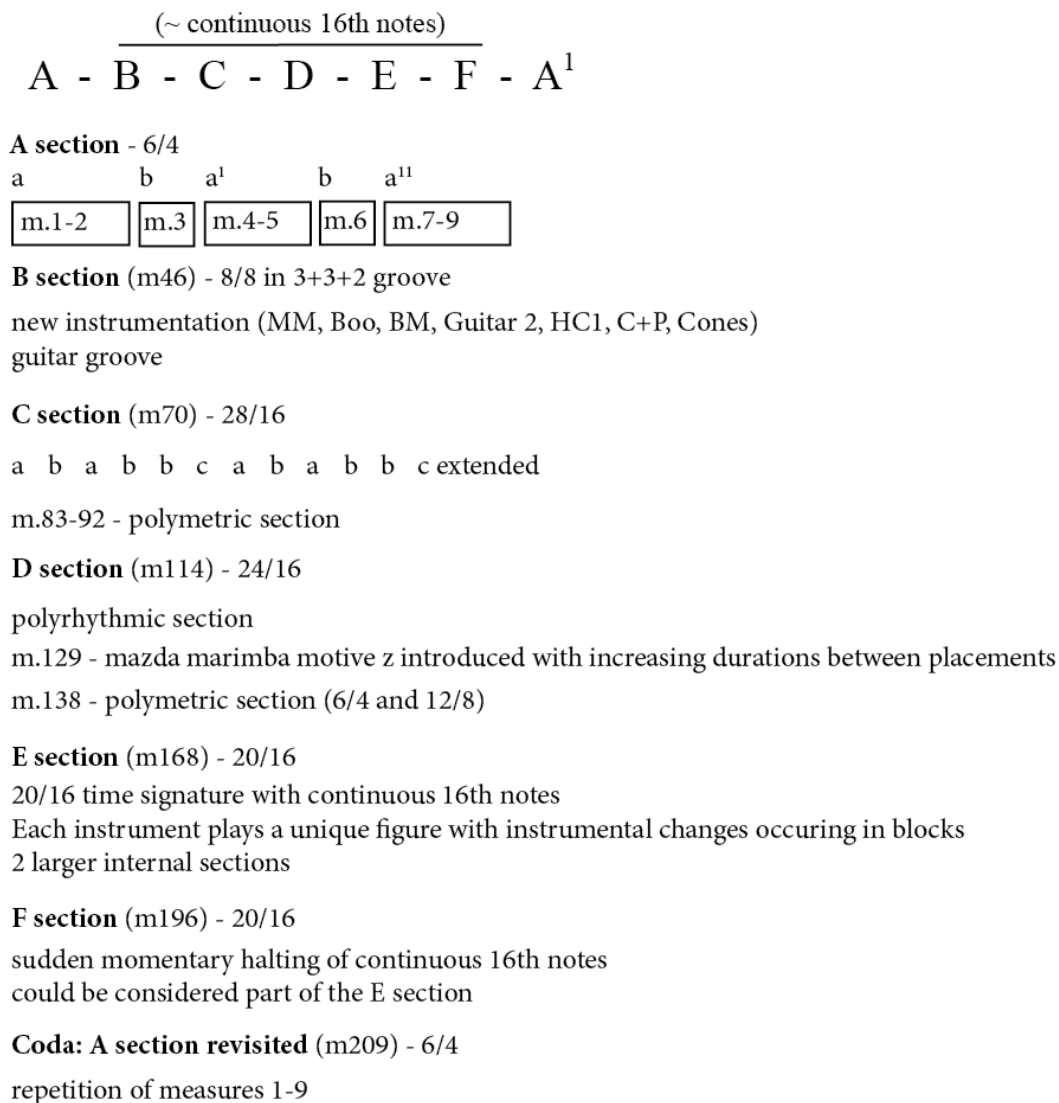
phrases, sub-phrases, single bars, and beats are all organized as blocks. These blocks are defined by dramatic shifts in orchestration, meter, rhythmic character, tempo, and pitch collection, the large-scale sections featuring more drastic changes such as tempo and meter while the smallest blocks that make up the phrases may be defined by changes in O- and U-tonalities or shifts in orchestration.

At the phrase level (usually 8 to 32 measure blocks), abrupt changes in pitch collection and drastic shifts in instrumentation commonly define the start and end points of the blocks. On the sub-phrase level, blocks are often formed through a call-and-response or the alternation between solo instruments or small instrumental groups and are mostly one or two measures long. These sub-phrase blocks feature some durational flexibility through extensions or truncations of the musical material passed between the instruments, though more often the changes in the length of sub-phrases are facilitated by complete repetitions of an entire block rather than the type of phrase extension one would find in a Classical or Romantic work. Considering the relationship between pitch and orchestration as outlined in section 2.1, it is clear that the shifts in instrumental combinations are inextricably linked with harmonic changes, and so each level of the phrase structure in *The Delusion of the Fury* is delineated by changes in pitch collection.

Beginning in m. 168 of the *Exordium*, we find a section that continues to m. 190 and contains two large internal sections. The first section features many different rhythmic cells, all lasting for one beat or five 16th notes. Each instrument in this section plays a unique rhythmic cell, constituting the smallest blocks, which are repeated different amounts of times to create the larger blocks at the level of measures. These measure-length blocks from m. 168 onwards provide instrumental combination changes every one or two measures at first, and then with smaller and smaller time units through to the beginning of the second large internal section at m.

190, which is marked by a sudden change in rhythmic profile as well as the addition of the conga and spoils of war and removal of the bass marimba. These two sections constitute the two large blocks that make up this section; similar analysis is possible for any given section throughout *The Delusion of the Fury*. Figure 22 provides an overview of the *Exordium*, showing the large-scale blocks as well as the smaller blocks within the A section.

Figure 22: *The Delusion of the Fury*, *Exordium*, large-scale block form



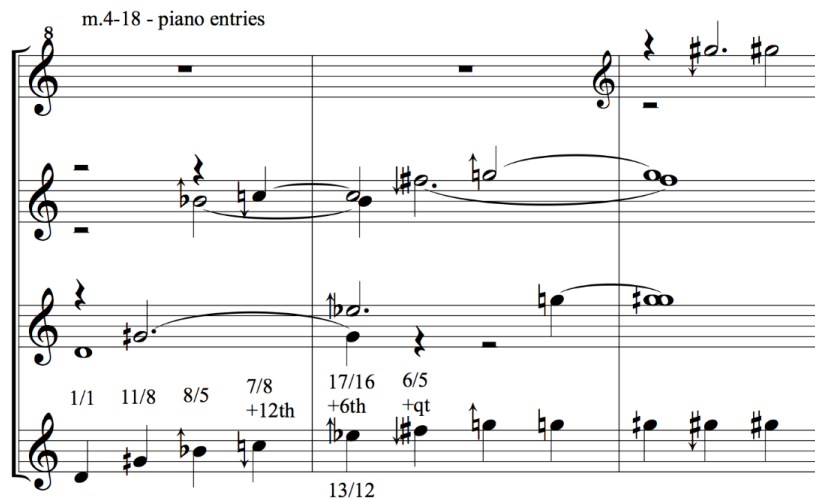
The relationship between phrase structure and pitch in *Limited Approximations* is generally straightforward, with each phrase exploring a different approach to pitch. These phrases are sometimes clearly delineated, though more often overlap and elide with one another, blurring their boundaries and presenting a fluid form. Some of the complexity of the phrase structure in *Limited Approximations* is derived from the superimposition of multiple, discrete, musical phrases as discussed in section 1.3.

The opening phrase of *Limited Approximations* is remarkable, providing an exposition of the various approaches to pitch organization found throughout the work as outlined in section 1.3. The opening passage features the string sections performing the first eight notes of the 12tet chord, beginning on a low D<sub>2</sub>, which continue on to perform a glissando to a microtonal cluster of quartertone increments around each pitch of the 12tet chord. These clusters are then transformed by glissandi back to a 12tet chord, once again with the D root but now with the perfect fourth at the bottom instead of the tritone. This process is shown in figure 23. It repeats several times over the first 18 measures. This process of alternating clusters and 12tet chords provides a quiet backdrop to a second musical layer in the foreground consisting of the pianos playing a compressed version of the JI chord that leads into high microtonal cluster of 12th tones in the upper register. This unfolding of the compressed overtone series by the pianos is shown in figure 24. The resulting clusters continue through a long section of music until m. 53, where Haas explores the effect of dense microtonal clusters in contrasting registers. The opening piano notes described above as a compressed overtone chord are an anomaly in the composition as this is the only place in the entire work where the overtone chord is not realized as a fixed, root position harmony.

Figure 23: *Limited Approximations*, opening measures reduction (strings)



Figure 24: *Limited Approximations*, piano entries mm. 4–18



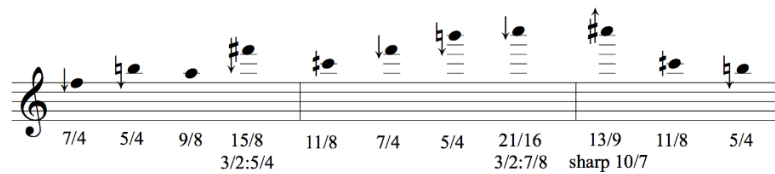
From this opening section, Haas moves gradually toward a pure JI chord on C, which serves as the final goal of the first large-scale section of the work at m. 166. The entire first part creates a gradual clearing out of intensity and complexity toward a pure, uncomplicated harmony (a JI chord on C, later reduced to the perfect fifth dyad of C-G), which serves as an end point and moment of repose before moving on to other ideas in the second and third parts of the composition.

The third section of *Limited Approximations* beginning at m. 342 is entitled *Aria I and II*, featuring the aria melody shown in figure 25. This aria melody unfolds between mm. 342–349, a



simple melody with a pleasant arc-like shape written in the overtone series with one secondary  $3/2$  interval and a single note outside of the overtone series that could be understood as a  $13/9$  or  $10/7$  interval, reflecting the structure of the overtone chord as used throughout *Limited Approximations*.

Figure 25: Aria melody from *Limited Approximations*

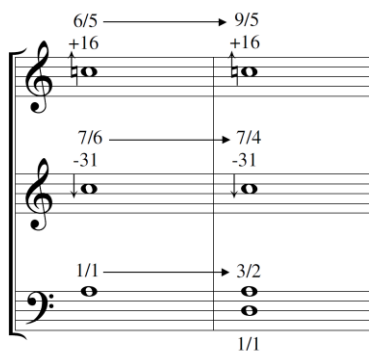


This melody is played by the pianos while the strings form a supportive overtone chord rooted in G. This Aria melody is a unique element in *Limited Approximations*, the only cantabile melodic element in the work and not appearing until near the end of the piece. The Aria melody can be understood as a horizontal arrangement of the overtone chord used throughout the piece. In the phrase following the presentation of the Aria melody, Haas immediately begins to subvert the pure intervals, adding microtonal clusters in the pianos around the structural pitches of the overtone chords. These clusters eventually give rise to another instance of the quasi-glissando effect from the pianos as the strings maintain the G overtone chord, providing the impression that the pianos and orchestra are being pulled apart from one another.

Returning to the first movement, *Prelude (Intonation)*, from *Asking Ocean*, we find that the phrase structure and pitch are closely linked. In this movement Sabat creates a cyclic structure with four iterations of the cycle, each with a different tonal center. The approximate points of articulation are m. 1, m. 11, m. 21, and m. 30 with tonal centers of A, D, G, and C

respectively. Each of these phrases features a gradual unfolding of the harmonies, using the  $3/2$ ,  $5/3$ ,  $6/5$ ,  $7/6$ ,  $7/4$ , and  $11/8$  intervals and their octave transpositions for each root note. The phrases in this first movement are not clearly defined, notes often fading in and out gradually, and the modulations themselves made in an extremely smooth way with multiple notes functioning as pivots. For example, the  $1/1$ ,  $7/6$ , and  $6/5$  intervals in A played by the violins in mm. 8 are recontextualized in the following measure in the key of D as  $3/2$ ,  $7/4$ , and  $9/5$  respectively as shown in figure 26.

Figure 26: Recontextualization of harmony in *Prelude (Intonation)* from *Asking Ocean*



The second movement of *Asking Ocean*, *Harmonium for Claude Vivier*, is also an excellent example of how Sabat links his harmonies with the phrase structure, as discussed in section 3.2.

#### 4.2 - LARGE-SCALE FORM

For all three works, the large-scale forms are inextricably linked to pitch structure. The delineation of form is signaled by changes in approach to pitch. In the Sabat work, this

delineation occurs on the largest scale, where each movement is defined by a different idea related to just intonation, as follows:

**I - *Prelude (tuning)***: A movement that gradually establishes the basic microtonal pitch material for the piece through a series of descending  $3/2$  modulations with local harmonization focusing on  $3/2$ ,  $5/4$ ,  $6/5$ ,  $7/4$ ,  $11/6$ , and  $11/8$  intervals.

**II - *Pythagoras Drawing I***: A palindromic expansion and contraction of pitch space by stacking  $3/2$  intervals to create a Pythagorean scale.

**III - *Harmonium for Claude Vivier***: Explores the natural harmonics of the solo string quartet. This movement gradually ascends in pitch, beginning with the low open string of the quartet cello. The movement continues to be in C, contrasting with the D root of the earlier movements and connecting with the end of the first movement. After the gradual rise in pitch, root returns to D with a type of plagal IV-I cadence at the very end of the movement at m. 140.

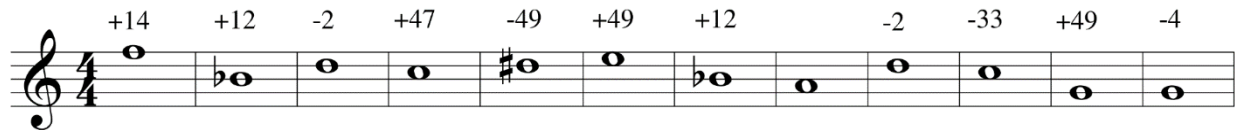
**IV - *Interlude (intonation)***: Returning to the ideas of the first movements but with more complex intervals derived from the tuning of the harp, viola da gamba, and harpsichord and the triadic possibilities of these tunings.

**V - *Harmonium for Ben Johnston***: Triadic movement through every note on the 23-limit Euler lattice (Figure 5) as a root with a single enharmonic shift reorienting the pitch space by leaping a skisma of roughly 4 cents.

**VI - *Trill Flowers Fell***: A *cantus firmus*-like melody in the solo quartet repeats in a descending pattern that is freely harmonized by changing subgroups of the ensemble. The *cantus firmus*-like melody is provided in figure 27.

VII - *Pythagoras Drawing II*: A reversal of the harmonic movement of the first movement, a series of ascending  $3/2$  modulations takes the harmony from a low C back to the root A that serves as the  $1/1$  in Sabat's 23-limit JI system.

Figure 27: *Asking Ocean, Trill Flowers Fell*, quasi *cantus firmus* melody

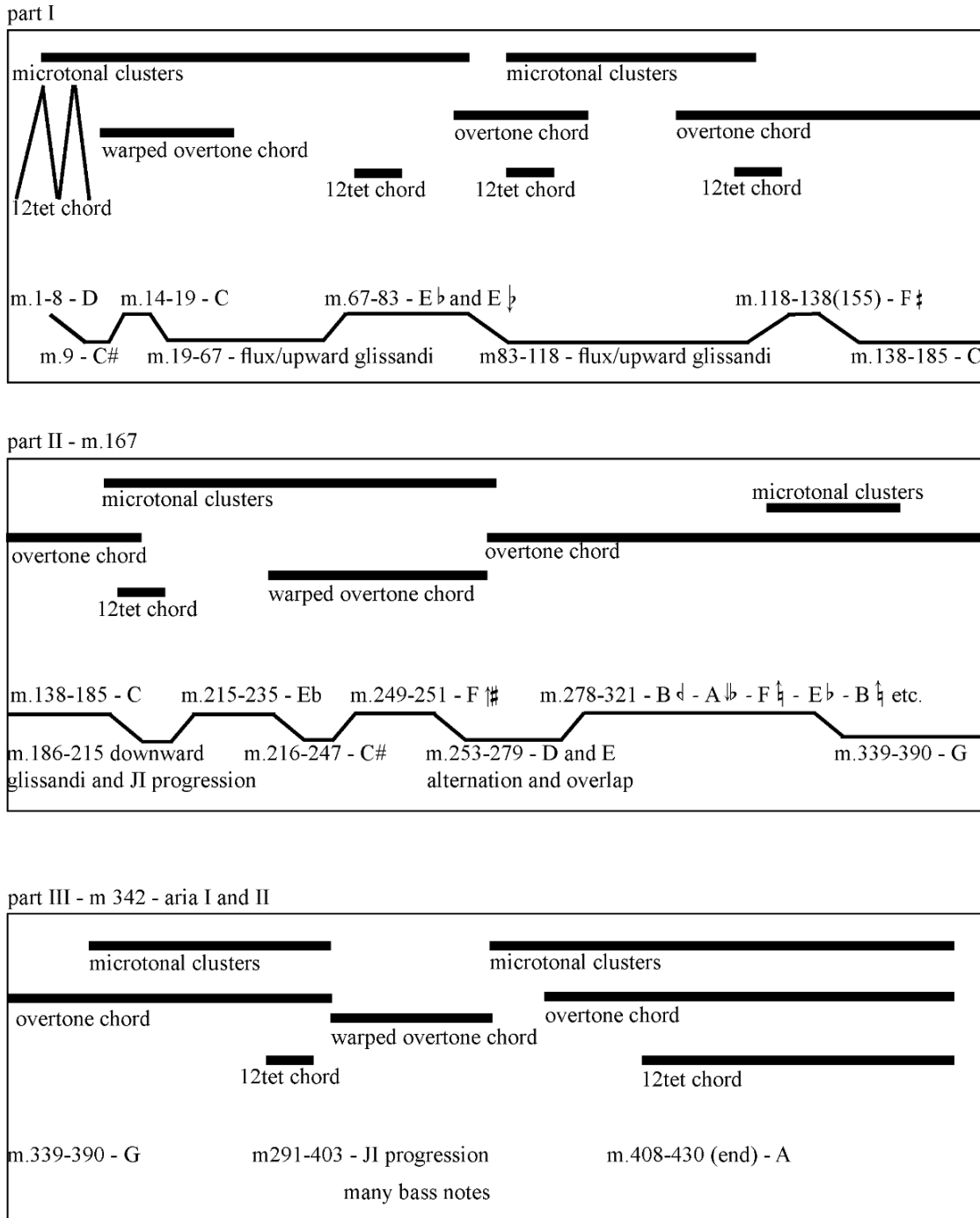


Each movement in *Asking Ocean* is thus guided by a different treatment of pitch. In *Limited Approximations* there is a similar method of forming large-scale form, though on a slightly smaller scale within a larger, continuous single-movement piece. Figure 28 provides an overview of *Limited Approximations*, showing the relationship between the large-scale form with tonal centers and various approaches to pitch organization, summarizing how Haas often overlaps different approaches to pitch.

Considering the tonal centers in *Limited Approximations*, we find a simple but effective pattern: The collection of tonal centers in part 1 are all closely related to a larger-scale root of C, which serves as the tonal goal of the entire section. Notably, the D root that begins the work is the  $9/8$  interval; the two different E-flats create a cluster around the minor third; and the F-quarter-tone-sharp is the  $11/8$  interval. In a large-scale sense, part 1 represents a resolution from D to C. The second part from m. 167 begins on the C root but then shifts through many harmonies—a section that is almost constantly in a state of flux, settling on a G root to begin part 3 of the piece at m. 342. Part 3 creates an interesting symmetrical relationship with part 1, instead of shifting down a whole tone from D to C, it shifts up a whole tone from G to A. On the

largest scale, *Limited Approximations* could be understood as a gradual movement through D, C, G, and A as tonal centers, together forming a series of stacked fifths.

Figure 28: *Limited Approximations* formal overview



The link between large-scale form and pitch structure is more tenuous in *The Delusion of the Fury*, where the connection is muddled due to the fusion of pitch and orchestration as described in section 4.1 on phrase structure. To zoom out to the largest sectional divisions of the work, we have the *Exordium*, *Entr'acte*, and the various scenes from the two acts. Figure 29 provides a summary of these sections:

Figure 29: Table summarizing the large-scale form of *The Delusion of the Fury*

<b>Title</b>	<b>Prominent Pitches</b>	<b>Prominent U/O-tonality</b>
<i>Exordium</i>	16/9	varies
Act I, scene I: <i>Chorus of Shadows</i>	5/3, 4/3	3O
Act I, scene II: <i>The Pilgrimage</i>	16/9	varies
Act I, scene III: <i>Emergence of the Spirit</i>	16/9, 4/3	varies, 3O
Act I, scene IV: <i>A Son in Search of His Father's Face</i>	5/3, 4/3, 11/8, 10/7, 12/7	varies, 3O, 4U, 7O
Act I, scene V: <i>Cry from Another Darkness</i>	5/3, 11/8, 9/5, varies	varies
Act I, scene VI: <i>Pray for Me</i>	7/5, 11/8, 16/9	3U, varies
<i>Sanctus and Entr'acte</i>	8/7, 9/5, 16/9	7O, varies
Act II, scene I: <i>Quiet Hobo Meal</i>	varies	varies
Act II, scene II: <i>The Lost Kid</i>	1/1, 5/3	3O, varies
Act II, scene III: <i>The Time of Fun Together</i>	16/15, 6/5, 1/1, 10/9	11U, 11O, 5O, 1O
Act II, scene IV: <i>The Misunderstanding</i>	16/9, 9/5, 8/5, 8/7	5O, 1U
Act II, scene V: <i>Arrest, Trial, and Judgment</i>	3/2, 5/3, 9/5, 3/2, 1/1	3O, 1O
Act II, scene VI: <i>Pray for Me Again and A Strange Fear</i>	3/2, 16/9	3O

The chart above outlines many interesting interactions between pitch and large-scale form and drama in *The Delusion of the Fury*. On the largest scale, each act focuses on particular O- and U-tonalities, creating contrast between the two acts. Furthermore, certain pitches are featured prominently throughout *The Delusion of the Fury*, providing large-scale unity to the work. The most prominent pitch is the 16/9, which holds an esteemed position in many of the scenes throughout both acts, the *Exordium* and *Entr'acte*. This extensive use and tonicization of the 16/9 is closely related to the recurring gesture of the strumming of the harmonic canon, as discussed in section 2.1, which is used to open and close the *Exordium*, Act I, and the *Entr'acte*.

Returning to Partch's "One-Footed Bride," shown in figure 4, and Partch's conception of the expressive and emotional content of interval regions, a deeper understanding of how these intervals contribute to the dramatic narrative of the piece becomes possible. In Act I, scene IV: *A Son in Search of His Father's Face*, the 11/8 interval is sounded at the precise moment of the first appearance of the ghost character. As an interval in the tritone region, the 11/8 is associated with suspense, and in this case, in combination with the narrative, has a decidedly uncanny and unsettling quality. This is the first introduction of the 11/8 as a prominent note in *The Delusion of the Fury*, and it remains salient through the remainder of the act in scenes V and VI as well. In the same scene (scene IV), the 7O-tonality is used for the dance of the father with the ghost of his deceased son. Partch associates the 7/4 interval that roots this 7O-tonality with "approach," which in this case points to an expression of longing, both a longing for the lost son and a longing to avenge his death.

Act I is a tragedy and Act II is a comedy, and the choices of prominent pitches and tonalities reflect this contrast. In Act I, the intervals and tonalities are nearly all associated with "emotion" and "approach," according to "The One-Footed Bride," suggesting the themes of

longing and suffering portrayed in the story. In this first act, the father encounters his son's killer, who has come to the son's grave seeking forgiveness. The two characters fight, but as the warrior who killed the son opens himself up to the father for a final deadly blow, the father does not strike and instead forgives his son's killer, declaring "you are not my enemy," as discussed also in section 4.1 and shown in figure 20. The dramatic climax of this work, when the protagonist realizes the futility of anger and vengeance, features one of the few instances of the  $3/2$  interval relating to "power," perhaps depicting empowerment and a sense of transcendence.

The *Sanctus/Entr'acte* recalls the *Exordium* in many ways and serves as an interlude between the two acts. Act II has a clearly contrasting mood to Act I; it is a comedy featuring bumbling characters, celebratory divertimenti, humorous misunderstandings, and ironic misdirected anger. Act II, scene II: *The Time for Fun Together* is a straightforward, joyous piece of music as social celebration. This movement is the first time in the entirety of *The Delusion of the Fury* where the root G, the  $1/1$  of the scale, and most acoustically consonant tonality in the system, the 1O-tonality, are used prominently. The music in this scene, found on page 173 of Partch's score, begins with an extended unison  $1/1$ , which is then developed within the 1O-tonality. Indeed, the  $1/1$  root note of the 11-limit system that Partch composes is notably avoided throughout Act I but often included in Act II, which reinforces the expressive content of the stories being told.

Act II also features dramatic moments whose expression are reinforced by pitch organization. In Act II, scene IV: *The Misunderstanding*, a crowd of villagers close in around the main characters to bring them before the village judge; this is accompanied by a dramatic series of chords that highlight the 1U-tonality and that could be understood as the tonic minor mode. In the following scene, *Arrest, Trial and Judgment*, the trial begins on page 222 of the score with a



clear prominence of the 9/5 interval from the “approach” region of “The One-Footed Bride.” When the judge lays down the sentencing, the pitch moves to the 3/2 interval associated with “power” to reflect the power and authority of the judge. The celebration of the villagers that follows this sentencing returns the music of Act II, scene II: *The Time for Fun Together*, with the emphasis on the root 1/1 and the 1O-tonality. From this description of the *Arrest, Trial, and Judgment* there is a clear relationship between pitch and dramatic action, one that is not based on theme or motive but on a perceived inherent expressive quality contained in the intervals themselves.

Partch does not depict the action onstage literally with the intervals but reinforces an interpretation and understanding of the text and dramatic action through pitch, as Jean-Jaques Nattiez states: “Music is not a narrative, but an incitement to make a narrative, to comment, to analyze. We could never overemphasize the difference between music, and music as the object of metalanguages to which it gives rise. Only thus can we start to outline its symbolic functioning.”<sup>30</sup>

## CHAPTER 5: CONCLUSION

In the three works discussed, Partch, Sabat, and Haas each present a great achievement in microtonal music that is in no small part due to sensitivity toward their novel pitch materials. The synergistic relationships between pitch with orchestration, rhythm, and form are created through a wide range of approaches that depend on this sensitivity.

The importance of orchestration is fundamental to these works, forming the basis of the practical realization of pitch. The tone of the instruments in all three works are inextricably intertwined with the pitch structure, and that connection becomes an opportunity as much as a limitation. The rhythmic languages of these composers also show an acute awareness of the ramifications of the pitch materials, providing the necessary time given to the performers and listeners to make the pitch language comprehensible. The practical concerns of playability are a salient concern that each composer is able to overcome and address in a productive way. Finally, the structure of these pieces displays how each composer uses the pitch materials to shape the small-scale phrase structure as well as large-scale forms of the pieces.

The novel approach to pitch organization often, but not always, creates demands that lead to original methods or organization of every aspect of a musical work. This essay does not argue for an historical imperative but instead advocates a sensitivity toward the music, balancing the analytical and technical aspects of composition with the expressive and subjective.

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## NOTES

<sup>1</sup> Bob Gilmore, “Changing the Metaphor: Ratio Models of Musical Pitch in the Work of Harry Partch, Ben Johnston, and James Tenney,” *Perspectives of New Music* 33, no. 1/2 (1995): 458–503.

<sup>2</sup> Kyle Gann, “How the 13th Harmonic Saved My Music,” microtonal conference at the University of Pittsburgh, 2015. <http://www.kylegann.com/13th-Harmonic.html> visited 11/7/2017

<sup>3</sup> Ben Johnston, “The Corporealism of Harry Partch,” *Perspectives of New Music* 13, no. 2 (Spring-Summer 1975): 83.

<sup>4</sup> Harry Partch, *Genesis of a Music*, 2nd ed. (Boston: Da Capo Press, 1979): 155.

<sup>5</sup> Reproduced from the *Asking Ocean* score front matter. Marc Sabat, *Asking Ocean*, musical score (Plainsound Music, 2016).

<sup>6</sup> Marc Sabat, “Three Tables for Bob,” *Tempo* 70, no. 278 (2016): 47–63.

<sup>7</sup> See front matter of *Asking Ocean* score. Marc Sabat, *Asking Ocean*, musical score (Plainsound Music, 2016).

<sup>8</sup> Marc Sabat, “Three Tables for Bob,” *Tempo* 70, no. 278 (2016): 54.

<sup>9</sup> William A. Sethares, *Tuning, Timbre, Spectrum, Scale*, 2nd ed. (London: Springer-Verlag, 2005), 70.

<sup>10</sup> Georg Friedrich Haas, “Fünf Thesen zur Mikrotonalität,” in *Georg Friedrich Haas: Im Klang denken*, by Lisa 29 Farthofer, trans. Raymond Massoud (Saarbrücken: PFAU-Verlag, 2001), 123.

<sup>11</sup> James Tenney, “About Changes: Sixty-Four Studies for Six Harps,” *Perspectives of New Music* 25, no. 1/2, 25th Anniversary Issue (Winter-Summer, 1987): 64–87.

<sup>12</sup> Varga, Bálint András, *Three Questions for Sixty-Five Composers* (Rochester, NY: University of Rochester Press, 2015), 104.

<sup>13</sup> Philip Blackburn, “Harry Partch and the Philosopher’s Tone,” *Hyperion* 3, no. 1 (2008): 1–20.

<sup>14</sup> Marc Sabat, correspondence with Taylor Brook, February 13, 2017.

<sup>15</sup> Reproduced from the *Asking Ocean* score front matter. Marc Sabat, *Asking Ocean*, musical score (Plainsound Music, 2016).

<sup>16</sup> Marc Sabat, correspondence with Taylor Brook, February 13, 2017.

<sup>17</sup> Georg Friedrich Haas, *Limited Approximations*, musical score program notes. <https://www.universaledition.com/composers-and-works/georg-friedrich-haas-278/works/limited-approximations-13386>. Visited November 8, 2017.

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- <sup>18</sup> Ronald Rasch, “A Word or Two on the Tuning of Harry Partch” in *Harry Partch: An Anthology of Critical Perspectives*, ed. David Dunn (Amsterdam: Harwood Academic Publishers, 2000), 25.
- <sup>19</sup> Pierre Boulez, *Penser la musique aujourd’hui* (Paris: Gallimard, 1987), 107–8.
- <sup>20</sup> Marc Sabat, *Asking Ocean*, musical score (Plainsound Music, 2016).
- <sup>21</sup> Marc Sabat, correspondence with Taylor Brook, February 13, 2017.
- <sup>22</sup> La Monte Young and Marian Zazeela, interviewed by Ian Nagoski, *Halana* 1 (Winter 1995/1996), 30.
- <sup>23</sup> Henry Cowell, *New Musical Resources*, 2nd ed. (New York: Something Else Press, 1969), 86–89.
- <sup>24</sup> Harry Partch, “The Rhythmic Motivations of Castor and Pollux and Even Wild Horses” in *Harry Partch: An Anthology of Critical Perspectives*, ed. David Dunn (Amsterdam: Harwood Academic Publishers, 2000), 20.
- <sup>25</sup> S. Andrew Granade, “Rekindling Ancient Values: The Influence of Chinese Music and Aesthetics on Harry Partch,” *Journal of the Society for American Music* Volume 4, Number 1 (2010): 5–13.
- <sup>26</sup> Simha Arom, *African Polyphony and Polyrhythm: Musical Structure and Methodology* (Cambridge: Cambridge University Press, 1991) 229–230
- <sup>27</sup> Harry Partch, *Genesis of a Music*, 2nd ed. (Boston: Da Capo Press, 1979), 48–49.
- <sup>28</sup> Partch, *Genesis of a Music*, 52.
- <sup>29</sup> Joseph N. Straus, *Stravinsky’s Late Music* (Cambridge: Cambridge University Press, 2001), 81–82.
- <sup>30</sup> Jean-Jacques Nattiez, *Music and Discourse: Toward a Semiology of Music*, trans. Carolyn Abbate (Princeton: Princeton University Press, 1990), 127–28.

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# Delusion of the Fury - Exordium

Transcription by Taylor Brook

## A section

a

b

♩ = 90  
harmonic canon strum

Intervals and cents values for the harmonic canon strum:

16/9	21/20	7/6	10/9	9/8	4/3	16/9	21/20	7/6	10/9	9/8	4/3
-3.9c	-15.5c	-33.1c	-17.6c	+3.9c	-2c	-3.9c	-15.5c	-33.1c	-17.6c	+3.9c	-2c

Castor: 4/3 (-2c), 10/9 (-17.6c), 5/3 (-15.6c)

Cloud Chamber Bwls: 16/9 (-3.9c)

spoils of war (cloud chamber bowls): 10/9 (-17.6c), 11/6 (+49.4c)

16/9 Tonicity

5:4:3 on 16/9

generally 3OT with a focus on 16/9 root with a quasi-chromatic segment at the top of the arpeggiation.

a<sup>1</sup>

b

4 harmonic canon strum

Intervals and cents values for the harmonic canon strum:

16/9	21/20	7/6	10/9	9/8	4/3	16/9	21/20	7/6	10/9	9/8	4/3
-3.9c	-15.5c	-33.1c	-17.6c	+3.9c	-2c	-3.9c	-15.5c	-33.1c	-17.6c	+3.9c	-2c

Koto: 4/3 (-2c), 9/7 (+35c), 11/7 (-17.5c)

Castor: 4/3 (-2c), 10/9 (-17.6c), 5/3 (-15.6c)

Cloud Chamber Bwls: 7/4 (-31.2c), 16/9 (-3.9c)

spoils of war (cloud chamber bowls): 10/9 (-17.6c), 11/6 (+49.4c)

spoils of war (wang guns): 16/15 (+11.7c), 6/5 (+15.6c)

cons. → diss. → cons. → diss. → cons.  
5:4:3 (major triad) with 16/9 root (11/6 upper neighbor) (7/4 lower neighbor)





14

harmonic canon strum

16/9 -3.9c   21/20 -15.5c   7/6 -33.1c   10/9 -17.6c   9/8 +3.9c   4/3 -2c   16/9 -3.9c   21/20 -15.5c   7/6 -33.1c   10/9 -17.6c   9/8 +3.9c   4/3 -2c

Cloud Chamber Bwls

4/3 -2c   8/5 +13.7c   5/4 -13.7c   7/5 -17.5c   40/27 -19.5c   7/5 -17.5c

16/15 +11.7c   **x variation**   16/15 +11.7c   8/5 +13.7c

Gourd Tree

10/7 +17.5c

Koto

1/1 0c

Crychord

3/2 -2c   10/7 +17.5c

chromelodeon 1

kithara 1

7/5 -17.5c   4/3 -2c   3/2 -2c

kithara 2

3/2 -2c

3/2 + 21/20

**d (evolution of c)**

17

Guitar 1  
 $10/7$   $4/3$   
 $+17.5c$   $-2c$

Guitar 2  
 $20/11$   $11/6$   $20/11$   $16/9$   
 $+35c$   $+49.4c$   $+35c$   $-3.9c$

kithara 1  
 $20/11$   $11/7$   $20/11$   $16/9$   
 $+35c$   $-17.5c$   $+35c$   $-3.9c$

kithara 2  
 $16/11$   $11/7$   $16/11$   $4/3$   
 $+48.7c$   $-17.5c$   $+48.7c$   $-2c$

chromelodeon 1  
 $20/11$   $11/6$   $20/11$   $16/9$   
 $+35c$   $+49.4c$   $+35c$   $-3.9c$

chromelodeon 2  
 $12/11$   $11/10$   $10/7$   $4/3$   
 $-49.4c$   $-35c$   $+17.5c$   $-2c$

spoils of war  
 $16/11$   $11/6$   $16/11$   $4/3$   
 $+48.7c$   $+49.4c$   $+48.7c$   $-2c$

11OT 11UT 11OT IUT

16/11 Pedal

**a111i (close to m 14-15)**

**c**

20

winding slide up

Gourd Tree  
 $10/7$   
 $+17.5c$

kithara 1  
 $7/6 + 10/7$   $7/6 + 4/3$

Koto  
 $1/1$   $11/7$   
 $0c$   $-17.5c$

harmonic canon strum  
 $16/9$   $21/20$   $7/6$   $10/9$   $9/8$   $4/3$   $16/9$   $21/20$   $7/6$   $10/9$   $9/8$   $4/3$   
 $-3.9c$   $-15.5c$   $-33.1c$   $-17.6c$   $+3.9c$   $-2c$   $-3.9c$   $-15.5c$   $-33.1c$   $-17.6c$   $+3.9c$   $-2c$

chromelodeon 1  
 $4/3$   $9/8$   $10/9$   $7/6$   $21/20$   $4/3$   $9/8$   $10/9$   $7/6$   $21/20$   
 $-2c$   $+3.9c$   $-17.6c$   $-33.1c$   $-15.5c$   $-2c$   $+3.9c$   $-17.6c$   $-33.1c$   $-15.5c$

Cloud Chamber Bowls  
 $4/3$   $8/5$   $5/4$   $7/5$   $40/27$   $7/5$   
 $-2c$   $+13.7c$   $-13.7c$   $-17.5c$   $-19.5c$   $-17.5c$

16/15  $16/15$   $8/5$   $10/7$   
 $+11.7c$   $+11.7c$   $+13.7c$   $+17.5c$

16/9 Tonality

23 Gourd Tree

6/5 +15.6c    9/7 +35c    8/7 +31.2c    9/7 +35c    10/7 3/2 27/16 +17.5c -2c +5.9c    10/7 +17.5c    3/2 -2c

Guitar 1  
8/7 +31.2c    1/1 0c    5/4 -13.7c    8/7 +31.2c    16/15 +11.7c    1/1 0c

Guitar 2  
16/15 +11.7c    40/21 +15.5c    16/15 +11.7c

Koto  
1/1 0c    1/1 0c

kithara 1  
1/1 0c    10/9 -17.6c    1/1 0c    10/9 -17.6c

kithara 2  
12/7 +33.1c    12/7+10/9 -15.5c    12/7 +33.1c    12/7+10/9 -15.5c

9/5 +17.6c    1/1 0c    9/5 +17.6c    1/1 0c

spoils of war (brass shell casings)  
6/5 + 6/5 +31.2c    6/5 + 4/3 +13.6c    7/5 -17.5c    10/7 +17.5c    40/27 -19.5c

chromelodeon 2  
27/20 +15.5c    40/21 1/1 0c    40/21 +15.5c    27/20 +20.6c    10/7 +17.5c    3/2 -2c

crychord  
8/5 +13.7c    3/2 -2c

27/16 +5.9c    32/21 +29.2c    5/3 -15.6c    32/21 +29.2c+5.9c    27/16 +48.7c    16/11 +33.1c

50T    70T    x variation    7UT    30T

9UT    7OT    3OT    7OT    9UT

27 Gourd Tree a

27/16 +5.9c    9/7 +35c    6/5 +15.6c

spoils of war (wang guns) 10/7 +17.5c    7/5 -17.5c

Guitar 2 4/3 -2c    10/9 -17.6c

kithara 1 11/10 -35c    11/7 -17.5c    11/8 +51.3c    11/10 -35c    11/6 +49.4c    11/8 +51.3c

8/7+10/7 +49.3    8/7+8/7 -35.6

12/7+10/7 +50.3    12/7+8/7 -34.7

4/3 -2c

chromelodeon 2 10/9 3/2 -17.6c -2c    16/11 +48.7c    12/7 +33.1c

1/1 0c    8/7 +31.2c    8/5 +13.7c

1/1 0c    9/7 +35c

16/9 -3.9c    21/20 -15.5c    7/6 -33.1c    10/9 -17.6c    9/8 +3.9c    4/3 -2c

4/3 -2c    9/8 +3.9c    10/9 -17.6c    7/6 -33.1c    21/20 -15.5c

16/9 -3.9c    8/5 +13.7c    16/9 -3.9c

harmonic canon strum

Guitar 1 5/3 -15.6c

8/5 +13.7c

90T    11UT    10T    70T    50T

31

**b** **a** **c**

harmonic canon strum

16/9 -3.9c 21/20 -15.5c 7/6 -33.1c 10/9 -17.6c 9/8 +3.9c 4/3 -2c

4/3 -2c 8/5 +13.7c 5/4 -13.7c 7/5 -17.5c

Cloud Chamber Bowls

16/15 +11.7c 7/8

21/20 -15.5c 1/1 0c

crychord

16/9 -3.9c 4/3 -2c 9/7 +35c 11/7 -17.5c

Koto

40/27 -19.5c

16/15 +11.7c

Gourd Tree

10/7 +17.5c

1/1 0c

spoils of war (wang guns)

chromelodeon 1

16/9 -3.9c

1/1 0c

35

**d** **a**

harmonic canon strum

16/9 -3.9c 21/20 -15.5c 7/6 -33.1c 10/9 -17.6c 9/8 +3.9c 4/3 -2c

4/3 -2c 9/8 +3.9c 10/9 -17.6c 7/6 -33.1c 21/20 -15.5c 16/9 -3.9c

spoils of war (cloud chamber bowls)

16/11 +48.7c 16/11 +48.7c

11/6 +49.4c 11/6 +49.4c

Cloud Chamber Bowls

20/11 +35c

14/9 -35.1c 4/3 -2c 10/9 -17.6c 16/9 -3.9c 4/3 -2c 16/9 -3.9c

Guitar 2

20/11 +35c 11/6 +49.4c 20/11 +35c 16/9 -3.9c

20/11 11/6 +35c +49.4c

20/11 11/6 +35c +49.4c

chromelodeon 1

20/11 +35c 11/6 +49.4c 20/11 +35c 16/9 -3.9c

12/11 -49.4c 11/10 -35c 12/11 -49.4c 16/15 +11.7c

20/11 11/6 +35c +49.4c

14/9 -35.1c 11/7 -17.5c

chromelodeon 2

16/9 -3.9c 27/16 +5.9c 16/9 -3.9c 18/11 -47.4c

1/1 0c 10/9 -17.6c 1/1 0c 160/81 -21.1c 20/11 11/6 +35c +49.4c

11OT 11UT 11OT 1UT 3OT

microtonal cluster around 16/9

38

c

d

38

**Guitar 2**  
11/6 +49.4c  
9/5 +17.6c

**Cloud Chamber Bowls**  
8/5 +13.7c 16/9 -3.9c 20/11 +35c

**Guitar 2**  
4/3 -2c

**chromelodeon 1**  
8/5 +13.7c 4/3 -2c 16/11 +48.7c

**chromelodeon 2**  
8/5 +13.7c 7/4 -31.2c 11/6 +49.4c

**spoils of war (cloud chamber bowls)**  
11/6 +49.4c 10/9 -17.6c

**Gourd Tree**  
6/5 +15.6c

**kithara 1**  
1/1 0c 12/11 -49.4c

**Hex 7**  
32/21 +29.2c 7/5 -17.5c

**Hex 12**  
15/8 -11.7c 3/2 -2c

**Hex 2**  
40/27 -19.5c

**REDUCTION OF LINES**

8/5 +13.7c	16/9 -3.9c	20/11 +35c	15/8 -11.7c	40/21 +15.5c	160/81 -21.1c
8/5 +13.7c	4/3 -2c	16/11 +48.7c	11/6 +49.4c	10/9 -17.6c	6/5 +15.6c
1/1 0c	1/1 0c	12/11 -49.4c			

50T 30T 110T 15/8 Tonality 5UT 6/5 Tonality

42

kithara 1  
Hex 6  
4/3 -2c → 9/8 +3.9c → 4/3 -2c

Hex 1  
1/1 0c → 3/2 -2c

Hex 6  
4/3 -2c → 5/4 -13.7c

kithara 1  
7/5 -17.5c → 16/11 +48.7c → 3/2 -2c → 4/3 -2c → 5/3 -15.6c

kithara 2  
11/8 +51.3c

Hex 12  
3/2 -2c → 9/8 +3.9c

9/8 +3.9c → 1/1 0c

Hex 2  
11/8 +51.3c → 7/4 -31.2c → 16/11 +48.7c → 3/2 -2c

Hex 12  
1/1 0c → 5/4 -13.7c

Cloud Chamber Bows  
16/15 +11.7c → 6/5 +15.6c → 5/4 -13.7c → 9/7 +35c → 4/3 -2c → 7/5 -17.5c → 40/27 -19.5c → 8/5 +13.7c

chromelodeon 1 (RH)  
4/3 -2c → 3/2 -2c → 7/4 -31.2c → 9/5 +17.6c → 9/7 +35c → 4/3 -2c → 14/11 +17.5c → 21/16 -29.2c → 11/8 +51.3c → 40/27 -19.5c → 32/21 +29.2c

chromelodeon 1 (LH)  
16/15 +11.7c → 6/5 +15.6c → 5/4 -13.7c → 9/7 +35c → 4/3 -2c → 11/8 +51.3c → 7/5 -17.5c → 16/11 +48.7c → 3/2 -2c → 8/5 +13.7c → 5/3 -15.6c

chromelodeon 2 (LH)  
9/7 +35c → 4/3 -2c → 11/8 +51.3c → 7/5 -17.5c → 16/11 +48.7c → 3/2 -2c → 8/5 +13.7c → 5/3 -15.6c

chromelodeon 2 (RH)  
16/15 +11.7c → 6/5 +15.6c → 5/4 -13.7c → 9/5 +17.6c → 16/9 -3.9c → 11/6 +49.4c → 7/4 -31.2c → 20/11 +35c → 3/2 -2c → 4/3 -2c → 5/4 -13.7c

spoils of war (brass shell casings)

spoils of war (cloud chamber bows)

spoils of war (wang guns)

Gourd Tree  
6/5 +15.6c → 9/7 +35c → 11/8 +51.3c → 7/5 -17.5c → 16/11 +48.7c → 3/2 -2c → 1/1 0c → 27/16 +5.9c

Guitar 1  
5/3 -15.6c → 8/5 +13.7c

Guitar 2  
4/3 -2c → 5/3 -15.6c

REDUCTION  
4/3 -2c → 3/2 -2c → 7/4 -31.2c → 9/5 +17.6c → 16/9 -3.9c → 11/6 +49.4c → 40/27 -19.5c → 20/11 +35c → 7/5 -17.5c → 16/11 +48.7c → 3/2 -2c → 8/5 +13.7c → 5/3 -15.6c

1/1 0c → 9/7 +35c → 4/3 -2c → 14/11 +17.5c → 21/16 -29.2c → 11/8 +51.3c → 40/27 -19.5c → 4/3 -2c → 32/21 +29.2c → 5/4 -13.7c

1UT 3UT 1OT 9UT 9OT 11UT 7UT 11OT 1OT 1UT 5UT

(just minor triad)  
(overtone chord)





53

Boo  
4/3  
-2c

Pollux  
11/8  
+51.3c

Mazda Marimba  
4/3 21/16 5/4 3/2 4/3 11/7 3/2 7/5 4/3  
-2c -29.2c -13.7c -2c -17.5c -2c -17.5c -2c 4/3 -2c

Guitar 2  
16/9 -3.9c  
14/9 -35.1c  
5/3 -15.6c  
16/9 -3.9c  
4/3 -2c  
10/9 -17.6c  
16/9 +16/9 -7.8c  
4/3 -2c

Harmonic Canon 1  
16/15 +4/3 16/15 +9/7  
+9.7c 16/9 +46.7c 4/3 +9/7 +35c  
21/16 -29.2c  
16/9 -3.9c  
4/3 -2c  
27/20 +20.6c  
14/9 -35.1c

upper line bends down gradually to m.62

56

Castor  
4/3  
-2c

Boo  
4/3  
-2c

Mazda Marimba  
4/3 21/16 5/4 4/3 5/4 11/7 4/3 4/3 21/16 5/4 11/7 3/2 11/8 4/3  
-2c -29.2c -13.7c -2c -13.7c -17.5c -2c -2c -2c -29.2c -13.7c -17.5c -2c +51.3c -2c

Guitar 2  
16/9 -3.9c  
14/9 -35.1c  
5/3 -15.6c  
16/9 -3.9c  
4/3 -2c  
10/9 -17.6c  
16/9 +16/9 -7.8c  
4/3 -2c

Harmonic Canon 1  
(upper line bends down gradually to m.62)  
8/5 +13.7c  
5/3 -15.6c  
8/5 +13.7c  
16/9 -3.9c  
4/3 -2c  
4/3 -2c  
16/9 -3.9c  
4/3 -2c  
4/3 -2c  
8/5 +13.7c

59

Castor  $\frac{4}{3}$  -2c

Pollux  $\frac{11}{8}$  +51.3c

Mazda Marimba  $\frac{7}{6}$  -33.1c

Guitar 2  $\frac{16}{9}$  -3.9c,  $\frac{14}{9}$  -35.1c

Harmonic Canon 1 (upper line bends down gradually to m.62)

8/5 16/9 11/6 8/7 +13.7c-3.9c+49.4c +31.2c 11/6 11/7 14/9 +49.4e17.5c -35.1c

3/2 7/5 11/8 4/3 11/7 14/9 11/8 21/16 -2c -17.5c +51.3c -2c -17.5c -35.1c+51.3c -29.2c

4/3 5/4 1/1 4/3 5/4 1/1 4/3 -2c -13.7c 0c -2c -13.7c 0c -2c

8/7 +31.2c

5/3 -15.6c 16/9 -3.9c

21/16 -29.2c 16/15 +11.7c 21/16 -29.2c 16/15 +51.3c +11.7c

4/3 -2c 16/9 +16/9 -7.8c 4/3 -2c

14/9 -35.1c

27/20 +20.6c 21/16 -29.2c

16/9 -3.9c 4/3 -2c 16/9 -3.9c 4/3 -2c

62

Bass Marimba  $\frac{4}{3}$  -2c

Mazda Marimba  $\frac{10}{9}$  -17.6c

Guitar 2  $\frac{16}{9}$  -3.9c,  $\frac{14}{9}$  -35.1c

Harmonic Canon 1

Cone Gong  $\frac{16}{9}$  -3.9c

Gourd Tree  $\frac{9}{7}$  +35c

Castor  $\frac{10}{9}$  -17.6c

Hex 6 kithara  $\frac{4}{3}$  -13.7c,  $\frac{5}{4}$  -2c

Cone Gong  $\frac{16}{9}$  -3.9c

Gourd Tree  $\frac{9}{7}$  +35c

Castor  $\frac{4}{3}$  -2c

Harmonic Canon 1  $\frac{16}{15} + \frac{4}{3}$  +9.7c,  $\frac{16}{9}$  -3.9c,  $\frac{21}{16}$  -29.2c,  $\frac{16}{15} + \frac{4}{3}$  +9.7c,  $\frac{16}{9}$  -3.9c,  $\frac{7}{6}$  -33.1c

X-set 29-36

C section

30T

Marimba Eroica often used in approximations due to the limited pitches it offers and the clarity of pitch from the instrument.

Eucal Blossom  
y transposed

72

Cloud Chamber Bowls

9/5 +17.6c

16/9 -3.9c 15/8 -11.7c 10/9 -17.6c 6/5 +15.6c 10/9 -17.6c 15/8 -11.7c 16/9 -3.9c

7/6 10/9 12/11 -33.1c -17.6c -49.4c

Quadrangularis

10/7 +17.5c

16/9 -3.9c 15/8 -11.7c 10/9 -17.6c 6/5 +15.6c

Boo

15/8 -11.7c 11/6 +49.4c 20/11 9/5 +35c+17.6c 9/5 +17.6c 11/6 +49.4c

40/21 +15.5c 16/9 -3.9c 20/11 +35c

Marimba Eroica

11/8 +51.3c 8/7 +31.2c

Gourd Tree

8/7 +31.2c

9/5 +17.6c 12/7 +33.1c

7OT Bass Marimba

8/7 +31.2c

74

Eucal Blossom

9/5 +17.6c 8/7 +31.2c

8/5 +13.7c 40/21 +15.5c

Quadrangularis

8/5 +13.7c 40/21 +15.5c 8/7 +31.2c

9/5 +17.6c

Boo

8/5 +13.7c

1/1 4/3 7/5 0c -2c -17.5c

1/1 64/33 1/1 64/33 1/1 64/33 7/4 27/16 0c +46.7c 0c +46.7c 0c +46.7c -31.2c +5.9c

160/81 -21.1c 40/21 +15.5c 160/81 -21.1c 40/21 +15.5c 160/81 -21.1c 40/21 +15.5c 12/7 +33.1c 5/3 -15.6c

4/3 -2c

1/1 0c

12/7 +33.1c 8/7 +31.2c

9/5 +17.6c 12/7 +33.1c

Cone Gong

4/3 -2c 12/11 -49.4c

Bass Marimba

4/3 -2c

1/1 0c

Marimba Eroica

11/8 +51.3c 8/7 +31.2c

9/5 +17.6c 12/7 +33.1c

76

Cloud Chamber Bows 12/11 10/9 7/6  
 7/5 9/5 -49.4c +17.6c -17.6c -33.1c

Cone Gong

Quadrangularis

Boo

Bass Marimba

Marimba Eroica

Eucal Blossom  
y transposed

5/3 11/6 16/15 7/6  
-15.6c +49.4c +11.7c -33.1c

7/5 11/8 4/3  
+17.5c +51.3c -2c

10/7 7/5 10/7 7/5 7/5 27/20  
+17.5c -17.5c +17.5c -17.5c -17.5c +20.6c

7/6 -33.1c

11/8 8/7  
+51.3c +31.2c

12/7 9/5 12/7  
+33.1c +17.6c +33.1c

7UT

3OT

78

Cloud Chamber Bows

spoils of war  
(cloud chamber bows)

Quadrangularis

Boo

Bass Marimba

Marimba Eroica

Eucal Blossom  
y transposed

7/6 10/9 12/11 9/5  
-33.1c -17.6c -49.4c +17.6c

7/4 9/8 5/4  
-31.2c +3.9c -13.7c

21/20 9/8 5/4  
-15.5c +3.9c -13.7c

7/4 12/7 5/3 8/5 14/9 3/2  
-31.2c +33.1c -15.6c +13.7c -35.1c -2c

7/4 27/16 18/11 11/7 32/21 32/21 40/27  
-31.2c +5.9c -47.4c -17.5c +29.2c +29.2c -19.5c

3/2 3/2 3/2  
-2c -2c -2c

11/8 8/7  
+51.3c +31.2c

9/5 12/7  
+17.6c +33.1c

IOT

80

Eucal Blossom  $\frac{5}{3}$   $\frac{11}{6}$   $\frac{16}{15}$   $\frac{7}{6}$   
 $-15.6c$   $+49.4c$   $+11.7c$   $-33.1c$

Quadrangularis  $\frac{7}{5}$   $\frac{5}{3}$   $\frac{11}{6}$   $\frac{16}{15}$   $\frac{7}{6}$   
 $-17.5c$   $-15.6c$   $+49.4c$   $+11.7c$   $-33.1c$

Boo  $\frac{7}{5}$   
 $-17.5c$

Marimba Eroica  $\frac{9}{5}$   $\frac{12}{7}$   $\frac{8}{7}$   
 $+17.6c$   $+33.1c$   $+31.2c$

Cone Gong  $\frac{4}{3}$   $\frac{12}{11}$   
 $-2c$   $-49.4c$

Bass Marimba  $\frac{1}{1}$   $\frac{7}{5}$   $\frac{4}{3}$   
 $0c$   $-17.5c$   $-2c$

$\frac{1}{1}$   $\frac{64}{33}$   $\frac{1}{1}$   $\frac{64}{33}$   $\frac{1}{1}$   $\frac{64}{33}$   $\frac{7}{4}$   $\frac{27}{16}$   
 $0c$   $+46.7c$   $0c$   $+46.7c$   $0c$   $+46.7c$   $-31.2c$   $+5.9c$

$\frac{160}{81}$   $\frac{40}{21}$   $\frac{160}{81}$   $\frac{40}{21}$   $\frac{160}{81}$   $\frac{40}{21}$   $\frac{12}{7}$   $\frac{5}{3}$   
 $-21.1c$   $+15.5c$   $-21.1c$   $+15.5c$   $-21.1c$   $+15.5c$   $+33.1c$   $-15.6c$

$\frac{1}{1}$   $0c$

$\frac{12}{7}$   $\frac{8}{7}$   
 $+33.1c$   $+31.2c$

82

Cone Gong  $\frac{6}{5}$   
 $+15.6c$

Gourd Tree  $\frac{1}{1}$   $\frac{6}{5}$   $\frac{9}{7}$   
 $0c$   $+15.6c$   $+35c$

Cloud Chamber Bells  $\frac{64}{33}$   
 $+46.7c$

Diamond Marimba  $\frac{7}{6}$   $\frac{1}{1}$   $\frac{7}{6}$   $\frac{9}{7}$   $\frac{1}{1}$   $\frac{9}{7}$   $\frac{11}{9}$   $\frac{11}{9}$   
 $-33.1c$   $0c$   $-33.1c$   $+35c$   $0c$   $+35c$   $+46.7c$   $+46.7c$

Quadrangularis Reversum  $\frac{6}{5}$   $\frac{6}{5}$   $\frac{6}{5}$   $\frac{7}{6}$   $\frac{7}{6}$   $\frac{9}{7}$   $\frac{9}{7}$   $\frac{1}{1}$   
 $+15.6c$   $+15.6c$   $+15.6c$   $-33.1c$   $-33.1c$   $+35c$   $+35c$   $0c$

Boo  $\frac{8}{5}$   $\frac{5}{3}$   $\frac{12}{7}$   $\frac{10}{7}$   $\frac{12}{7}$   $\frac{14}{9}$   $\frac{4}{3}$   $\frac{14}{9}$   $\frac{18}{11}$   $\frac{14}{11}$   $\frac{18}{11}$   
 $+13.7c$   $+13.7c$   $+33.1c$   $+17.5c$   $+33.1c$   $-35.1c$   $-2c$   $-35.1c$   $-47.4c$   $+17.5c$   $-47.4c$

Eucal Blossom  $\frac{8}{5}$   $\frac{5}{3}$   $\frac{4}{3}$   $\frac{5}{3}$   $\frac{5}{3}$   $\frac{5}{3}$   $\frac{12}{7}$   $\frac{12}{7}$   $\frac{14}{9}$   $\frac{14}{9}$   $\frac{8}{5}$   $\frac{5}{3}$   $\frac{12}{7}$   $\frac{14}{9}$   
 $+13.7c$   $-15.6c$   $-2c$   $-15.6c$   $-15.6c$   $-15.6c$   $+33.1c$   $+33.1c$   $-35.1c$   $-35.1c$   $+13.7c$   $-15.6c$   $-2c$   $-15.6c$   $-15.6c$   $+33.1c$   $+33.1c$   $-35.1c$   $-35.1c$

$\frac{1}{1}$   $0c$

$\frac{8}{5}$   $\frac{5}{3}$   $\frac{12}{7}$   $\frac{14}{9}$   
 $+13.7c$   $-15.6c$   $+33.1c$   $-35.1c$

Polymetric Segment Begins



88 Cloud Chamber Bowls

spoils of war

Gourd Tree

Eucal Blossom

Boo

Bass Marimba

5OT

IOT

3/2 Tonality

1/1 Tonality

90 Cloud Chamber Bowls

spoils of war  
(brass shell casings)

Gourd Tree

Eucal Blossom

Boo

Bass Marimba



92 Cloud Chamber Bowls

4/3 -2c      7/5 -17.5c      8/5 +13.7c      5/3 -15.6c      4/3 -2c      5/4 -13.7c

Gourd Tree 10/7 +17.5c      9/7 +35c      64/33 +46.7c      8/7 +31.2c      9/7 +35c      8/7 +31.2c      64/33 +46.7c      9/7 +35c

Eucal Blossom 12/7 +33.1c      5/3 -15.6c      8/5 +13.7c      12/7 +33.1c      5/3 -15.6c      10/9 -17.6c      10/9 -17.6c

Boo 12/7 +33.1c      5/3 -15.6c      8/5 +13.7c      5/3 -15.6c      12/7 +33.1c      5/3 -15.6c      16/11 +48.7c      16/11 +48.7c      16/11 +48.7c

Bass Marimba 5/3 -15.6c      8/7 +31.2c

Marimba Eroica

4/3 -2c      8/7 +31.2c

4/3 Tonality    3OT      8/7 Tonality

94 spoils of war (cloud chamber bowls)

16/11 +48.7c

Cloud Chamber Bowls

Eucal Blossom 10/9 -17.6c      16/11 +48.7c      12/11 -49.4c      12/7 +33.1c      18/11 -47.4c      8/5 +13.7c      3/2 -2c      10/7 +17.5c      11/8 +51.3c

Boo 20/11 +35c      16/11 +48.7c      10/7 +17.5c      7/5 -17.5c      11/8 +51.3c      27/20 +20.6c

Marimba Eroica 9/5 +17.6c

16/9 -3.9c      12/11 -49.4c      16/9 -3.9c      12/11 -49.4c

16/9 -3.9c      12/11 -49.4c

16/9 Tonality

$\frac{16}{9}$   
 -3.9c  
 Eucal Blossom  
 $\frac{4}{3}$   
 -2c  
 Boo  
 $\frac{27}{20}$   
 +20.6c  
 $\frac{4}{3}$   
 -2c  
 Marimba Eroica  
 $\frac{9}{5}$   
 +17.6c  
 Bass Marimba  
 $\frac{4}{3}$   
 -2c  
 Diamond Marimba  
 $\frac{4}{3}$  -2c,  $\frac{5}{3}$  -15.6c,  $\frac{1}{1}$  0c,  $\frac{7}{6}$  -33.1c,  $\frac{3}{2}$  -2c,  $\frac{11}{6}$  +49.4c  
 Reversum  
 $\frac{4}{3}$  -2c,  $\frac{5}{3}$  -15.6c,  $\frac{1}{1}$  0c,  $\frac{7}{6}$  -33.1c,  $\frac{3}{2}$  -2c,  $\frac{11}{6}$  +49.4c  
 Quadrangularis  
 $\frac{4}{3}$  -2c,  $\frac{10}{7}$  +17.5c,  $\frac{4}{3}$  -2c,  $\frac{10}{7}$  +17.5c  
 chromelodeon 1  
 $\frac{1}{1}$  0c  
 chromelodeon 2  
 $\frac{5}{3}$  -15.6c,  $\frac{4}{3}$  -2c  
 $\frac{4}{3}$  -2c

98 Marimba Eroica

12/7 +33.1c  
8/7 +31.2c  
8/7 +31.2c  
10/7 +33.1c +17.5c  
10/7 +17.5c  
1/1 0c

9/5 +17.6c  
16/9 -3.9c  
10/9 -17.6c  
16/9 -3.9c +17.5c  
4/3 -2c  
16/9 -3.9c

16/11 +48.7c  
12/11 -49.4c  
20/11 +35c  
9/5 +17.6c  
16/11 +48.7c  
16/11 +48.7c

8/7 +31.2c  
3/2 -2c  
6/5 +15.6c 1/1 0c  
3/2 -2c  
3/2 -2c

7OT 9OT 11OT 3UT

102 Marimba Eroica spoils of war (cloud chamber bowls)

12/7 +33.1c  
5/3 -15.6c  
5/4 -13.7c 1/1 0c  
5/3 -15.6c  
5/4 -13.7c  
5/3 -15.6c

16/9 -3.9c  
4/3 -2c  
1-Odentity  
4/3 -2c 1/1 0c  
8/5 +13.7c  
4/3 -2c  
1/1 0c

16/11 +48.7c  
16/11 +48.7c  
Diamond Marimba 12/11 -49.4c 10/9 -17.6c 8/7 +31.2c 14/11 +17.5c  
Reversum 12/11 -49.4c 10/9 -17.6c 20/11 +35c 14/11 +17.5c  
16/11 +48.7c

16/11 +48.7c  
16/9 -3.9c  
16/9 -3.9c  
16/9 -3.9c

5UT 1UT 11OT 9OT 11OT

105

chromelodeon 1  
5/3 -15.6c 10/9 -17.6c

chromelodeon 2  
5/3 -15.6c

Bass Marimba  
16/9 -3.9c 16/11 +48.7c 8/5 +13.7c 1/1 0c 5/3 -15.6c 10/9 -17.6c

Diamond Marimba  
4/3 -2c 10/9 -17.6c 8/5 +13.7c 5/3 -15.6c 4/3 -2c 10/9 -17.6c

Reversum  
4/3 -2c 10/9 -17.6c 8/5 +13.7c 5/3 -15.6c 4/3 -2c 10/9 -17.6c

Eucal Blossom  
4/3 -2c

9OT 3OT

107

Gourd Tree  
9/7 +35c 9/7 +35c 5/4 -13.7c 11/9 +46.7c

Boo  
4/3 -2c

chromelodeon 1

chromelodeon 2

Bass Marimba  
5/3 -15.6c

Diamond Marimba  
10/9 -17.6c

Reversum  
10/9 -17.6c

Eucal Blossom  
4/3 -2c 9/7 +35c 5/4 -13.7c 11/9 +46.7c

9OT

109 Eucal Blossom 8/7 +31.2c 10/9 -17.6c 16/15 +11.7c 33/32 -46.7c 40/21 +15.5c 9/5 +17.6c 8/7 +31.2c 9/8 +3.9c

6/5 +15.6c 7/6 -33.1c 9/8 +3.9c 12/11 -49.4c 21/20 -15.5c 1/1 0c 64/33 +46.7c 15/8 -11.7c 11/6 +49.4c 16/9 -3.9c

Boo 32/27 -5.9c 8/7 +31.2c 10/9 -17.6c 12/11 -49.4c 21/20 -15.5c 81/80 +21.5c 160/81 -21.1c 40/21 +15.5c 11/6 +49.4c 9/5 +17.6c 27/16 +5.9c

6/5 +15.6c 7/6 -33.1c 9/8 +3.9c 11/10 -35c 16/15 +11.7c 33/32 -46.7c 1/1 0c 64/33 +46.7c 15/8 -11.7c 20/11 +35c 12/7 +33.1c 5/3 -15.6c

chromelodeon 1

chromelodeon 2

Bass Marimba 5/3 -15.6c

Diamond Marimba 10/9 -17.6c

Reversum 10/9 -17.6c

spoils of war 32/21 +29.2c 3/2 -2c

9OT

111 Eucal Blossom 10/9 -17.6c 12/11 -49.4c 16/15 +11.7c 21/20 -15.5c 10/7 +17.5c 7/5 -17.5c 11/8 +51.3c 4/3 -2c

Boo 5/3 -15.6c 18/11 -47.4c 8/5 +13.7c 18/11 -47.4c 5/3 -15.6c

chromelodeon 1

chromelodeon 2

Bass Marimba 5/3 -15.6c

Diamond Marimba 10/9 -17.6c

Reversum 10/9 -17.6c

spoils of war 40/27 -19.5c 16/11 +48.7c 7/5 -17.5c 11/8 +51.3c 4/3 -2c

Cone Gong

9OT 11OT 5OT mixed

SMALL INTERVAL SEGMENTS



118

Boo 16/15  
+11.7c

Gourd Tree

Bass Marimba

Marimba Eroica 16/9  
-3.9c

Quadrangularis Reversum

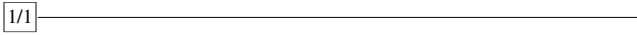
Diamond Marimba

Intervallic labels and cents values for Quadrangularis Reversum and Diamond Marimba:

- Quadrangularis Reversum: 10/7, 20/11 +35c, 10/9 +17.5c, 5/3 -17.6c, 1/1 -15.6c, 5/4 -13.7c, 1/1 0c, 21/20 -15.5c, 16/15 +11.7c, 16/11 -3.9c, 8/7 +31.2c, 4/3 +13.7c, 8/5 -2c, 21/20 -15.5c, 16/15 +11.7c, 21/20 alternating -15.5c.
- Diamond Marimba: 10/7, 20/11 +35c, 10/9 +17.5c, 5/3 -17.6c, 1/1 -15.6c, 5/4 -13.7c, 18/11 -47.4c, 18/11 -47.4c, 5/3 -15.6c, 16/9 +17.5c, 8/7 +31.2c, 4/3 +13.7c, 8/5 -2c, 5/3 -15.6c, 5/3 alternating -15.6c, 12/7 alternating +33.1c.

5UT  
1UT

small interval segments and tremolos



120

Boo  
10/9  
-17.6c

8/7  
+31.2c

chromelodeon 1  
20/11  
+35c alternating

16/9  
-3.9c

16/9 alternating  
-3.9c

40/21 alternating  
+15.5c

15/8  
-11.7c

11/6  
+49.4c

chromelodeon 2  
16/15  
+11.7c

11/8  
+51.3c

15/8  
-11.7c

40/21  
+15.5c

10/7  
+17.5c

Bass Marimba  
8/5  
+13.7c

9/8  
+3.9c

Gourd Tree

1/1  
0c

Quadrangularis Reversum  
1/1 7/6 3/2 11/6  
0c -2c +49.4c

5/3 1/1 7/6 3/2 11/6  
-33.1c -33.1c +49.4c

4/3 -15.6c 0c 10/9  
-2c -17.6c

10/9 alternating  
-17.6c

8/7 alternating  
+31.2c

10/7 1/1 9/7 11/7  
0c +35c -17.5c

8/7 +17.5c 12/7 16/15  
+31.2c +33.1c +11.7c

9/8  
+3.9c

9/8  
+3.9c

Diamond Marimba  
1/1 7/6 3/2 11/6  
0c -2c +49.4c

5/3 1/1 7/6 3/2 11/6  
-33.1c -33.1c +49.4c

4/3 -15.6c 0c 10/9  
-2c -17.6c

10/7 1/1 9/7 11/7  
0c +35c -17.5c

8/7 +17.5c 12/7 16/15  
+31.2c +33.1c +11.7c

Eucal Blossom  
15/8  
-11.7c

11/6  
+49.4c

3OT

7OT



chromelodeon 1 sub bass

**Boo**  
8/7 +31.2c      6/5 +15.6c

**chromelodeon 1**  
40/21 alternating +15.5c      1/1 0c      33/32 -46.7c      5/4 -13.7c

**chromelodeon 2**  
40/21 alternating +15.5c      1/1 0c      33/32 -46.7c      5/4 -13.7c

**Bass Marimba**  
7/6 -33.1c      7/6 -33.1c      5/4 -13.7c

**Diamond Marimba**  
6/5 +15.6c      6/5 +15.6c

**Quadrangularis**  
8/7 +31.2c      7/6 -33.1c      6/5 +15.6c      5/4 -13.7c

**Eucal Blossom**  
40/21 alternating +15.5c      1/1 0c      33/32 -46.7c      5/4 -13.7c

small segments moving towards consonance → Major/Minor Just Triad

124 spoils of war  
(cloud chamber bowls)

**Quadrangularis Reversum**  
5/4 -13.7c

**Eucal Blossom**  
5/4 -13.7c

**Bass Marimba**  
7/6 -33.1c 9/8 +3.9c

**Marimba Eroica**  
8/7 +31.2c 12/7 +33.1c

**Diamond Marimba**  
5/4 -13.7c

3/2 -2c

7/4 21/20 9/8 -31.2c -15.5c +3.9c

7/4 27/20 9/8 -31.2c +20.6c +3.9c

7/6 9/8 -33.1c +3.9c

8/7 +31.2c 12/7 +33.1c

1/1 0c

1/1 5/4 3/2 7/4 9/8 11/8 0c -13.7c -2c -31.2c +3.9c +51.3c

1/1 5/4 3/2 7/4 9/8 11/8 0c -13.7c -2c -31.2c +3.9c +51.3c

3/2 -2c

1/1 0c

126

**Gourd Tree**  
3/2 -2c

**Quadrangularis Reversum**  
5/4 -13.7c

**Eucal Blossom**  
5/4 -13.7c

**Bass Marimba**  
7/6 -33.1c 9/8 +3.9c

**Marimba Eroica**  
8/7 +31.2c

**Zymo-Xyl**  
11/9 +46.7c 4/3 -2c 10/7 +17.5c 11/7 -17.5c 5/3 -15.6c 12/7 +33.1c 20/11 +35c 40/21 +15.5c

3/2 -2c

7/4 21/20 9/8 -31.2c -15.5c +3.9c

7/4 27/20 9/8 -31.2c +20.6c +3.9c

7/6 9/8 -33.1c +3.9c

8/7 +31.2c

6/5 +15.6c

1/1 0c

**Diamond Marimba**  
6/5 +15.6c

1/1 0c

3/2 Pedal

Cloud Chamber Bowls

The musical score is divided into two systems. The first system includes the Cloud Chamber Bowls, Gourd Tree, Zymo-Xyl, and Diamond Marimba. The second system includes the Quadrangularis Reversum, Mazda Marimba, Bass Marimba, and Marimba Eroica. The Cloud Chamber Bowls part features a melodic line with various intervals and accidentals. The Diamond Marimba part has a complex rhythmic pattern with many accidentals. The Quadrangularis Reversum part has a similar rhythmic pattern. The Mazda Marimba part has a few notes with accidentals. The Bass Marimba and Marimba Eroica parts are mostly rests.

12/7 +33.1c  
 7OT      3UT      7OT      1UT      3OT      7UT      1UT      11OT

130 spoils of war  
(cloud chamber bowls)

10/9 -17.6c

Gourd Tree

7/5 -17.5c

Diamond Marimba

Quadrangularis Reversum

Mazda Marimba

z partial inversion

z

132 spoils of war  
(cloud chamber bowls)

10/9 -17.6c

Gourd Tree

Diamond Marimba

Quadrangularis Reversum

Mazda Marimba

4/3

1/1

Cloud Chamber Bowls

10/7  
+17.5c

spoils of war (cloud chamber bowls)

Gourd Tree

Diamond Marimba

Quadrangularis Reversum

Mazda Marimba

z partial inversion

Diamond Marimba

Quadrangularis Reversum

Eucal Blossom

Boo

Mazda Marimba

Zymo-Xyl

small interval segments

138

8/5 +13.7c 8/7 +31.2c 16/11 +48.7c  
 1/1 8/5 16/9 -3.9c  
 16/9 -3.9c 4/3 -2c 1/1 0c  
 16/11 +48.7c 8/7 +31.2c 8/5 +13.7c  
 20/11 +35c 10/7 +17.5c 1/1 0c  
 10/9 -17.6c 5/3 -15.6c 5/4 -13.7c  
 5/4 -13.7c 5/3 -15.6c 10/9 -17.6c  
 1/1 10/7 20/11 0c +17.5c +35c  
 3/2 -2c 1/1 0c 4/3 -2c  
 6/5 +15.6c 12/7 +33.1c 12/11 -49.4c  
 7/4 -31.2c 7/6 -33.1c 14/9 -35.1c  
 7/5 -17.5c 1/1 0c 14/11 +17.5c  
 12/11 -49.4c 12/7 +33.1c 6/5 +15.6c  
 4/3 -2c 1/1 0c 3/2 -2c  
 14/9 -35.1c 7/6 -33.1c 7/4 -31.2c  
 14/11 +17.5c 1/1 0c 7/5 -17.5c

Boo

Bass Marimba  
 16/11 +48.7c 1/1 0c  
 8/7 +31.2c  
 5/3 -15.6c  
 3/2 -2c 5/3 -15.6c  
 8/7 +31.2c 16/11 +48.7c

Marimba Eroica 11/8 +51.3c  
 8/7 +31.2c 12/7 +33.1c 9/5 +17.6c

140

Zymo-Xyl 7/5 -17.5c 8/5 +13.7c 16/9 -3.9c  
 3/2 -2c 27/16 +5.9c 11/6 +49.4c  
 7/4 -31.2c 12/11 -49.4c 16/15 +11.7c 21/20 -15.5c 21/20 -15.5c 33/32 -46.7c 1/1 0c 64/33 +46.7c 1/1 0c  
 12/7 +33.1c 5/3 -15.6c 5/3 -15.6c 18/11 -47.4c 8/5 +13.7c 14/9 -35.1c 8/5 +13.7c  
 7/4 -31.2c  
 12/7 +33.1c 27/16 +5.9c 5/3 -15.6c 18/11 -47.4c 8/5 +13.7c 11/7 -17.5c 8/5 +13.7c

Boo 7/4 -31.2c

Bass Marimba  
 4/3 -2c 3/2 -2c 5/3 -15.6c 16/11 +48.7c 8/7 +31.2c 1/1 0c

Marimba Eroica 11/8 +51.3c 16/9 -3.9c 12/7 +33.1c 8/7 +31.2c

142 Cloud Chamber Bowls

**Zymo-Xyl**

**Diamond Marimba**

**Quadrangularis Reversum**

**Eucal Blossom**

**Boo**

**Bass Marimba**

**Marimba Eroica**

10T      50T      30T      70T

chromelodeon 1 sub bass

chromelodeon 2

kithara 1

Cloud Chamber Bwls

Boo

Quadrangularis Reversum

Diamond Marimba

Bass Marimba

Marimba Eroica

16/9 -3.9c

15/8 -11.7c 20/11 +35c

16/11 +48.7c

8: 16/11 +48.7c

12/11 +48.7c -49.4c

4/3 -2c

20/11 +35c

16/11 +48.7c

10/9 -17.6c 14/9 -35.1c 11/7 -17.5c

20/11 +35c 14/11 +17.5c 1/1 0c

16/9 -3.9c 4/3 -2c 1/1 0c

12/11 -49.4c 18/11 -47.4c

16/11 +48.7c

1/1 0c 4/3 -2c 5/3 -15.6c 1/1 0c 8/7 +31.2c 16/11 +48.7c

11/8 +51.3c 9/5 +17.6c

9OT

11OT



chromelodeon 1

146  $\frac{18}{11}$   
-47.4c

chromelodeon 2

$\frac{14}{11}$   
+17.5c

$\frac{18}{11}$   
-47.4c

chromelodeon 2

kithara 1

$\frac{16}{11}$   
+48.7c

11 Udentiy chord

Boo

$\frac{16}{11}$   
+48.7c

Quadrangularis Reversum

$\frac{16}{11}$   
+48.7c

$\frac{20}{11}$  +35c  $\frac{14}{11}$  +17.5c  $\frac{1}{1}$  0c

Diamond Marimba

Diamond Marimba

Bass Marimba

$\frac{16}{11}$   
+48.7c

Marimba Eroica

$\frac{9}{5}$   
+17.6c

$\frac{12}{11}$  -49.4c  $\frac{14}{11}$  +17.5c

$\frac{18}{11}$  -47.4c

$\frac{15}{8}$  -11.7c  $\frac{20}{11}$  +35c

$\frac{16}{11}$  +48.7c

$\frac{8}{8}$   $\frac{16}{11}$

$\frac{12}{11}$  +48.7c -49.4c

$\frac{12}{11}$  -49.4c  $\frac{18}{11}$  -47.4c

110T

148

chromelodeon 1

11/7 -17.5c

18/11 -47.4c

11/7 -17.5c

chromelodeon 2

14/11 +17.5c

11/8 +51.3c

10/7 +17.5c

11/8 +51.3c

14/11 +17.5c

18/11 -47.4c

12/11 -49.4c

10/7 +17.5c

18/11 -47.4c

20/11 +35c

11/6 +49.4c

20/11 +35c

18/11 -47.4c

20/11 +35c

14/11 +17.5c

11/6 +49.4c

chromelodeon 2

kithara 1

15/8 -11.7c

20/11 +35c

16/11 +48.7c

16/11 +48.7c

12/11 -49.4c

11 Udentiy chord

10/7 +17.5c

16/11 +48.7c

Kithara 1 hex 1 sliding

12/7 + 3/2

12/7 + 16/11

Boo

16/11 +48.7c

Quadrangularis Reversum

16/11 +48.7c

20/11 +35c

14/11 +17.5c

1/1 0c

Diamond Marimba

12/11 -49.4c

18/11 -47.4c

Diamond Marimba

Bass Marimba

16/11 +48.7c

Marimba Eroica

9/5 +17.6c

150

chromelodeon 1  
16/9  
-3.9c

18/11  
-47.4c

chromelodeon 2  
16/15  
+11.7c

14/11  
+17.5c

16/9  
-3.9c

18/11  
-47.4c

chromelodeon 2

Kithara 1 hex 6 sliding

7/6 + 4/3      7/6 + 16/15      12/7 + 3/2      12/7 + 16/11

15/8  
-11.7c    20/11  
+35c

16/11  
+48.7c

16/11  
+48.7c

12/11  
+48.7c

12/11  
-49.4c

Boo  
16/11  
+48.7c

Quadrangularis Reversum      Quadrangularis Reversum

16/11    20/11    14/11    1/1  
+48.7c    +35c    +17.5c    0c

Diamond Marimba      Diamond Marimba

12/11    18/11  
-49.4c    -47.4c

Bass Marimba

16/11  
+48.7c

Marimba Eroica

9/5  
+17.6c

110T

152

kithara 1  
 $\frac{8}{5}$   
 $+13.7c$   $\frac{8}{7}$   $\frac{1}{1}$   
 $+31.2c$   
 $0c$   
 $\frac{8}{5}$   
 $+13.7c$   
 $\frac{1}{1}$   $\frac{4}{3}$   
 $0c$   $-2c$

chromelodeon 1  
 $\frac{1}{1}$   
 $0c$

chromelodeon 1 sub bass  
 $\frac{1}{1}$   
 $0c$

chromelodeon 2  
 $\frac{1}{1}$   
 $0c$

chromelodeon 2  
 $\frac{8}{5}$   
 $+13.7c$

Surrogate Kithara

Surrogate Kithara  
 $\frac{1}{1}$   
 $0c$

Quadrangularis Reversum  
 $\frac{8}{5}$   
 $+13.7c$   
 $\frac{4}{3}$   $\frac{1}{1}$   
 $-2c$   $0c$

DM and QR  
 $\frac{7}{6}$   $\frac{1}{1}$   
 $\flat$   $+33.1c$   $0c$   
 $\frac{1}{1}$   $\frac{12}{7}$   $\frac{5}{3}$   
 $0c$   $+33.1c$   $-15.6c$

Boo  
 $\frac{1}{1}$   
 $0c$

Bass Marimba  
 $\frac{1}{1}$   
 $0c$

Marimba Eroica  
 $\frac{11}{8}$   
 $+51.3c$

IOT

154 Surrogate Kithara

32/21 + 7/6

DM and QR

5/3 -15.6c

5/3 -15.6c

1/1 0c

5/3 -15.6c

10/7 +17.5c

5/3 -15.6c

1/1 0c

4/3 -2c

4/3 -2c

5/3 -15.6c

10/7 +17.5c

10/9 -17.6c

4/3 -2c

5/3 -15.6c

12/7 +33.1c

Boo

1/1 0c

9/8 +3.9c

7/4 -31.2c

27/20 +20.6c

156 Surrogate Kithara

32/21 + 6/5

DM and QR

9/7 +35c

5/4 -13.7c

6/5 +15.6c

3/2 -2c

1/1 0c

5/4 -13.7c

3/2 -2c

1/1 0c

12/7 +33.1c

4/3 -2c

8/5 +13.7c

1/1 0c

Boo

1/1 0c

3/2 -2c

6/5 +15.6c

parallel thirds

27/20 +20.6c

Surrogate Kithara

8/5 +13.7c

40/21 +15.5c

158

DM and QR

8/7 +31.2c

7/4 -31.2c

Eucal Blossom

5/4 -13.7c

Boo

5/4 -13.7c

3/2 -2c

Surrogate Kithara  
40/21  
8/5 +15.5c  
+13.7c

27/20 +20.6c 27/16 +5.9c

40/21 +15.5c 8/5 +13.7c

Surr kith orange + 10/9

8/7 +31.2c 3/2 -2c 9/8 +3.9c

8/7 +31.2c 32/21 +29.2c

DM and QR  
16/9 7/4 3/2 16/9 7/4 3/2 7/4 5/4 7/5 -17.5c 6/5 +15.6c

-3.9c -31.2c -2c -3.9c -31.2c -2c -31.2c -13.7c

3/2 5/4 1/1 7/5 6/5 3/2 5/4 1/1 6/5 1/1 8/5 7/6 5/3 3/2 5/4 4/3 6/5 10/7 7/6 5/3 4/3

+15.6c 0c -17.5c -2c -13.7c -2c 0c +15.6c 0c +13.7c -33.1c -15.6c 0c -15.6c -2c +15.6c +17.5c -33.1c -15.6c 4/3 -2c

Eucal Blossom  
6/5 +15.6c

5/4 -13.7c 11/9 +46.7c

8/7 +31.2c 10/9 -17.6c 21/20 -15.5c 1/1 0c

Boo  
11/6 +49.4c

3/2 -2c 16/11 +48.7c 7/5 -17.5c 4/3 -2c 10/9 -17.6c

9/7 +35c

SMALL INTERVAL SEGMENTS

163

Surr kith Green + 64/33

Surr kith Green + 15/8

Surr kith orange + 2/1

Surr kith orange + 3/2

Diamond Marimba  
5/3 -15.6c

3/2 -2c 9/5 +17.6c 11/10 -35c 11/6 +49.4c

10/7 +17.5c 7/5 -17.5c 1/1 0c

4/3 -2c 7/5 -17.5c 5/4 -13.7c 7/4 -31.2c 9/8 +3.9c 9/5 +17.6c 3/2 -2c 5/4 -13.7c 6/5 +15.6c 10/7 +17.5c

Quadrangularis Reversum  
10/7 alternating +17.5c

12/7 4/3 12/11 20/11 16/11 12/11 4/3 12/7 7/6 12/7

+33.1c -2c -49.4c +35c +48.7c -49.4c -2c +33.1c 0c -33.1c +33.1c

4/3 -2c 5/3 -15.6c 10/7 +17.5c 10/9 -17.6c 16/9 -3.9c 16/9 -3.9c 10/9 -17.6c 10/7 +17.5c 5/3 -15.6c 8/5 +13.7c 5/3 -15.6c 10/7 +17.5c

Eucal Blossom  
1/1 0c

Boo  
10/7 +17.5c 4/3 -2c 9/7 +35c 7/6 -33.1c

16/11 +48.7c 7/5 -17.5c 11/8 +51.3c 5/4 -13.7c 3/2 -2c

chromelodeon 1 and 2

The musical score consists of several staves:

- Staff 1 (Bass):** Labeled "chromelodeon 1 and 2". It shows a long note with a chord of  $1/1$  and  $0c$ .
- Staff 2 (Treble):** Labeled "Surrogate Kithara". It features a melodic line with a chord of  $9/8$  and  $+3.9c$ .
- Staff 3 (Treble):** Labeled "spoils of war (brass shell casings)". It contains three rests.
- Staff 4 (Bass):** Labeled "Gourd Tree". It contains three rests.
- Staff 5 (Treble):** Labeled "Diamond Marimba". It has a complex melodic line with chords  $10/7$  (+17.5c),  $8/7$  (+31.2c),  $5/4$  (-13.7c), and  $1/1$  ( $0c$ ).
- Staff 6 (Treble):** Labeled "Quadrangularis Reversum". It has a complex melodic line with chords  $8/7$  (+31.2c),  $10/7$  (+17.5c),  $12/7$  (+33.1c),  $1/1$  ( $0c$ ),  $6/5$  (+15.6c),  $5/4$  (-13.7c),  $5/4$  (-13.7c),  $3/2$  (-2c),  $3/2$  (-2c),  $3/2$  (-2c),  $7/4$  (-31.2c),  $3/2$  (-2c),  $5/4$  (-13.7c),  $5/4$  (-13.7c),  $6/5$  (+15.6c),  $7/5$  (-17.5c),  $6/5$  (+15.6c),  $1/1$  ( $0c$ ), and  $8/5$  (+13.7c).
- Staff 7 (Treble):** Labeled "Eucal Blossom". It features a rhythmic pattern of eighth notes.
- Staff 8 (Treble):** Labeled "Boo". It features a rhythmic pattern of eighth notes with a chord of  $3/2$  and  $-2c$ .

mixed chord related to m.158 chord

E section

167 Surrogate Kithara

9/8  
+3.9c

chromelodeon 1 and 2

spoils of war  
(brass shell casings)

3/2  
-2c

Gourd Tree

1/1  
0c

3/2  
-2c

10/7  
+17.5c

Diamond Marimba

5/4 1/1 3/2  
-13.7c 0c -2c

7/4  
-31.2c

Quadrangularis Reversum

5/4 3/2 6/5 7/6 9/7 7/6 6/5 3/2 7/4  
-13.7c -2c +15.6c -33.1c +35c -33.1c +15.6c -2c -31.2c

9/8  
+3.9c

1/1 7/4 5/4  
0c -31.2c -13.7c

Eucal Blossom

1/1  
0c

40/21  
+15.5c

Boo

3/2  
-2c

8/5 7/4  
+13.7c -31.2c

27/20  
+20.6c

Bass Marimba

1/1  
0c

Marimba Eroica

9/5  
+17.6c

10T

70T



169 Boo  $\frac{8}{5}$  +13.7c  $\frac{18}{11}$  -47.4c  $\frac{9}{5}$  +17.6c

27/20 +20.6c  $\frac{7}{4}$  -31.2c  $\frac{4}{3}$  -2c  $\frac{11}{6}$  +49.4c  $\frac{4}{3}$  -2c  $\frac{9}{8}$  +3.9c

Bass Marimba  $\frac{9}{8}$  +3.9c  $\frac{7}{6}$  -33.1c  $\frac{16}{9}$  -3.9c  $\frac{11}{6}$  +49.4c  $\frac{9}{8}$  +3.9c  $\frac{7}{6}$  -33.1c  $\frac{11}{6}$  +49.4c  $\frac{9}{8}$  +3.9c  $\frac{16}{9}$  -3.9c  $\frac{11}{6}$  +49.4c  $\frac{16}{11}$  +48.7c

Marimba Eroica  $\frac{9}{5}$  +17.6c

9UT 7UT 9OT 11UT 9UT

x variation

171 Cloud Chamber Bowls

$\frac{9}{5}$  +17.6c  $\frac{7}{6}$  -33.1c  $\frac{10}{9}$  -17.6c  $\frac{12}{11}$  -49.4c  $\frac{9}{5}$  +17.6c  $\frac{7}{6}$  -33.1c  $\frac{10}{9}$  -17.6c  $\frac{12}{11}$  -49.4c  $\frac{1}{1}$  0c

Boo  $\frac{9}{5}$  +17.6c  $\frac{18}{11}$  -47.4c  $\frac{11}{6}$  +49.4c

$\frac{4}{3}$  -2c  $\frac{9}{8}$  +3.9c  $\frac{4}{3}$  -2c

Bass Marimba  $\frac{8}{7}$  +31.2c  $\frac{1}{1}$  0c  $\frac{5}{3}$  -15.6c  $\frac{3}{2}$  -2c  $\frac{16}{9}$  -3.9c  $\frac{9}{8}$  +3.9c  $\frac{8}{5}$  +13.7c  $\frac{11}{6}$  +49.4c  $\frac{16}{9}$  -3.9c  $\frac{9}{8}$  +3.9c  $\frac{11}{6}$  +49.4c  $\frac{16}{9}$  -3.9c  $\frac{11}{6}$  +49.4c

11/6 +49.4c 7/6 -33.1c 16/9 -3.9c 11/6 +49.4c

mixed (instrumental limitations)

173 Eucal Blossom  $\frac{18}{11}$  -47.4c  $\frac{9}{8}$  +3.9c  $\frac{7}{6}$  -33.1c  $\frac{16}{11}$  +48.7c  $\frac{6}{5}$  +15.6c  $\frac{4}{3}$  -2c  $\frac{7}{6}$  -33.1c  $\frac{6}{5}$  +15.6c

Cloud Chamber Bowls  $\frac{7}{6}$  -33.1c  $\frac{9}{5}$  +17.6c

Boo  $\frac{18}{11}$  -47.4c  $\frac{11}{6}$  +49.4c  $\frac{14}{11}$  +17.5c  $\frac{4}{3}$  -2c  $\frac{1}{1}$  0c

Quadrangularis  $\frac{16}{15}$  +11.7c

$\frac{4}{3}$  -2c  $\frac{8}{5}$  +13.7c  $\frac{18}{11}$  -47.4c  $\frac{1}{1}$  0c  $\frac{9}{8}$  +3.9c  $\frac{7}{6}$  -33.1c  $\frac{5}{4}$  -13.7c  $\frac{7}{6}$  -33.1c

Bass Marimba  $\frac{9}{8}$  +3.9c  $\frac{8}{5}$  +13.7c  $\frac{11}{6}$  +49.4c  $\frac{8}{5}$  +13.7c  $\frac{16}{11}$  +48.7c  $\frac{1}{1}$  0c  $\frac{16}{9}$  -3.9c  $\frac{7}{6}$  -33.1c  $\frac{16}{9}$  -3.9c  $\frac{16}{11}$  +48.7c  $\frac{16}{9}$  -3.9c  $\frac{8}{7}$  +31.2c  $\frac{8}{5}$  +13.7c  $\frac{3}{2}$  -2c

1/1 0c

1/1



181

spoils of war  
(cloud chamber bowls)

Quadrangularis 10/7 +17.5c 8/7 +31.2c 10/7 +17.5c 16/11 +48.7c

Eucal Blossom 12/11 -49.4c 9/8 +3.9c 12/11 -49.4c 9/8 +3.9c

Boo 20/11 +35c 9/5 +17.6c 7/6 -33.1c 7/6 -33.1c 20/11 +35c 9/5 +17.6c 11/6 +49.4c 11/6 +49.4c

Bass Marimba 1/1 0c 7/5 -17.5c 8/5 +13.7c 16/9 -3.9c 11/6 +49.4c 9/8 +3.9c 9/8 +3.9c 11/6 +49.4c 16/9 -3.9c 7/6 -33.1c 8/5 +13.7c 16/9 -3.9c

11OT 9OT 11OT 9UT

183

spoils of war  
(cloud chamber bowls)

Quadrangularis 16/11 +48.7c 21/20 -15.5c 9/8 +3.9c 21/20 -15.5c 5/4 -13.7c 21/20 -15.5c 9/8 +3.9c 21/20 -15.5c 7/6 -33.1c 5/4 -13.7c

Eucal Blossom 12/11 -49.4c 9/8 +3.9c 12/11 -49.4c 9/8 +3.9c

Boo 20/11 +35c 9/5 +17.6c 7/6 -33.1c 7/6 -33.1c

Bass Marimba 16/9 -3.9c 11/6 +49.4c 11/6 +49.4c 16/9 -3.9c 7/6 -33.1c 16/11 +48.7c 8/5 +13.7c 9/8 +3.9c 16/9 -3.9c 7/6 -33.1c

11OT 9UT

185

Quadrangularis 3/2 -2c 21/20 -15.5c 7/6 -33.1c 5/4 -13.7c 3/2 -2c

Eucal Blossom 3/2 -2c 8/5 +13.7c 4/3 -2c 3/2 -2c

Boo 6/5 +15.6c 4/3 -2c 10/9 -17.6c

Bass Marimba 3/2 -2c 5/3 -15.6c 16/11 +48.7c

11OT 9UT

Cloud Chamber Bowls

Quadrangularis  
9/8 +3.9c  
1/1 0c  
40/21 +15.5c  
8/7 +31.2c  
7/4 -31.2c

Eucal Blossom  
9/8 +3.9c  
7/6 -33.1c  
8/7 +31.2c  
10/7 +17.5c  
12/7 +33.1c

Boo  
9/5 +17.6c  
11/6 +49.4c  
9/5 +17.6c  
11/6 +49.4c  
8/7 +31.2c  
12/7 +33.1c  
10/7 +17.5c

Bass Marimba  
8/5 +13.7c  
11/6 +49.4c  
9/8 +3.9c  
7/6 -33.1c  
16/11 +48.7c  
8/7 +31.2c

7OT

spoils of war  
(brass shell casings)

Cone Gong  
7/5 -17.5c  
10/7 +17.5c  
16/9 -3.9c

Diamond Marimba  
7/6 -33.1c  
6/5 +15.6c  
11/9 +46.7c  
5/4 -13.7c

Eucal Blossom  
10/7 +17.5c  
12/7 +33.1c  
8/7 +31.2c

Boo  
12/7 +33.1c  
8/7 +31.2c  
10/7 +17.5c  
7/5 -17.5c  
7/5 -17.5c  
10/7 +17.5c  
10/7 +17.5c  
10/7 +17.5c  
10/7 +17.5c  
10/7 +17.5c  
10/7 +17.5c  
11/8 +51.3c  
11/8 +51.3c  
7/5 -17.5c  
7/5 -17.5c  
7/5 -17.5c  
7/5 -17.5c  
7/5 -17.5c  
7/5 -17.5c

Bass Marimba  
8/7 +31.2c  
1/1 0c

7OT

7UT

7OT

191

Cloud Chamber Bowls

spoils of war (brass shell casings)

Gourd Tree

Diamond Marimba

Quadrangularis

Boo

7/4 -31.2c

7/5 -17.5c

40/27 -19.5c

7/5 -17.5c

11/8 +51.3c

9/7 +35c

3/2 -2c

9/7 +35c

10/7 +17.5c

3/2 -2c

7/4 -31.2c

9/5 +17.6c

11/6 +49.4c

9/8 11/10 +3.9c -35c alternating

1/1 0c

10/7 +17.5c

7/4 -31.2c

11/6 +49.4c

11/6 +49.4c

10/7 +17.5c

16/11 +48.7c

16/11 +48.7c

3/2 -2c

11/6 +49.4c

11/6 +49.4c

10/7 +17.5c

7/5 -17.5c

7/5 -17.5c

10/7 +17.5c

10/7 +17.5c

11/6 +49.4c

7/4 -31.2c

7/4 -31.2c

10/7 +17.5c

7/5 -17.5c

7/5 -17.5c

10/7 +17.5c

10/7 +17.5c

11/6 +49.4c

7/4 -31.2c

7/4 -31.2c

7UT

10T

7UT

11UT

193

spoils of war

Gourd Tree

Diamond Marimba

Quadrangularis

Boo

11/8 +51.3c

3/2 -2c

11/8 +51.3c

11/10 -35c

11/8 +51.3c

11/10 -35c

11/10 -35c

11/8 +51.3c

11/10 -35c

11/8 +51.3c

11/8 +51.3c

9/8 +3.9c

9/8 +3.9c

9/8 +3.9c

9/8 +3.9c

9/8 +3.9c

9/7 +35c

9/8 +3.9c

9/7 +35c

9/8 +3.9c

3/2 -2c

16/11 +48.7c

16/11 +48.7c

10/7 +17.5c

16/11 +48.7c

16/11 +48.7c

10/7 +17.5c

40/21 +15.5c

10/9 -17.6c

4/3 -2c

7/5 -17.5c

16/11 +48.7c

16/11 +48.7c

11/8 +51.3c

11/8 +51.3c

10/7 +17.5c

10/7 +17.5c

7/5 -17.5c

7/5 -17.5c

10/7 +17.5c

10/7 +17.5c

7/5 -17.5c

7/5 -17.5c

11/10 -35c

9/7 +35c

11/8 +51.3c

7/5 -17.5c

7/5 -17.5c

16/11 +48.7c

10T

**F section**

chromelodeon 1  
1/1 0c  
8/5 +13.7c  
3/2 -2c  
4/3 -2c

chromelodeon 2  
3/2 -2c  
8/5 +13.7c

chromelodeon 2  
6/5 +15.6c  
3/2 -2c  
1/1 0c

chromelodeon 1 sub bass  
1/1 0c

spoils of war  
11/8 +51.3c  
3/2 -2c

Gourd Tree  
3/2 -2c

Diamond Marimba  
9/8 +3.9c  
11/10 -35c  
11/8 +51.3c  
11/10 -35c  
9/7 +35c  
9/8 +3.9c  
9/7 +35c  
9/8 +3.9c

Quadrangularis  
3/2 -2c

Boo  
40/21 +15.5c  
10/9 -17.6c  
4/3 -2c  
11/10 -35c  
9/7 +35c  
11/8 +51.3c  
7/5 -17.5c  
16/11 +48.7c  
16/11 +48.7c  
11/8 +51.3c  
11/8 +51.3c  
16/11 +48.7c

Bass Marimba  
3/2 -2c

spoils of war  
3/2 -2c  
6/5 +15.6c  
16/9 -3.9c  
1/1 0c

Kithara 1 and 2 sliding

Cloud Chamber Bowls  
6/5 +15.6c  
8/5 +13.7c

Marimba Eroica  
11/8 +51.3c  
16/9 -3.9c

3/2	1/1
6/5	8/5
5/3	4/3

alternating chords

Kithara 1 and 2 sliding

**kithara 1**  
33/32 -46.7c  
1/1 0c  
8/5 +13.7c 6/5 +15.6c

**kithara 2**  
11/10 6/5 -35c +15.6c  
1/1 0c  
9/5 +17.6c 7/5 -17.5c 8/5 +13.7c

**kithara 2**  
11/10 6/5 -35c +15.6c  
7/5 -17.5c 8/5 +13.7c

**chromelodeon 1**  
1/1 8/5 +13.7c  
0c -2c  
3/2 4/3 -2c

**chromelodeon 2**  
8/5 +13.7c  
3/2 -2c  
6/5 +15.6c

**chromelodeon 2**  
9/5 +17.6c  
3/2 -2c 1/1 0c

**chromelodeon 1 sub bass**  
1/1 0c

**spoils of war**  
3/2 -2c

**Cloud Chamber Bows**  
6/5 +15.6c 8/5 +13.7c  
6/5 +15.6c

**Quadrangularis**  
3/2 -2c 1/1 0c  
3/2 -2c 1/1 0c  
3/2 -2c 1/1 0c

**Gourd Tree**  
6/5 +15.6c  
16/9 -3.9c 1/1 0c  
6/5 +15.6c 16/9 -3.9c 1/1 0c  
6/5 +15.6c 16/9 -3.9c 1/1 0c

**Bass Marimba**  
5/3 -15.6c 4/3 -2c  
5/3 -15.6c 4/3 -2c  
5/3 -15.6c 4/3 -2c

**Marimba Eroica**  
10/7 +17.5c 9/5 +17.6c

2-chord alternation with chromelodeon pedal

200

chromelodeon 1  
 $\frac{3}{2}$   $\frac{40}{27}$   
 $-2c$   $-19.5c$

chromelodeon 2  
 $\frac{3}{2}$   $\frac{40}{27}$   
 $-2c$   $-19.5c$

chromelodeon 2  
 $\frac{3}{2}$   $\frac{40}{21}$   
 $-2c$   $+15.5c$

Cloud Chamber Bwls  
 $\frac{6}{5}$   $\frac{40}{27}$   
 $+15.6c$   $-19.5c$

spoils of war  
 $\frac{40}{27}$   $\frac{10}{9}$   
 $-19.5c$   $-17.6c$

Gourd Tree  
 $\frac{3}{2}$   $\frac{40}{21}$   
 $-2c$   $+15.5c$

Quadrangularis  
 $\frac{3}{2}$   $\frac{40}{21}$   
 $-2c$   $+15.5c$

Bass Marimba  
 $\frac{3}{2}$   $\frac{16}{9}$   
 $-2c$   $-3.9c$

Marimba Eroica  
 $\frac{10}{7}$   $\frac{9}{5}$   
 $+17.5c$   $+17.6c$

$\frac{9}{5}$   
 $+17.6c$

10T 90T alternating chords



203 chromelodeon 1 and 2

The musical score consists of the following parts and annotations:

- Chromelodeon 1 and 2:** Bass clef, notes with annotations  $5/3$  and  $-15.6c$ .
- Vocal Line:** Lyrics include "spoils of war (brass shell casings)". Annotations:  $10/7$   $+17.5c$  and  $7/5$   $-17.5c$ .
- Cloud Chamber Bowls:** Treble clef, notes with annotations  $5/3$  and  $-15.6c$ .
- Gourd Tree:** Treble clef, notes with annotation  $10/9$   $-17.6c$ .
- Diamond Marimba:** Treble clef, rhythmic pattern with annotation  $16/9$   $-3.9c$ .
- Quadrangularis:** Bass clef, rhythmic pattern with annotation  $10/9$   $-17.6c$ .
- Boo:** Treble clef, rhythmic pattern with annotations  $7/4$   $-31.2c$  and  $12/7$   $+33.1c$ ,  $27/16$   $+5.9c$ ,  $5/3$   $-15.6c$ ,  $18/11$   $-47.4c$ ,  $8/5$   $+13.7c$ .
- Bass Marimba:** Bass clef, notes with annotations  $5/3$  and  $-15.6c$ .
- Marimba Eroica:** Bass clef, notes with annotation  $10/7$   $+17.5c$ .

At the bottom left, there is a boxed label: 3OT

205 chromelodeon 1 sub bass

The musical score is organized into two systems, each with five staves. The instruments and their associated data are as follows:

- Chromelodeon 1 sub bass:** Interval  $5/3$ , -15.6c (left); Interval  $16/11$ , +48.7c (right).
- Cloud Chamber Bwls:** Interval  $5/3$ , -15.6c.
- spoils of war (brass shell casings):** Intervals  $10/7$  (+17.5c) and  $7/5$  (-17.5c) (left); Interval  $10/7$  (+17.5c) (right).
- Gourd Tree:** Interval  $10/9$ , -17.6c.
- Diamond Marimba:** Intervals  $16/9$  (-3.9c) and  $20/11$  (+35c).
- Quadrangularis:** Interval  $10/9$ , -17.6c.
- Eucal Blossom:** Intervals:  $10/9$  (-17.6c),  $12/11$  (-49.4c),  $16/15$  (+11.7c),  $21/20$  (-15.5c),  $33/32$  (-46.7c),  $1/1$  (0c),  $64/33$  (+46.7c),  $40/21$  (+15.5c),  $15/8$  (-11.7c),  $11/6$  (+49.4c),  $9/5$  (+17.6c),  $16/9$  (-3.9c),  $7/4$  (-31.2c),  $12/7$  (+33.1c),  $5/3$  (-15.6c),  $18/11$  (-47.4c),  $8/5$  (+13.7c),  $14/9$  (-35.1c),  $3/2$  (-2c).
- Boo:** Interval  $7/4$ , -31.2c. Intervals:  $12/7$  (+33.1c),  $27/16$  (+5.9c),  $5/3$  (-15.6c),  $18/11$  (-47.4c),  $8/5$  (+13.7c),  $11/7$  (-17.5c),  $14/9$  (-35.1c),  $32/21$  (+29.2c),  $3/2$  (-2c),  $40/27$  (-19.5c),  $16/11$  (+48.7c).
- Bass Marimba:** Interval  $5/3$ , -15.6c.
- Marimba Eroica:** Interval  $10/7$ , +17.5c.

5UT

small interval segments

207 chromelodeon 1 sub bass

16/11  
+48.7c

spoils of war  
(brass shell casings)

10/7  
+17.5c

Gourd Tree

10/9  
-17.6c

Diamond Marimba

20/11  
+35c

Quadrangularis

10/9  
-17.6c

Eucal Blossom

16/11 10/7 7/5 11/8 4/3 16/11 10/7 7/5 11/8 4/3  
+48.7c +17.5c -17.5c +51.3c -2c +48.7c +17.5c -17.5c +51.3c -2c

Boo <sup>7/5</sup>  
-17.5c

10/7 11/8 27/20 4/3 10/7 11/8 27/20 4/3  
+17.5c +51.3c +20.6c -2c +17.5c +51.3c +20.6c -2c

Bass Marimba

4/3  
-2c

Marimba Eroica

11/8  
+51.3c

4/3  
-2c

**A<sup>1</sup> section**

harmonic canon strum

209

16/9 -3.9c    21/20 -15.5c    7/6 -33.1c    10/9 -17.6c    9/8 +3.9c    4/3 -2c    16/9 -3.9c    21/20 -15.5c    7/6 -33.1c    10/9 -17.6c    9/8 +3.9c    4/3 -2c

4/3 -2c    9/8 +3.9c    10/9 -17.6c    7/6 -33.1c    21/20 -15.5c    16/9 -3.9c

4/3 -2c    9/8 +3.9c    10/9 -17.6c    7/6 -33.1c    21/20 -15.5c    16/9 -3.9c

4/3 -2c

Castor 5/3 -15.6c

10/9 -17.6c    10/9 -17.6c

Gourd Tree 10/9 -17.6c

Cone Gong 16/9 -3.9c

spoils of war (cloud chamber bowls) 10/9 -17.6c    11/6 +49.4c

Diamond Marimba 20/11 +35c

Quadrangularis 10/9 -17.6c

Eucal Blossom 4/3 -2c

Boo 4/3 -2c

Bass Marimba 4/3 -2c

Marimba Eroica 11/8 +51.3c

**3OT**

elided with new section

harmonic canon strum

212

16/9 -3.9c 21/20 -15.5c 7/6 -33.1c 10/9 -17.6c 9/8 +3.9c 4/3 -2c 16/9 -3.9c 21/20 -15.5c 7/6 -33.1c 10/9 -17.6c 9/8 +3.9c 4/3 -2c

4/3 -2c 9/8 +3.9c 10/9 -17.6c 7/6 -33.1c 21/20 -15.5c 16/9 -3.9c 4/3 -2c 9/8 +3.9c 10/9 -17.6c 7/6 -33.1c 21/20 -15.5c 16/9 -3.9c

Castor

5/3 -15.6c

4/3 -2c 10/9 -17.6c

Koto

4/3 -2c 9/7 +35c 11/7 -17.5c

Cloud Chamber Bowls

7/4 -31.2c 16/9 -3.9c

spoils of war  
(cloud chamber bowls)

10/9 -17.6c 11/6 +49.4c 10/9 -17.6c 11/6 +49.4c

harmonic canon strum

215

16/9 -3.9c 21/20 -15.5c 7/6 -33.1c 10/9 -17.6c 9/8 +3.9c 4/3 -2c 16/9 -3.9c 21/20 -15.5c 7/6 -33.1c 10/9 -17.6c 9/8 +3.9c 4/3 -2c 16/9 -3.9c 21/20 -15.5c 7/6 -33.1c 10/9 -17.6c 9/8 +3.9c 4/3 -2c

4/3 -2c 9/8 +3.9c 10/9 -17.6c 7/6 -33.1c 21/20 -15.5c 16/9 -3.9c 4/3 -2c 9/8 +3.9c 10/9 -17.6c 7/6 -33.1c 21/20 -15.5c 16/9 -3.9c

Koto

4/3 -2c 9/7 +35c 11/7 -17.5c

Cloud Chamber Bowls

20/11 +35c 16/9 -3.9c

spoils of war  
(cloud chamber bowls)

10/9 -17.6c 11/6 +49.4c 10/9 -17.6c 11/6 +49.4c